

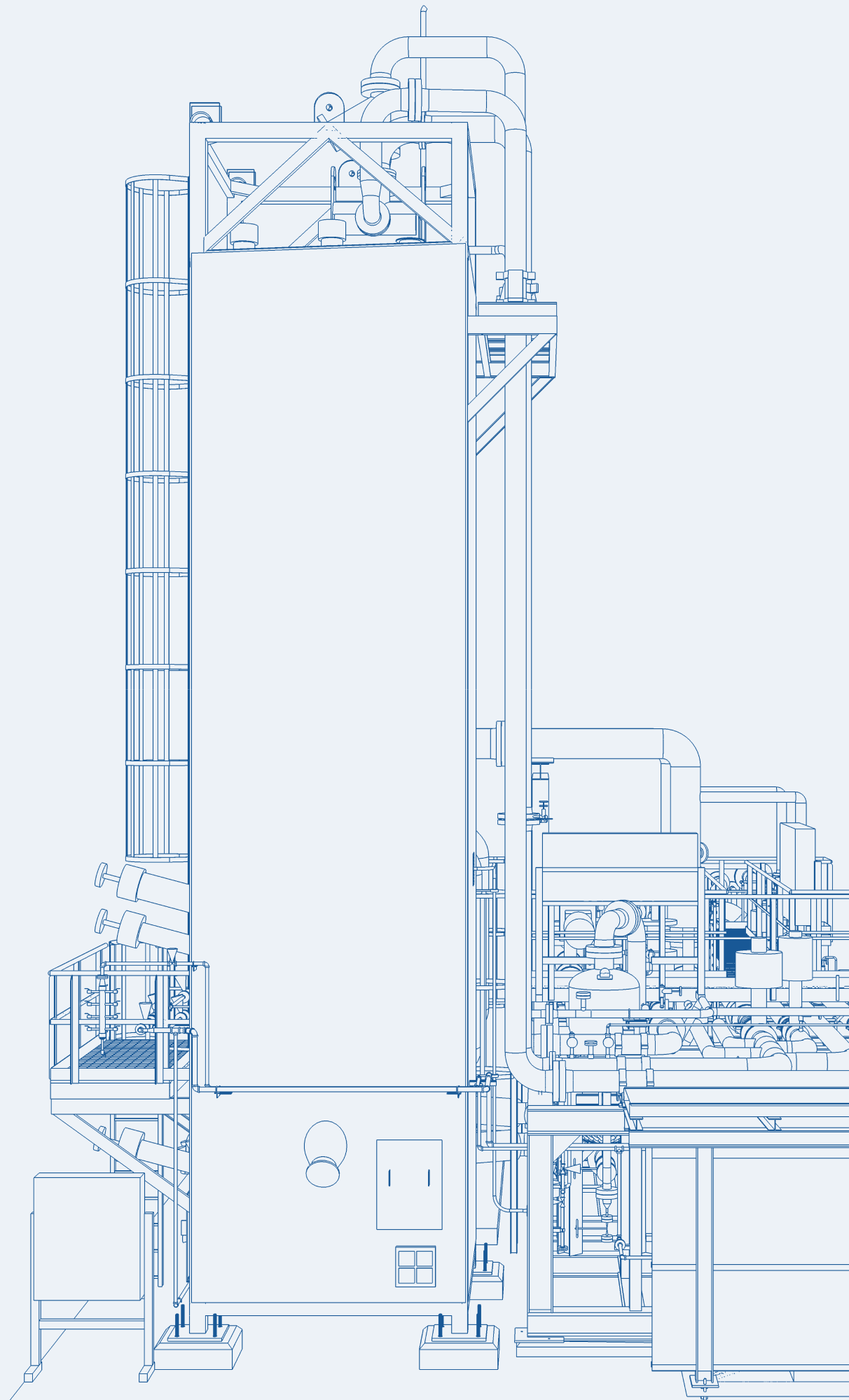
THE LINDE GROUP

*Linde*

# Purge gas recovery.

High-quality, customised solutions  
for the recovery of valuable gases from  
ammonia synthesis purge streams.





