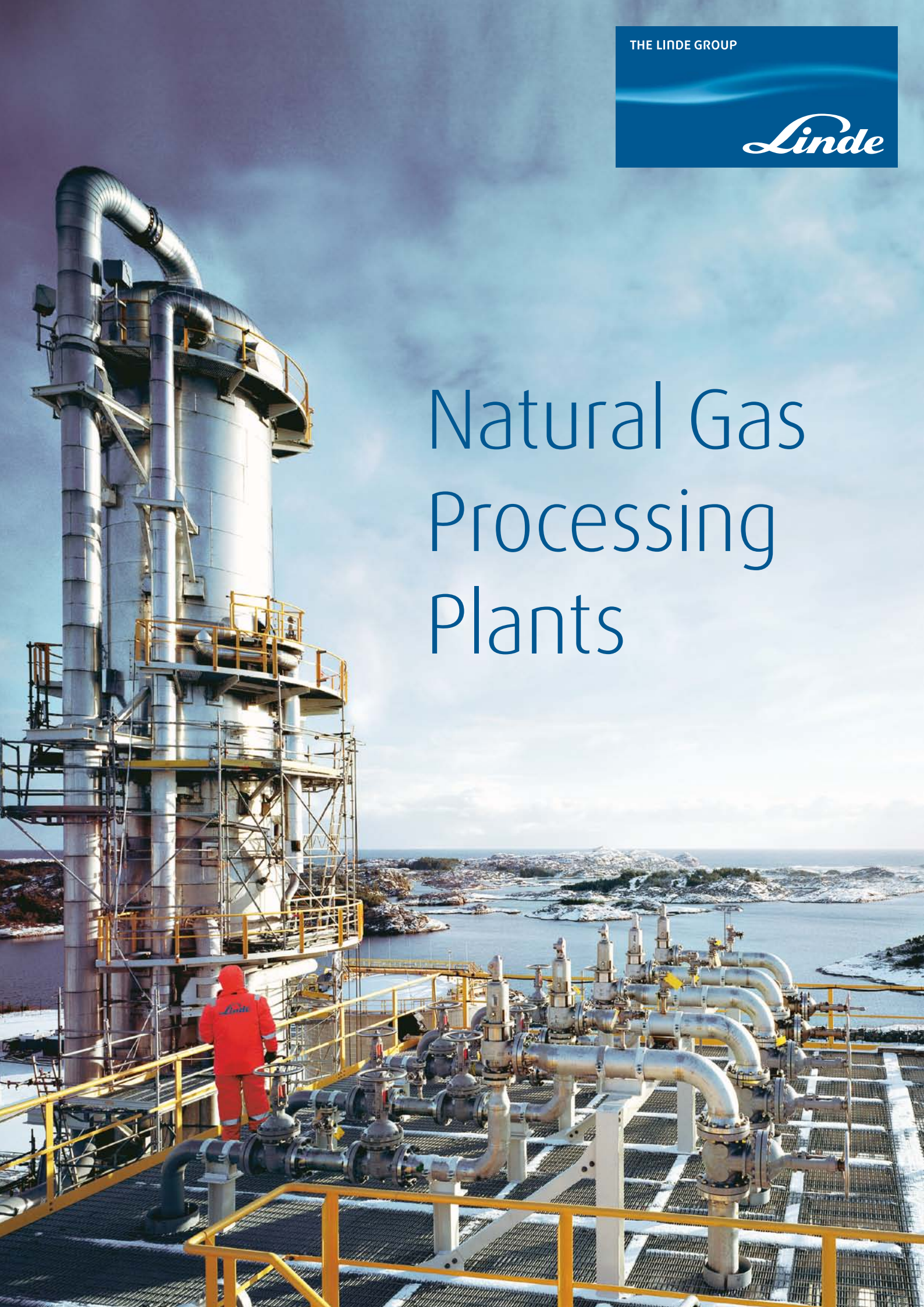
THE LINDE GROUP

Linde

Natural Gas Processing Plants



Contents.

Introduction.

Natural gas is valuable both as a clean source of energy and as a chemical feedstock. Before reaching the customer, it has to pass several processing steps. These steps are partly necessary to be able to transport the gas over long distances and partly necessary for the recovery of valuable components contained in the gas.

Linde AG´s Engineering Division has world-class experience in the entire natural gas processing chain. Linde offers engineering as well as technical and commercial services, including feasibility studies, pre-FEED, FEED, detail engineering and turnkey plant construction. Plant design and scope of supply typically includes specialized and tailor made cryogenic equipment manufactured in Linde workshops such as plate-fin and coil-wound heat exchangers.

Linde´s competence in project development, planning, execution and construction of turn-key plants is clearly demonstrated by the fact that it has built more than 3,800 plants world-wide.

Components and pretreatment of natural gas.

