Flexibility meets efficiency.

CGM™ and oxy-fuel for fibreglass production.

THE LINDE GROUP

Linde

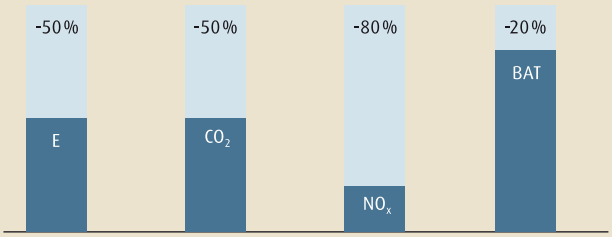
Introduction.

The reinforcement fibreglass industry is a line of business that is consistently growing as more and more components change from metal to composites, such as distribution piping, automotive components, electronics and home appliances. And the demand for fibreglass-reinforced products will increase even more as growing numbers of people in developing regions, such as South America, China and India, become purchasers of these products. State-of-the-art glass melting technologies and innovative gas supply solutions from Linde can now make fibreglass production more efficient, more eco-friendly and more profitable than ever before.

Preview

Want to know right away what using oxy-fuel and Linde's CGM™ technology in fibreglass production can do for your company? Here is a sneak peak summary of the combined advantages:

Effective consumption, cost and emission reductions*



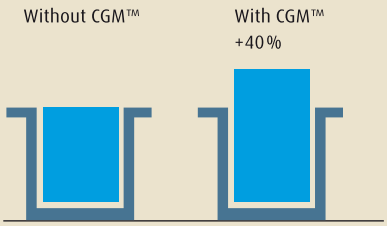
Energy consumption: 50 % less

Carbon dioxide emissions: 50 % less

Nitrogen oxide emissions: 80 % less

Batch costs: 20 % less

Efficiency increase**



Up to 40 % increase in production from the same melter

*) Plus: no capital and operating costs for particulate emissions control devices.
**) No additional melter required.

Reduced emissions, less costs.
The advantages of non-boron glass compositions.

Up until about 1996, reinforcement fibreglass (which has different properties than insulation fibreglass or fibreglass yarn) was usually manufactured from a boron-containing glass composition referred to as "E-glass".

Conventional fibreglass composition
Since boron volatilises during glass production, conventional fibreglass furnaces produce high levels of particulates that require expensive collection systems. Moreover, boron is difficult to get in some regions of the world and therefore, depending on the location of the glassworks, the cost of batch materials can be rather high.

New fibreglass composition
These disadvantages can now be eliminated by the application of new, non-boron glass compositions. Non-boron-containing fibreglass logically doesn't require corresponding particulate collection systems and doesn't generate any procurement costs for the boron itself. In addition to these manufacturing cost advantages, the new compositions have the following improved product characteristics over the former E-glass compositions:

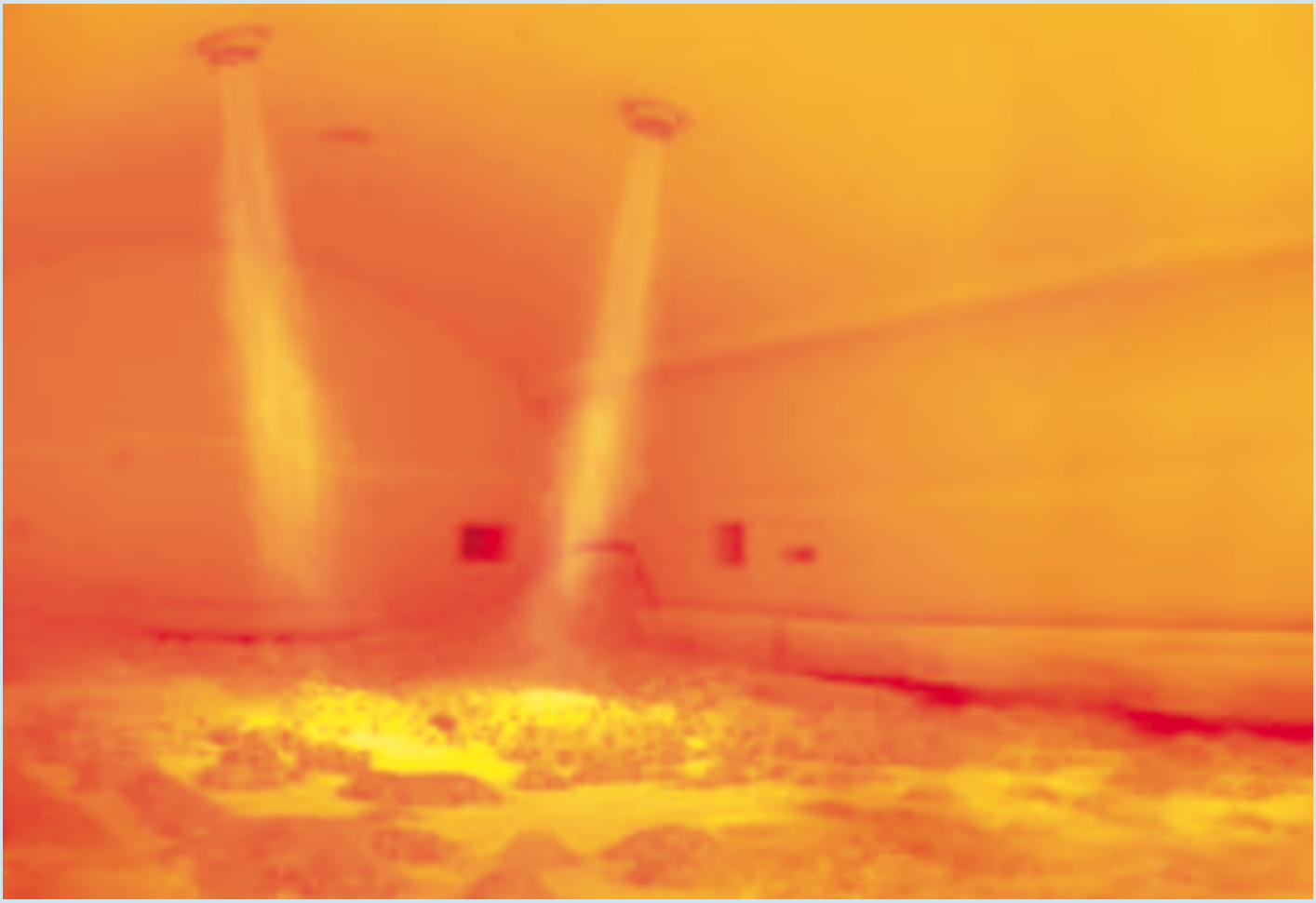
- → They retain their properties at higher temperatures
- → They have a higher chemical resistance
- → They are generally more durable

New fibreglass technologies
On top of that, and at least equally important: Non-boron compositions allow the application of advanced and highly efficient glass melting technologies in the glass furnace, such as Linde's CGM™. This new oxy-fuel melting technology reduces overall energy consumption while lowering CO_2 and NO_x emissions.

Typical reinforcement fibreglass compositions*

Conventional E-glass composition	New non-boron composition
54 % SiO_2	60 % SiO_2
15 % Al_2O_3	13 % Al_2O_3
23 % CaO/MgO	25 % CaO/MgO
6 % B_2O_3	0 % B_2O_3
2 % other components	2 % other components

*) Please note: These are typical compositions that will vary from manufacturer to manufacturer.



The problems with boron

Until 1996, boron-containing E-glass was the universally accepted composition for the reinforcement segment of the fibreglass industry. However, the following parameters have since encouraged manufacturers to move away from the established composition:

- The chemically aggressive nature of the composition on refractory and heat recovery devices
- The cost of the environmental control devices (due to more demanding environmental legislation)
- The cost and restricted global availability of boron

No candidate for CGM™

The conventional E-glass composition cannot benefit from the increased melting action of Linde's CGM™ technology since the boron-containing batch materials must melt rather slowly to allow the silica and boron to chemically bond and not create silica-rich glass (also known as batch segregation). The CGM™ crown burners over the batch area may increase the early loss of boron compounds. Therefore, conventional fibreglass furnaces for boron-containing batch materials have little or no firing for the first two metres from the charging end wall, thus losing valuable batch melting area.

Ingenious composition, advanced production.
Non-boron-containing fibreglass.

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The removal of most or all of the boron from the typical E-glass composition has become broadly accepted in the reinforcement fibreglass manufacturing industry. Moreover, the forming technologies for non-boron E-glass compositions are now becoming more widely known. Today, companies specialising in fibreglass production can provide the complete melter and forming designs for these products.