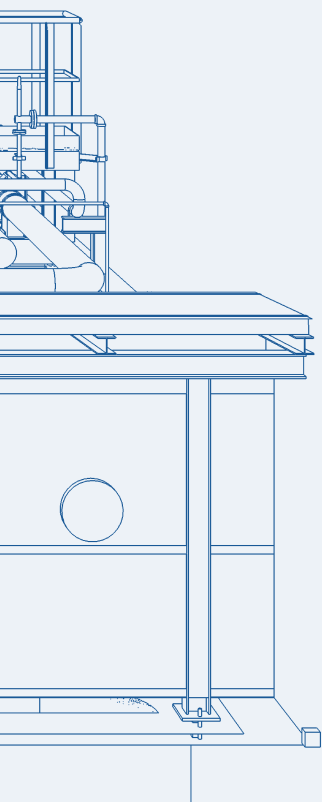
## Introduction.

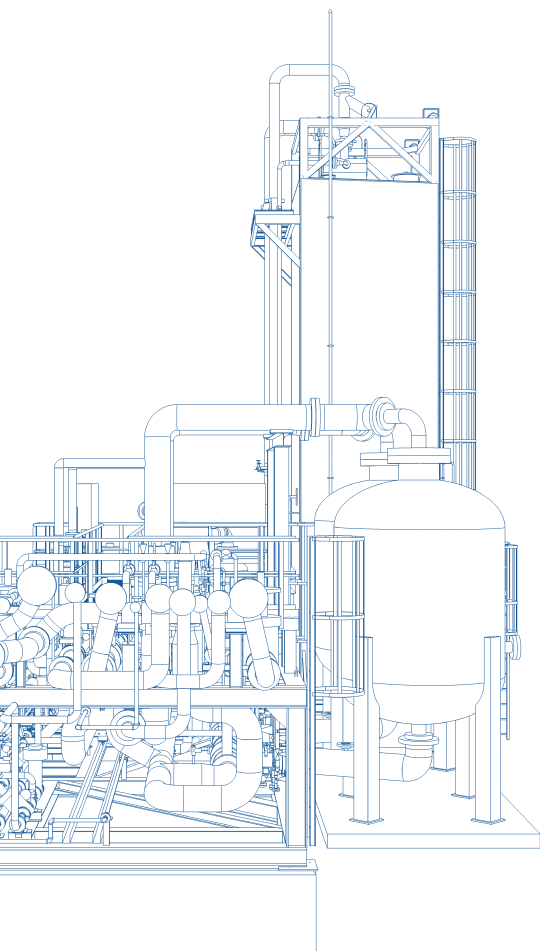
Faced with strong competitive pressures, operators of ammonia synthesis plants are often keen to increase cost efficiency. The recovery of valuable gases from the purge gas stream presents an attractive window of opportunity.

Ammonia synthesis uses syngas generated by steam reforming natural gas (as the feedstock). However, this reaction also produces a number of other gases that do not contribute to the ammonia reaction. These purge gases need to be continuously removed from the synthesis loop and are generally fed back to the reformer furnaces as fuel gas.

A typical purge gas contains about 60% hydrogen, 20% nitrogen, 5% argon, 10% methane and 4% ammonia in varying concentrations, depending on the process in place at the ammonia plant. Instead of burning purge gases, it makes good financial sense to recover valuable gases such as ammonia, hydrogen, nitrogen and argon.

Since 1958, we have been engineering, constructing, delivering and commissioning purge gas recovery plants for our customers. Building on our long-standing experience in the field, we have developed a wide portfolio of reliable, customisable solutions that allow operators to maximise the financial benefits of purge gas recovery.





Detailed view of the ammonia synthesis plant in Moron, Venezuela.

## Benefits you can count on.

### Customised to your needs

At Linde, we understand that performance needs, process requirements and investment constraints vary considerably from one plant to another. That is why we work with you to develop solutions that are customised to your individual business and application challenges.

Building on our extensive technology portfolio, our experts cover everything from ammonia recovery through cryogenic or membrane-based hydrogen recovery to cryogenic argon recovery. We bundle the technologies you need to create the perfect fit for your plant.

