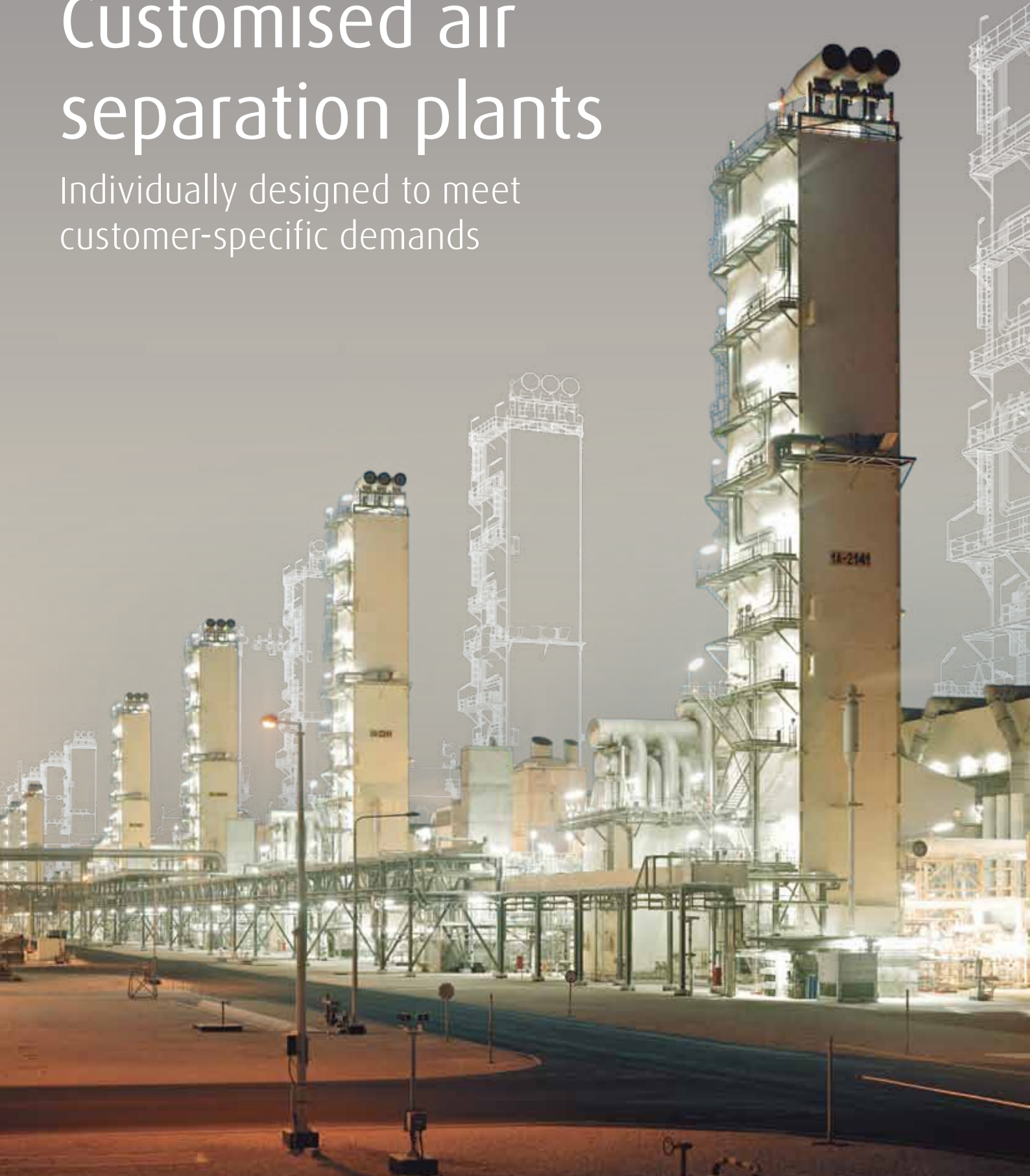


Making our world more productive



# Customised air separation plants

Individually designed to meet customer-specific demands





# Proven technology – tailored to your needs.

The design, procurement, construction and operation of customised, multi-train air separation projects can present a number of challenges, particularly in remote locations. Having successfully engineered and executed most of the largest air separation complexes in the world, Linde Engineering has the experience and expertise to master all of these challenges.