This change is primarily driven by a reduction of 20 % or more in batch material cost (depending on the plant location) and by eliminating the capital and operating expense for waste gas particulate collecting devices, such as bag houses or electrostatic precipitators.

However, in order to profit from the manufacturing cost and product advantages of the new glass compositions, the fibreglass manufacturer has to consider the design and operating changes that have to be made in the forming process. Moreover, the manufacturer has to be aware that there will be increased fuel consumption due to higher distributor and forehearth temperatures.

On the other hand, the melter size and/or operating conditions do not require major modifications. And last but not least, some of the initial investments can be balanced by a significant increase in furnace life that comes with the chemically less aggresive non-boron compositions.

Approved by the inventors of fibreglass.
CGM™ advanced glass melting technology.

About CGM™

CGM™ is Linde's advanced glass melting technology that locates oxy-fuel burners in the crown of the furnace, principally over the un-melted batch, to achieve increased heat transfer and faster melting. For a more detailed description of our advanced glass melting technology, please refer to Linde's CGM™ brochure.

CGM™ was first introduced to the public by a paper presented in 2001 at the North American Glass Problems Conference. The paper documented the first application of CGM™ on a reinforcement fibreglass furnace operating on a non-boron composition in 1996. At that time, the following results were presented:

- Pull increase of 50 % or more over conventional oxy-fuel capacity*
- No increase in emissions on a per-ton basis
- No changes in the analysed glass chemistry
- No damage to the melter superstructure
- Reduced glass defects as measured by break rates

CGM™ was first applied to an Owens Corning furnace when they were developing their new, non-boron-containing glass composition – and it worked extremely well. As the company that invented fibreglass and today's global leader in the reinforcement fibreglass market, Owens Corning has been using oxy-fuel and CGM™ technology ever since.

Inasmuch as the benefits of using these innovative methods for fibreglass production are becoming more widely known, many smaller fibreglass producers as well as other large players in developing geographical areas are now moving away from conventional, boron-containing fibreglass compositions and switching to non-boron fibreglass production that allows for the application of oxy-fuel and CGM™.

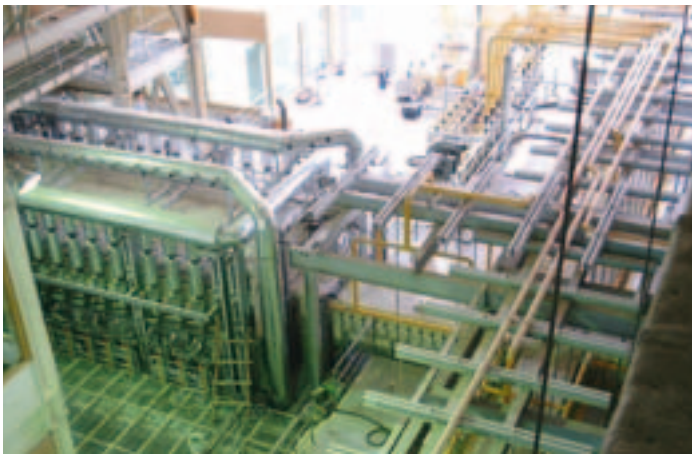
*) Please note: The results of any given test are influenced by a number of factors, including the relative size of the furnace, its initial physical condition, the glass chemistry, operating parameters etc. Since the presentation, CGM™ has consistently demonstrated that it can increase the pull rate of a glass melting furnace by up to 40 %.

The benefits of using oxy-fuel and CGM™ for fibreglass production.

Linde's advanced glass melting technology CGM™ is the ideal melting system for non-boron fibreglass compositions. Since the technology's first official presentation in 2001, it has been proven that CGM™ can increase the melting capacity of glass furnaces by up to 40 %, thus providing significantly more production capacity without adding another furnace.

On the other hand, the application of CGM™ does require the conversion of the glass melting operation from air-fuel to oxy-fuel, a fact that doesn't sound like much of an advantage at first but, actually, is a blessing in disguise since it bears the opportunity to reduce the overall fuel cost for fibreglass production.

This is due to the fact that not only the glass melting furnaces, but the fibreglass forehearths as well can be operated with oxy-fuel. As a rule, fibreglass forehearths consume as much oxy-fuel per batch as the glass melters. The combined oxygen demands of the melter and the forehearth are usually large enough to allow the installation of an on-site oxygen generator that provides low-cost oxygen for the entire facility.