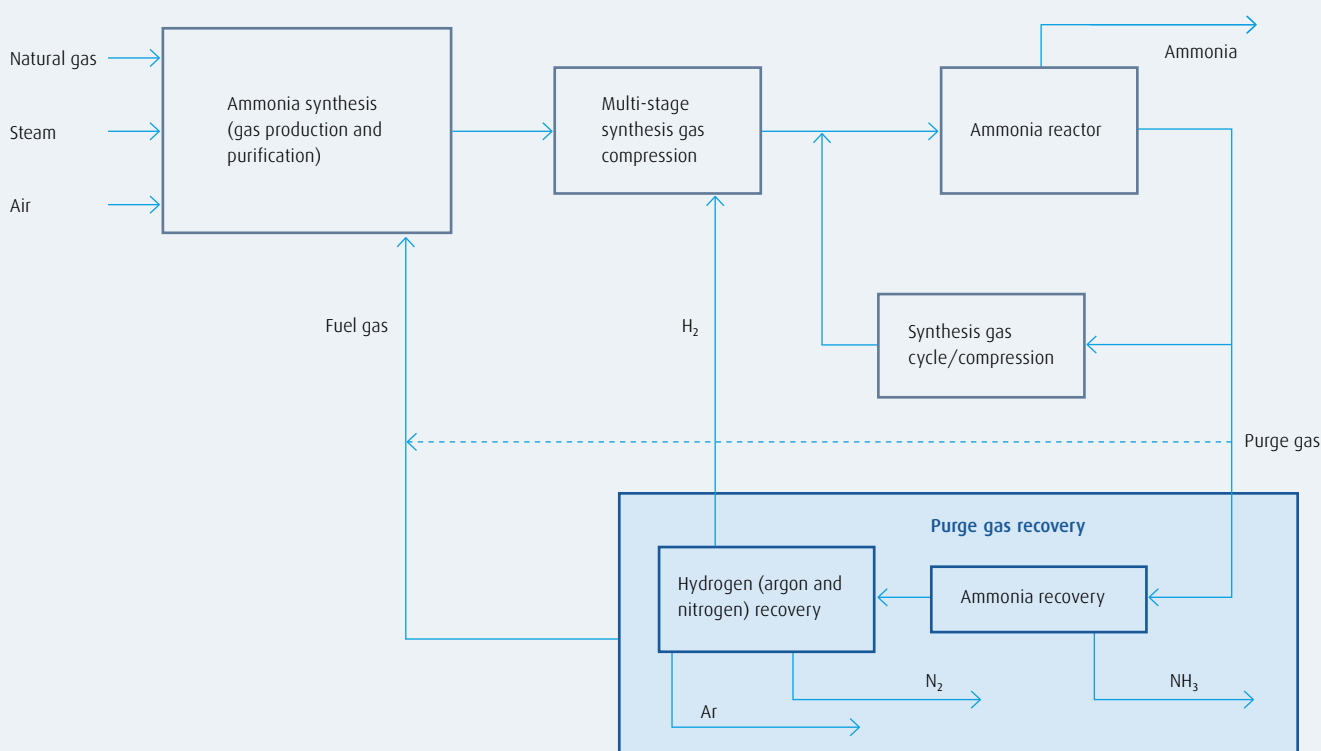
### Highest quality standards

We manufacture all key cryogenic equipment in house to ensure the highest, predictable quality standards. A global leader in the field of plate-fin heat exchanger technology, we have supplied over 10,000 units since production started in 1981. Columns used as rectifiers are designed and fabricated according to our own hydraulic design blueprint. Drawing on 125 years of experience in the field of cryogenic process plant design, we deliver both assembled packaged units and coldboxes.