## Extensive experience in engineering, procurement and construction

Linde is one of the largest and most experienced suppliers of air separation plants and industrial gases worldwide. We have already delivered over 3,000 cryogenic air separation plants around the globe and operate more than 550 air separation plants ourselves. Building on our long-standing experience in both plant engineering and operation, we are able to individually design plants to meet customer-specific demands. They can produce oxygen, nitrogen and argon as well as krypton/xenon and helium/neon. Daily oxygen production capacities range from 1,000 tonnes (30,000 Nm<sup>3</sup>/h) to 5,500 tonnes (165,000 Nm<sup>3</sup>/h).

- State-of-the-art technology and proven design for reliable operation
- Global execution capabilities due to worldwide presence
- Vast experience in the engineering and operation of customised ASUs
- Global sourcing and procurement capabilities for cost efficiencies
- Professional support services from consulting through commissioning to start-up and operation
- Peace of mind thanks to our strong focus and excellent track record in quality, health, safety and environmental (QHSE) protection
- High power efficiency
- Ease of maintenance for low OPEX
- Services over the entire lifecycle of a plant

## Industry-proven expertise

We serve clients across a broad range of industries. The hands-on experience we have gathered enables us to recommend, design and deliver the perfect fit for individual needs – regardless of the industry you operate in. Our references span:

- Iron and steel
- Non-ferrous metallurgy
- Chemicals
- Energy (synfuels, gasification, methanol)
- Petrochemicals (ethylene oxide/glycol)
- Enhanced oil recovery



Lifting of a column.

*“Understanding our customers’ needs, offering a value-creating solution and executing are key capabilities at Linde Engineering.”*

Jürgen Nowicki  
Executive Vice President  
Linde plc and CEO of  
Linde Engineering



## Execution excellence – every step of the way.

### Execution capabilities

Linde has a large engineering and project execution workforce for the implementation of engineering, procurement and construction (EPC) projects worldwide. Project managers with extensive experience in complex multinational / multi-partner projects supported by advanced tools and methods for project control are the best way to ensure the success of your project.

discipline will readily answer any requests you may have and support plant modifications and revamps, maintenance and repair, spare parts, operational support such as troubleshooting, immediate repairs, expert reviews for plants as well as operator training over the entire lifecycle.

### Construction

Extensive pre-fabrication and pre-assembly activities combined with efficient, dedicated material logistics and organisational workflows give us the tools we need to always deliver on time and to the highest quality standards.

### Global sourcing and localisation

Worldwide staffing and training, global procurement and fabrication capabilities and a broad partner ecosystem bring maximum flexibility to your project.

Our adherence to health and safety regulations coupled with our design philosophy ensure robust protection of the health and safety of our employees and our contractors' staff as well as the surrounding environment.

### Engineering excellence – made in house

We design and manufacture all key and proprietary cryogenic components required for air separation plants in our own fabrication workshops. The fact that the plant and process engineering as well as the manufacturing team are integral parts of one company ensures your project is seamlessly executed.

### Commissioning, training and customer service

Skilled commissioning teams on site ensure smooth start-up and hand-over of the plant to your team. And our support does not stop when your plant goes on stream. Our service specialists covering every engineering

We manufacture:

- Plate-fin heat exchangers
- Columns
- Packings
- Turbomachinery, expanders
- Cryogenic pumps

**3,000+**  
cryogenic air separation plants  
delivered worldwide



Remote Operating Centre (ROC).




Sieve tray column.





Delivery of world's largest coldbox weighing 800 tonnes for Jamnagar, India.



$5 \times 5,250 \text{ t}$   
 $\text{O}_2$  per day for  
Jamnagar, India

## Teaming up to deliver the world's largest ASUs.

The Jamnagar refining complex in Gujarat, India, is home to the world's largest crude oil refinery. Now in its third expansion phase, the complex is being equipped with the ability to generate its own synthesis gas as well as energy through the gasification of petroleum coke. Linde supported the gasification project by delivering five of the world's largest air separation units (ASUs), scaling up various plant component designs to take performance into uncharted territory. Each of the five ASUs is designed for an oxygen production capacity of 5,250 tonnes per day. By teaming up with the customer and equipment manufacturers, Linde Engineering managed to optimise the plant configuration to leverage economies of scale and boost energy efficiency.