Typical reinforcement fibreglass furnace and forehearth layout. Picture courtesy of Glass Strand, Inc.

Oxy-fuel and refractory issues

Linde's Glass and Fibres Applications Group has expertise in all elements of the glass melting process. Due to the concern of refractory deterioration under oxy-fuel conditions, we published "A User's Guide to Oxy-Fuel Furnace Crown Selection". This guide explains the chemical attack mechanism between a standard soda-lime glass (i. e. tableware, float or container glass) under an oxy-fuel combustion environment. The primary issue with silica crowns is the transformation of sodium sulphate to sodium silicate in the joints of the crown refractory.

However, within the new glass compositions for the fibreglass industry, there is very little soda in the batch, no formation of sodium sulphate, and therefore no crown refractory deterioration. CGM™ has been in operation in fibreglass furnaces since 1998, with no deterioration of the crown. Since the crown is the only negative issue regarding the application of oxy-fuel in a glass melting furnace and that issue does not exist in a new-composition fibreglass furnace, CGM™ can be included as a part of the furnace design without creating any problems.

Step by step to a higher efficiency.
More oxy-fuel and CGM™ benefits.

The new glass compositions for fibreglass production permit the immediate application of energy to the batch as it leaves the chargers. Therefore, CGM™ burners can be located accordingly to take advantage of this increased melting space. In addition, the increase in temperature of the batch materials under the CGM™ flames melts the silica faster than any other conventional melting technology.

The conversion of a new-composition fibreglass furnace from air-fuel to oxy-fuel and CGM™ provides the following benefits:

- Up to 40-% increase in pull rate from a same-sized melter at a similar break rate
- Alternatively: 30-% reduction in break rate at the same pull rate
- Savings in the capital and operating costs of a heat recovery device (typically a recuperator)
- Savings in the capital and operating costs of a particulate emissions control device
- 35-% reduction in energy consumption

Moreover, the significant increase in pull rate can eliminate (or delay) the requirement to construct another glass furnace by:

- Obtaining the same glass melting capability with only two instead of three furnaces
- The ability to add a (fibreglass) forehearth or another line to the existing furnace

Using a non-boron glass composition, oxy-fuel flames and Linde's CGM™ technology is the ideal combination for the fibreglass production process that opens up a whole range of tangible benefits:

The ideal combination

Non-boron fibreglass composition	Oxy-fuel	CGM™
About 20 % less batch cost	35 % less fuel cost	40 % higher pull rate
No particulate control required	35 % lower CO_2 emissions	30 % lower break rate
	80 % lower NO_x emissions	

Environmental advantages

If the increase in pull rate cannot be used, the reduction in break rate provided by CGM™ decreases the amount of waste glass products that often have to be disposed of in a landfill (a practice that is getting more difficult as environmental laws are tightening). And contrary to other glass products, it is difficult to recycle waste fibreglass. Moreover, the cost of this waste product is high since you are completely throwing away the batch materials and the cost of energy to make it.

Using Linde's CGM™ technology to reduce the break rate by 30 % therefore presents a significant cost advantage even for fibreglass manufacturers that have no immediate need for a significantly higher pull rate.

Forehearth operation with oxy-fuel

The distributor and forehearth of a reinforcement fibreglass furnace are two of the more challenging combustion heating applications:

- The relatively low pull rates do not bring a significant amount of the total required energy from the melter.
- The small channels have a small combustion space.
- The high temperature demand requires a higher energy input.
- The small combustion space along with the higher energy input may result in high internal pressures that can result in deterioration of the superstructure refractory.