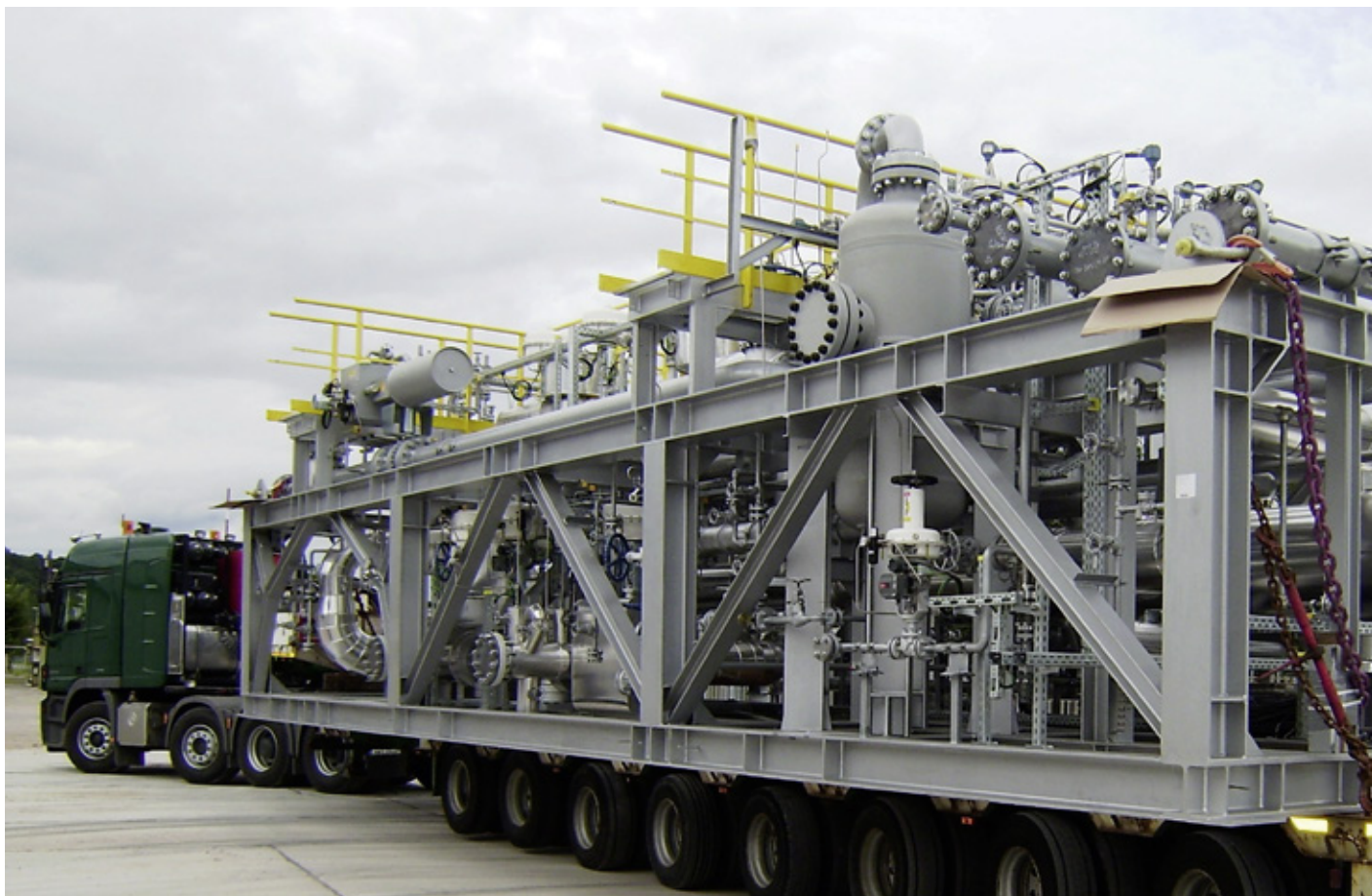
### Reduced installation and assembly effort

To further reduce risk and assembly effort on site, we also offer skid-mounted solutions. These pre-assembled and pre-tested units ensure a high level of quality.

### Typical process flow for purge gas recovery in an ammonia synthesis plant





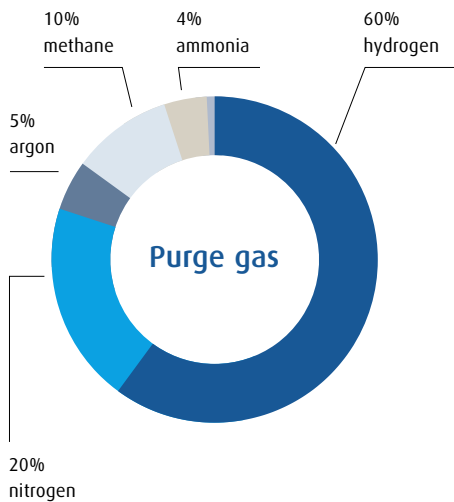


Skid-mounted solution for a purge gas recovery unit, ready for shipment.