**8 × 3,800 t**  
O<sub>2</sub> per day in  
Ras Laffan, Qatar

## Oxygen for mega GTL and CTL plants.

An eight-train air separation facility in the Qatar desert is a prime example of Linde Engineering's ability to deliver cutting-edge, multi-train solutions to support oxygen-intensive applications such as coal to liquids (CTL) and gas to liquids (GTL) processes. The plant is located at the site of the world's largest GTL plant to date, which went on stream after a planning and construction period spanning several years. Today, the plant produces 140,000 barrels of liquid fuels per day from natural gas. The eight identical air separation units provide the oxygen required for the conversion process. Together, they generate 30,000 tonnes of oxygen every day from the surrounding air. Each coldbox weighs 470 tonnes and is 60 metres high.

Linde sourced key components such as the aluminium plate-fin heat exchangers and rectification columns from its production sites in Germany and China. The coldboxes were also fully assembled as packaged units at these locations. Pre-assembling the components in this way meant that Linde did not need to carry out complex assembly and construction work in a hostile desert environment. As the main contractor, Linde was responsible over the entire project lifecycle for ensuring timely completion of the turnkey facility, which was gradually brought on stream exactly as planned.







Air separation units at the Pearl GTL complex in Ras Laffan, Qatar.



Air separation units near Yinchuan City, China.

## Engineering masterpiece in China.

In March 2013, we won another major contract – this time for a plant near Yinchuan City in the mid-west of China. Here we built a six-train air separation facility with a capacity of 21,600 tonnes of oxygen per day. Drawing also on experience gained through other world-class projects such as Pearl GTL, Qatar, we succeeded in securely delivering these vast gas volumes cost effectively and reliably. Despite the remote location of the site, we were able to rely on our global and

local network of partners to ensure seamless execution of the project. Our engineering centres in Pullach (Germany) and Hangzhou (China) as well as our production sites in Schalchen (Germany) and Dalian (China) were all involved in the project. As a result, the six rectification coldboxes, with more than 2,000 tonnes of steel structure, were completed in record time.





**6 × 3,600 t**  
O<sub>2</sub> per day for a plant near  
Yinchuan City, China



Air separation units at Cantarell, Mexico.





**5 × 10,000 t**  
**N<sub>2</sub> per day for**  
**Cantarell, Mexico**

## Cooperating to more than double oil recovery rates.

Located around 100 kilometres offshore in the Gulf of Mexico, the Cantarell oil field is one of the world's biggest. To boost dwindling recovery rates, the field operator turned to Linde to support its enhanced oil recovery (EOR) plans. EOR entails injecting nitrogen into the reservoir at high pressure and this calls for a steady stream of the gas. Linde completed a purpose-built land-based nitrogen complex in 2000.

At the heart of this complex are five air separation units. It is the largest nitrogen facility in the world, with each of the five units producing 10,000 tonnes per day of high-pressure nitrogen. The plant is located in a remote area and is operated in “standalone” mode with no connection to third-party utilities. It produces its own power through five large gas turbines using an advanced seawater cooling system.

Once the nitrogen has been separated, it is transported around 100 kilometres in high-pressure, 36-inch pipelines to the offshore oil field, where it is injected into the reservoir – at times increasing flow rates from one million to 2.2 million barrels a day.

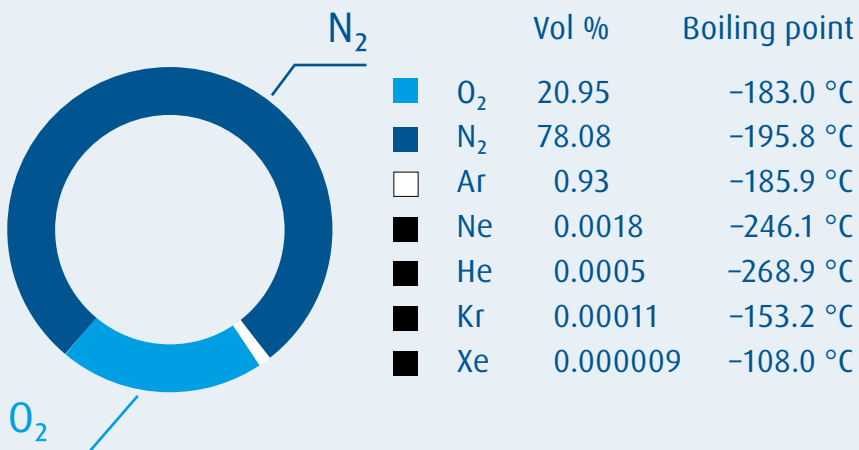
Based on positive experiences, the field operator has extended the supply agreement with Linde. Meanwhile, the Cantarell air separation plants are also supplying nitrogen to surrounding oil fields to similarly increase their recovery rates.