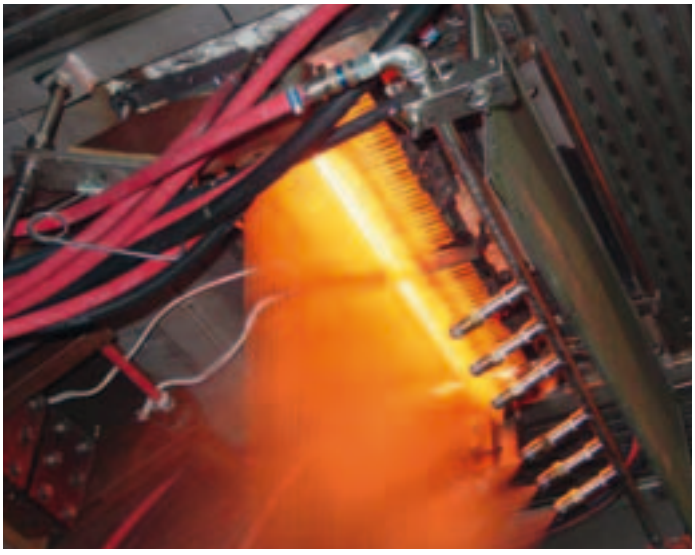
Since the air is not preheated for these applications, a significant portion of the energy applied to a forehearth is used to increase the temperature of the combustion air to the level required by the forehearth.

The total energy consumption of the distributor and forehearth temperatures for the new fibreglass compositions is increased due to the higher forming temperature requirements. By the conversion of an air-fuel forehearth to oxy-fuel, however, total energy savings of 60 % can be achieved – a significant reduction of costs for the glass manufacturer.

Conclusion

The combination of converting a typical fibreglass furnace along with its associated distributor and forehearths will save 47 to 50 % of the total energy consumed by the total plant. Additionally, this will result in the following economical and environmental benefits:

- Particulate values low enough that no emission equipment is required
- 80-% reduction in NO_x emissions
- 50-% reduction in CO_2 emissions



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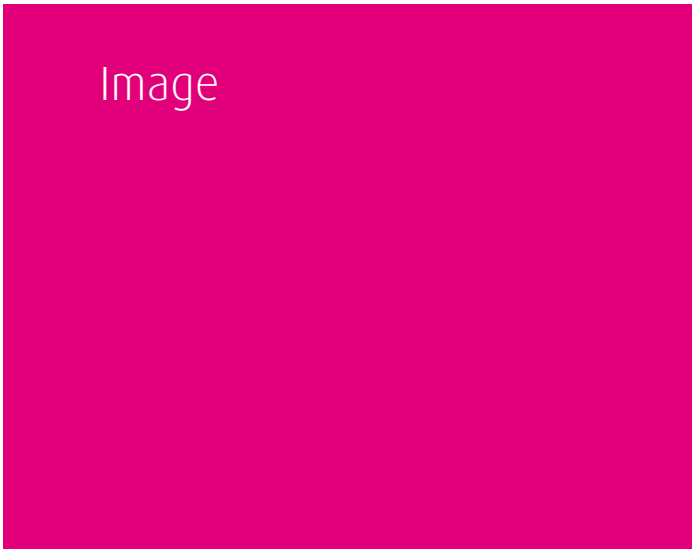

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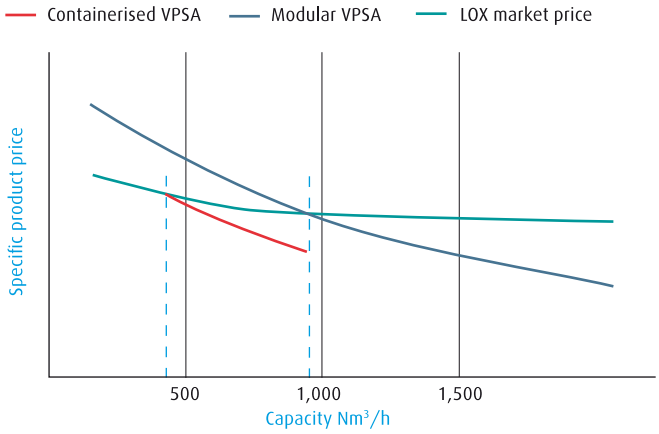
Meeting the demand. Oxygen supply solutions from Linde.

Two-bed vertical VPSA with a vertical surge tank (???)

ADSOSS®-O: New containerised VPSA – range 400–900 Nm³/h



The price of oxygen depends, to a great extent, on the oxygen demand of the customer. Quantities under 30 metric tons per day (875 Nm³/h) are often supplied as liquid oxygen (LOX) and delivered by trucks in 20-tonne loads. This is the more expensive form of oxygen since it requires the capital and energy to liquefy gaseous oxygen along with constantly increasing transportation costs. With demands above 30 tonnes per day, however, it becomes more economical to install an on-site oxygen generator – usually a vacuum pressure swing adsorption (VPSA) type of plant.