Hydrogen recovery from the purge gas stream generated by an ammonia synthesis plant in Moron, Venezuela.

## Purge gas recovery in detail: How recovery plants work.



Composition of a typical purge stream.

**Hydrogen, argon, nitrogen and ammonia can be recovered from the purge gas stream. The recovery method depends on the feedstock in question and the gas(es) the customer wishes to recover. Ammonia is recovered in a water wash system; hydrogen in a cryogenic or membrane recovery system; and argon and nitrogen in a cryogenic recovery system.**

### Hydrogen recovery (cryogenic)

The pre-purified purge gas from the ammonia recovery plant is water saturated. As a first step, the purge gas is dried and freed from traces of ammonia in an adsorber station.

The hydrogen is separated in a coldbox. The drop in temperature necessary for a stable process is achieved with a throttle valve using the Joule-Thomson effect. The purge gas is cooled down in the coldbox heat exchanger using the cooling power of some of the cryogenic hydrogen separated in the coldbox.

Thus the gas is partly liquefied. The gas phase is separated in the hydrogen separator, warmed up, and the hydrogen is sent to the syngas compressor.

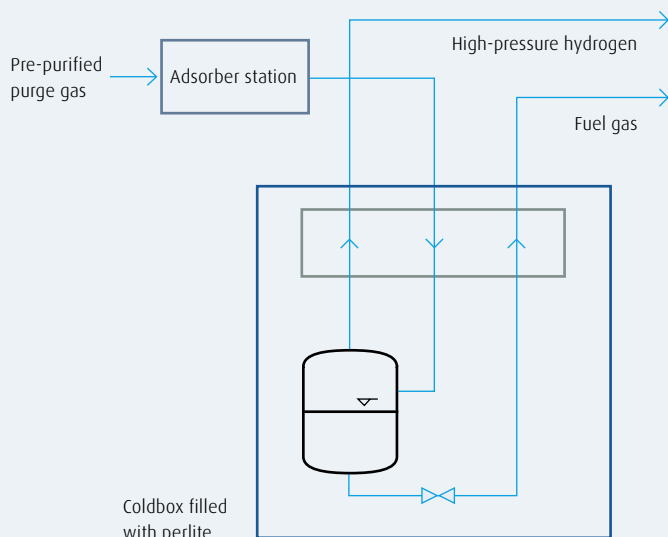
### Hydrogen recovery (membrane)

The pre-purified purge gas is warmed up to increase the water saturation value of the purge gas before entering the membrane unit. The membrane unit is usually set up in two stages. One part of the hydrogen recovered is fed to the suction part of the syngas compressor and another part is fed back to an intermediate pressure stage of the compressor.

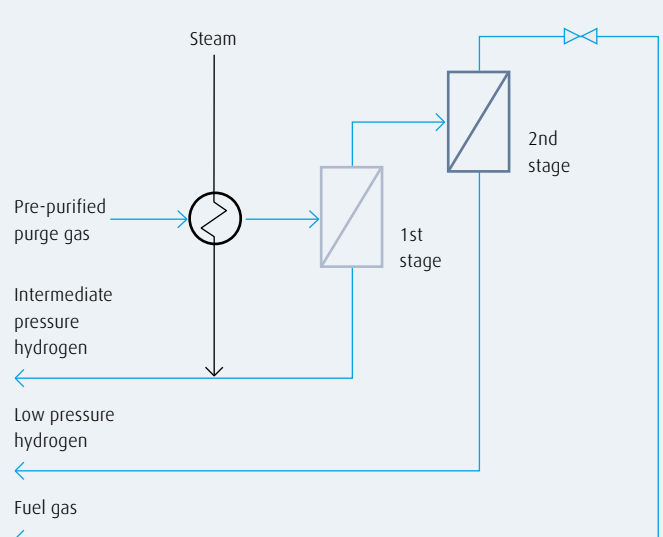
### Hydrogen, argon and nitrogen recovery (cryogenic)

The separation of hydrogen, argon and nitrogen takes place in a coldbox. First the pre-purified purge gas from ammonia

### Typical process flow for hydrogen recovery (cryogenic)



### Typical process flow for hydrogen recovery (membrane)





recovery needs to be dried and freed from traces of ammonia in an adsorber station.