Linde Engineering.

# Facts and figures.

Our air separation business.

Composition of air



Number of patents

**180+**

innovations in air separation filed for patent application in the last 5 years

**3,000+**

air separation plants have been built by Linde

**550**

air separation units owned and operated by Linde

World's largest single-train air separation unit delivers

**5,250 tpd**  
oxygen

**1902**

... World's first air separation unit for oxygen production

**1990**

... Linde introduced argon production by rectification



**19%**  
**TCO**  
(Total Cost of  
Ownership)  
savings in past  
**10**  
**YEARS**

Heat exchanger

**1,700 m<sup>2</sup>/m<sup>3</sup>**  
max. surface

**-15%**

average power consumption  
of our ASUs over the last  
10 years

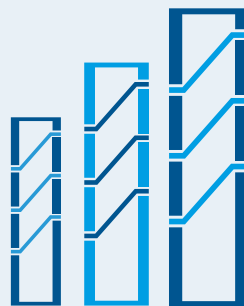
Read more:

[linde-engineering.com/air\\_separation\\_plants](http://linde-engineering.com/air_separation_plants)



Linde air separation units  
built in more than

**90**  
countries



Biggest  
prefabricated coldbox:

**Height 70 m**  
**Weight 800 t**

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# Your partner for the production and processing of gases

## Delivering reliable process plants for maximum capital efficiency

Linde has been optimizing gas processing technologies for 140 years, successfully delivering more than 4,000 plant engineering projects around the globe. Favoring trusted, lasting business relationships, the company collaborates closely with customers to enhance plant lifecycle productivity and innovate process flows. The company's proven gas processing expertise plays an indispensable role in the success of customers across multiple industries – from natural gas and oil refining through petrochemicals and fertilizers to electronics and metal processing.

## Operational excellence along the entire plant lifecycle

We work closely with our customers to gain an in-depth understanding of individual needs. Building on the unique synergies of Linde as an integrated plant operator and engineering company, Linde offers innovative process technologies and services to exceed our customers' reliability and profitability expectations. This commitment to innovation extends along the entire plant lifecycle. The LINDE PLANTSERV® service team supports customers every step of the way – from maintenance and repairs to full revamps. Leveraging the latest digital technologies to offer on-site and remote operational and support services, we consistently take asset performance to the next level.

## Making the impossible possible

From the desert to the Arctic, from small- to world-scale, from standardized to customized designs, Linde's engineering specialists develop solutions that operate under all conditions. The company covers every step in the design, project management and construction of gas processing plants and components. Customers can always rely on Linde to deliver the plants, components and services that fit their needs best – anywhere in the world.

Discover how we can contribute to your success at [www.linde-engineering.com](http://www.linde-engineering.com)

Get in touch with air separation plants

Phone +49 89 7445-3526, inquiry: [www.linde-engineering.com/contact](http://www.linde-engineering.com/contact)

## Core competencies at a glance

### Plant engineering

- Air separation plants
- LNG and natural gas processing plants
- Petrochemical plants
- Hydrogen and synthesis gas plants
- Adsorption plants
- Cryogenic plants
- Carbon capture and utilization plants
- Furnaces, fired heaters, incinerators

### Component manufacturing

- Coldboxes and modules
- Coil-wound heat exchangers
- Plate-fin heat exchangers
- Cryogenic columns
- Cryogenic storage tanks
- Liquefied helium tanks and containers
- Air-heated vaporizers
- Water bath vaporizers
- Spiral-welded aluminum pipes

### Services

- Revamps and plant modifications
- Plant relocations
- Spare parts
- Operational support, troubleshooting and immediate repairs
- Long-term service contracts
- Expert reviews for plants, operations and spare part inventory
- Operator training