On-site oxygen supply

The conversion of a typical fibreglass melter and forehearth to oxy-fuel usually increases the oxygen demand to a degree that justifies the installation of an on-site oxygen plant, typically supplying a gas mixture with 90–93 % oxygen and a product pressure at the inlet of the burner skid of 0.5 to 0.8 bar(g).

Simplified example for a 60-tpd oxy-fuel fibreglass melter and forehearth

Melter energy demand	330 Nm³/h of natural gas or 675 Nm³/h oxygen
Forehearth energy demand	330 Nm³/h of natural gas or 675 Nm³/h oxygen
Total energy demand	660 Nm³/h of natural gas or 1,350 Nm³/h oxygen

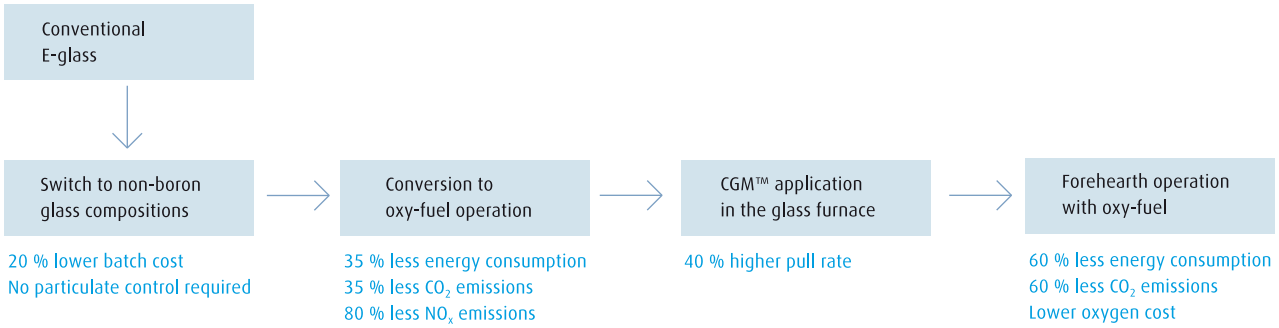
Linde's on-site oxygen supply offer

The Linde VPSA on-site oxygen plant offered for fibreglass production facilities is optimally standardised and containerised in order to minimise investment and erection time and to ensure the highest oxygen quality, operational safety and reliability as well as global adaptability.

Furthermore, employing vibration-damped containers results in simple base plate foundations. All these features significantly reduce oxygen operating costs and thus present a clear advantage for fibreglass producers around the world.

All the benefits at a glance.

Range of advantages



Eco-friendly, efficient and profitable

Switching to new, non-boron glass compositions and using both oxy-fuel and Linde's advanced glass melting technology CGM™ opens up a whole new range of advantages for your fibreglass production. Here are some of the most significant benefits at a glance:

- → No boron procurement costs, therefore lower batch costs
- → No more costs for waste gas particulate collecting devices
- → Clear environmental benefits thanks to oxy-fuel operation
- → Significantly less energy consumption with oxy-fuel operation
- → 40 % higher pull rate with Linde's CGM™ technology in the furnace
- → Lower oxygen cost with Linde's on-site oxygen supply solution
- → Improved fibreglass product quality
- → Increased furnace life

On top of that, Linde offers you an extensive portfolio of services, support and expertise for your fibreglass manufacturing tasks. With decades of experience in the gas and engineering sector and international connections to the glass industry, we are the ideal partner for glass producers worldwide. Just ask our experts for advice. They'll be happy to help your company with our eco-friendly, efficient and profitable solutions.

Getting ahead through innovation.

With its innovative concepts, Linde is playing a pioneering role in the global market. As a technology leader, it is our task to constantly raise the bar. Traditionally driven by entrepreneurship, we are working steadily on new high-quality products and innovative processes.

Linde offers more. We create added value, clearly discernible competitive advantages, and greater profitability. Each concept is tailored specifically to meet our customers' requirements – offering standardised as well as customised solutions. This applies to all industries and all companies regardless of their size.

If you want to keep pace with tomorrow's competition, you need a partner by your side for whom top quality, process optimisation, and enhanced productivity are part of daily business. However, we define partnership not merely as being there for you but being with you. After all, joint activities form the core of commercial success.

Linde – ideas become solutions.

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