The purge gas is cooled down in the coldbox heat exchanger. The hydrogen product is separated in the hydrogen separator and warmed up. Some of the hydrogen is then sent to the syngas compressor and some is used as a cooling medium in the coldbox.

The argon, nitrogen and fuel gas are separated in cryogenic rectification columns. Recovery is based on an open nitrogen cycle, which generates the refrigeration capacity required to liquefy the argon gas. If required, the customer can also recover liquid nitrogen.

With small modifications, this cryogenic recovery solution for hydrogen, argon and nitrogen can also be installed as a separate argon and nitrogen recovery solution downstream of an existing hydrogen recovery unit.

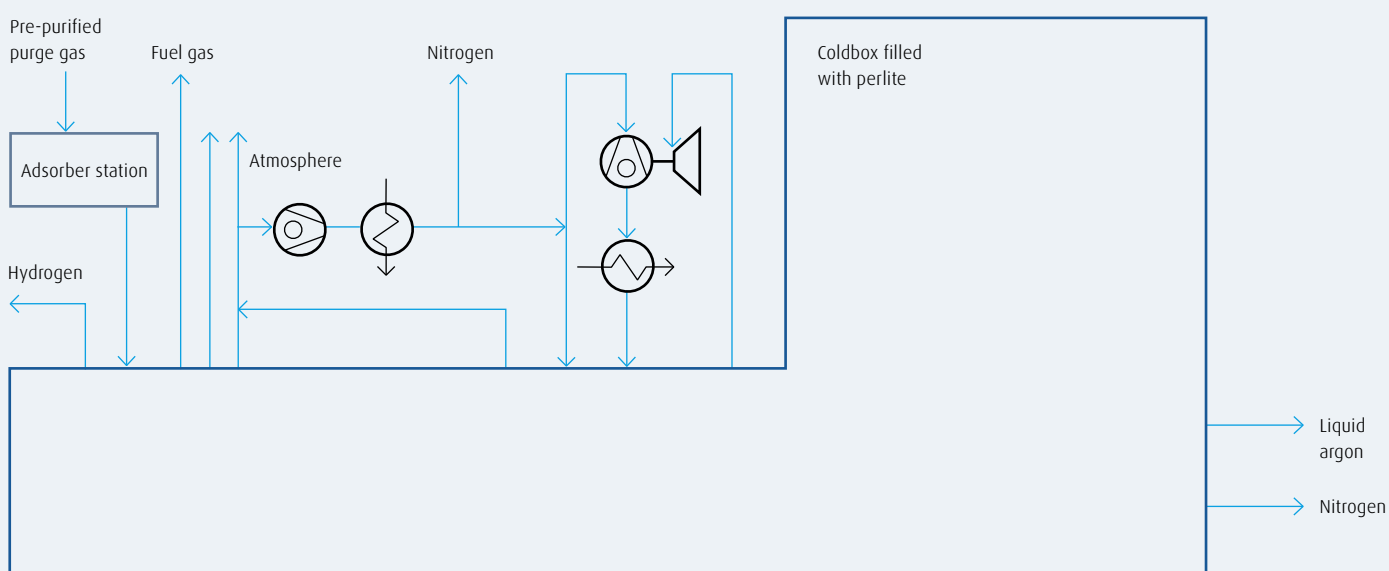


Hydrogen recovery from the purge gas stream generated by an ammonia synthesis plant in Palembang, Indonesia.



Plant for the recovery of liquid argon from ammonia synthesis purge gas in Hazira, India.

### Typical process flow for hydrogen, argon and nitrogen recovery (cryogenic)



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

Jürgen Nowicki  
Managing Director  
Member of the Board of Directors

- Indicates a positive trend  
(e.g. drop in costs, new business potential)
- Indicates no significant difference  
between the technologies
- Indicates a negative trend  
(e.g. slight/marked drop in performance,  
increase in costs)

## Our recovery solutions at a glance. Tailored to your specific needs.

The recovery technology best suited to your needs depends on a number of factors. These include the target product (i.e. the gas(es) you wish to recover), your performance requirements and your investment/operating budget. The following table gives a rough overview of recovery options with cryogenic and membrane technologies. It also shows how these technologies compare with each other – both in relation to key performance indicators (such as recovery rate, purity and pressure) and in relation to investment and operating costs. The final line in the table compares the business opportunities of each method.

	Hydrogen recovery (cryogenic)	Hydrogen recovery (membrane)	Hydrogen, argon and nitrogen recovery (cryogenic)
Targeted product(s)	H <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> , Ar, N <sub>2</sub>
Hydrogen recovery rate	→	→	→
Hydrogen purity	→	→	→
Hydrogen pressure	→	↓	→
Hydrogen-specific investment cost savings	→	↗	→
Hydrogen-specific operating cost savings (incl. recompression costs to recycle hydrogen to the ammonia plant)	→	↓	→
Business opportunities (through recovery of argon and nitrogen)	→	↘	↗

### Talk to our experts

Our experts would be delighted to evaluate your individual needs. To advise on the best set-up for your plant, we would need technical data about your upstream ammonia synthesis gas plant and the gas products you wish to recover downstream.

We have prepared a dedicated questionnaire outlining the technical data we require. You can find this online at [www.linde-engineering.com/purge-gas-recovery](http://www.linde-engineering.com/purge-gas-recovery)





Linde engineers at work.

## Our services for you.

At Linde Engineering, we do a lot more than deliver complete, customer-specific, turnkey solutions for hydrogen, ammonia, argon and nitrogen recovery from ammonia purge gases. At every stage of the project – from your very first query – our service-focused engineers are there to support you. You can rely on our team to deliver the project development services you need to make the best investment in purge gas recovery technology and maximise your return on that investment.

### Our services include:

- Feasibility studies
- Market analyses
- Profitability analyses
- Technical design
- Front-end engineering
- Procurement of licences
- Permit management
- Complex logistics handling
- Financing solutions

In addition, you can rely on us for process gases (e.g. air and synthesis gases) in the supply mode that best suits your needs, whether that be bulk deliveries or pipeline supplies from an independent, over-the-fence facility.

*“Our people, operational excellence and patented technologies empower us to deliver value to our customers.”*

Dr Christian Bruch  
Member of the Executive Board

### Published by:

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# Collaborate. Innovate. Deliver.

Linde's Engineering Division is a leading player in the international plant engineering business. Across the globe, we have delivered more than 4,000 plants and cover every step in the design, project management and construction of turnkey industrial facilities. Our proven process and technology know-how plays an indispensable role in the success of our customers across multiple industries – from crude oil, natural gas extraction and refining to chemical and metal processing.

At Linde, we value trusted, lasting business relationships with our customers. We listen carefully and collaborate closely with you to meet your needs. This connection inspires us to develop innovative process technologies and equipment at our high-tech R&D centres, labs and pilot plants – designed in close collaboration with our strategic partners and delivered with passion by our employees working in more than 100 countries worldwide.

From the desert to the Arctic, from small- to world-scale, from standardised to customised builds, our specialists develop plant solutions that operate reliably and cost-effectively under all conditions. You can always rely on us to deliver the solutions and services that best fit your needs – 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 our hydrogen and synthesis gas plant team:  
Phone: +49 351 250-3760, e-mail: [hs2@linde-le.com](mailto:hs2@linde-le.com)

## Core competencies at a glance

### Plant engineering

- Air separation plants
- LNG and natural gas processing plants
- Petrochemical plants
- Hydrogen and synthesis gas plants
- Chemical plants
- Adsorption plants
- Cryogenic plants
- Carbon capture and utilisation 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 vaporisers
- Water bath vaporisers
- Spiral-welded aluminium 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