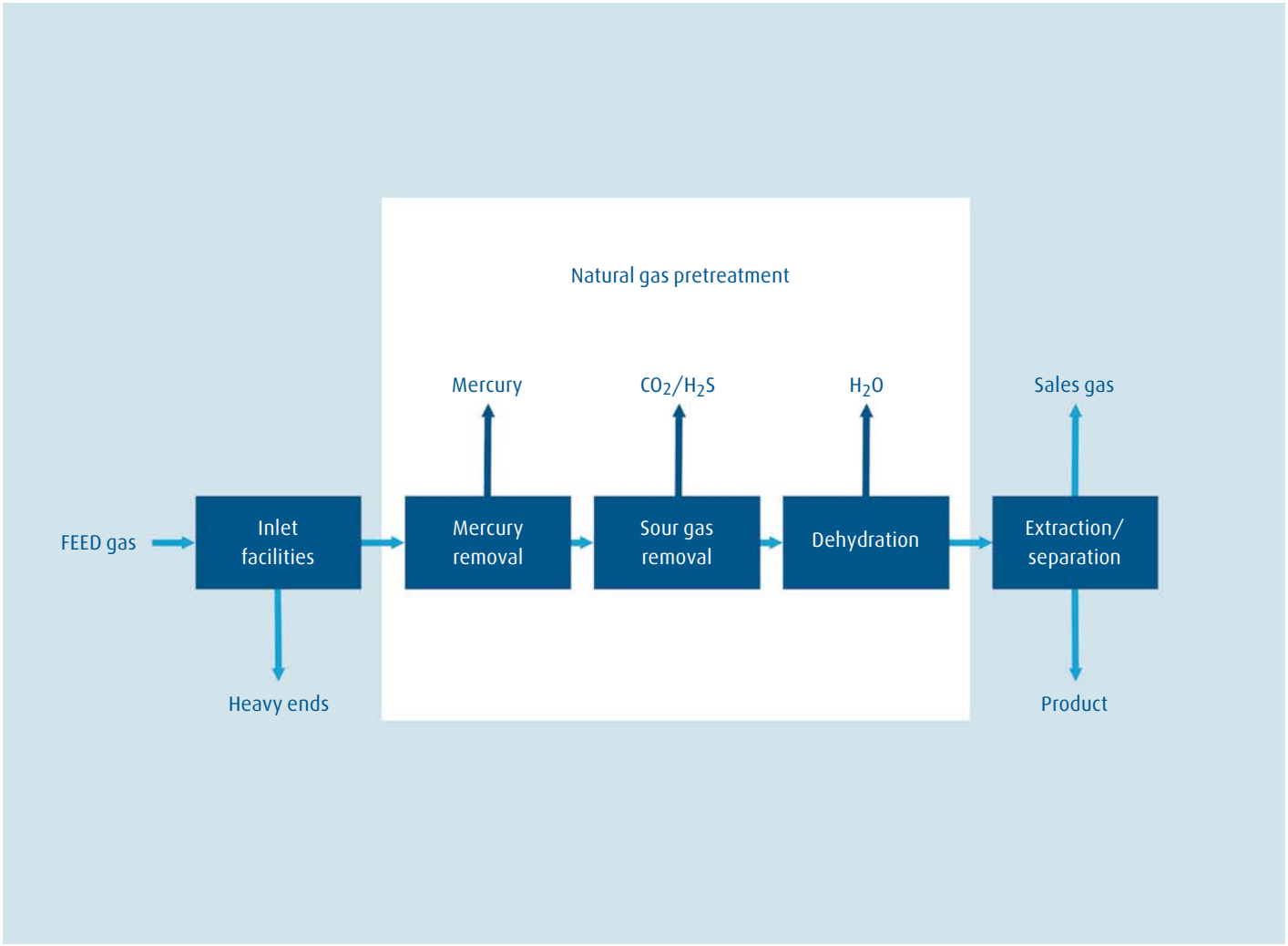
Components of natural gas

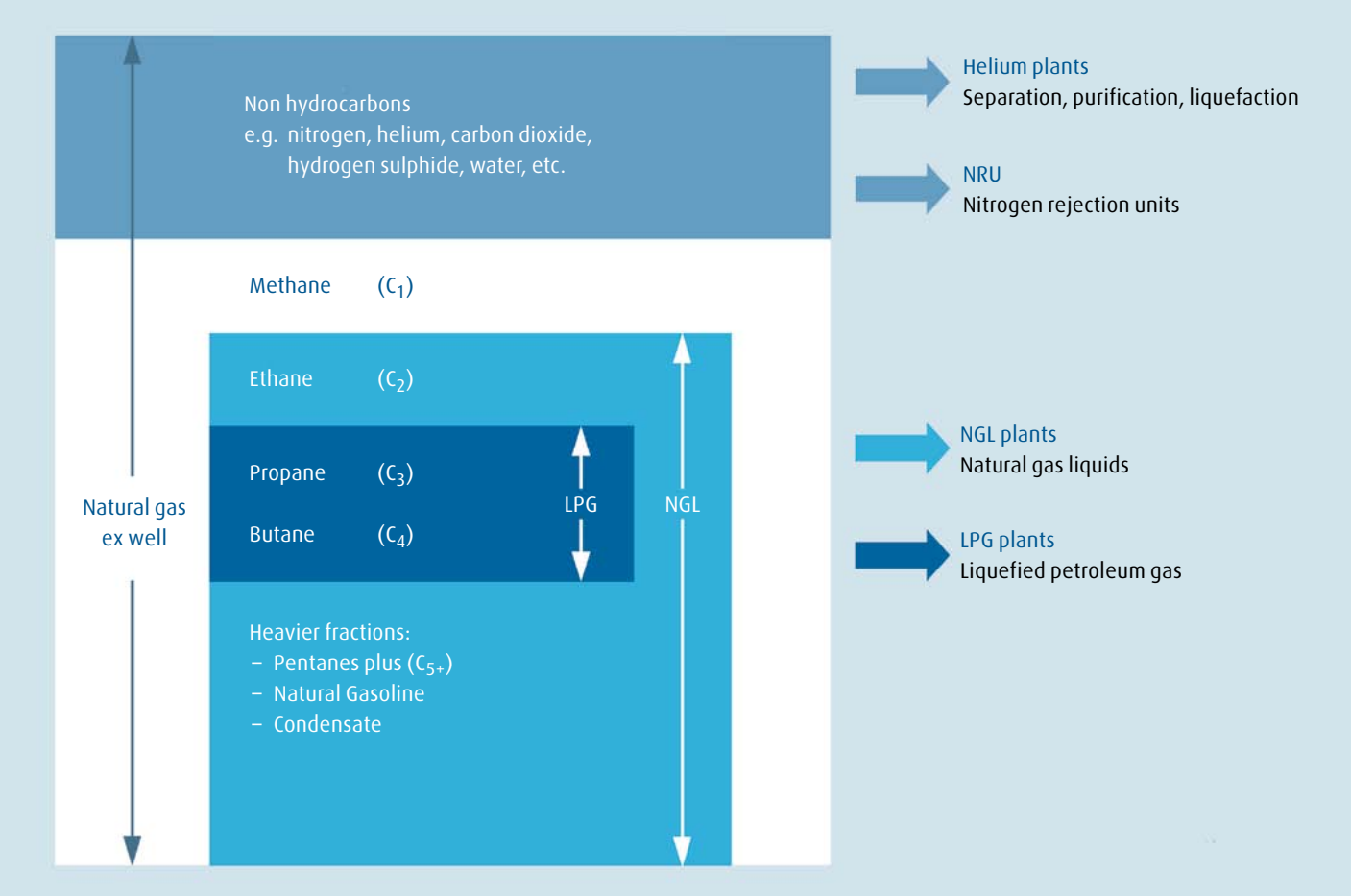
Natural gas is a mixture of gases containing primarily hydrocarbon gases. It is colorless and odorless in its pure form. It is the cleanest fossil fuel with the lowest carbon dioxide emissions. Natural gas is an important fuel source as well as a major feedstock for fertilizers and petrochemicals.

Pretreatment of natural gas

Natural gas pretreatment typically consists of mercury removal, gas sweetening and drying. Natural gas is dried in molecular sieve adsorbers. Depending on the downstream processing steps and the concentration of the sour gas components, it may be necessary to remove H_2S and CO_2 from the natural gas. Scrubbing processes such as MDEA, Benfield or SULFINOL are offered for this service. Should only minor amounts of sour gas be present, they can be removed by adsorption along with the removal of water. Mercury guard beds are recommended to protect people and equipment.

Pretreatment of natural gas





Portfolio of natural gas processing plants

Natural gas plants.

Cryogenic processes are the most economical method for separating natural gas components.

Nitrogen is removed from natural gas to reduce transportation volumes and increase heating value.

Nitrogen removal is combined with the recovery of helium, when present. High purity helium is produced by the combination of cryogenic and pressure swing adsorption process steps.

NGL, LPG and condensate as well as the pure components methane, ethane, propane and butane often have higher sales values compared to the pipeline gas itself. Therefore, they are often extracted and fractionated in tailor made processing plants according to the specific requirements of the regional market and the customers.

Processes for the pretreatment and separation of natural gas as well as the extraction of NGL, LPG, nitrogen and helium are offered by the Engineering Division. Combined with Linde´s project execution know-how, these processes can be implemented on a turn-key basis for all kinds of projects.

Extraction of hydrocarbons and LPG plants.

Extraction of hydrocarbons

Due to their added value, heavier hydrocarbons are often extracted from natural gas and fractionated by using several tailor made processing steps.

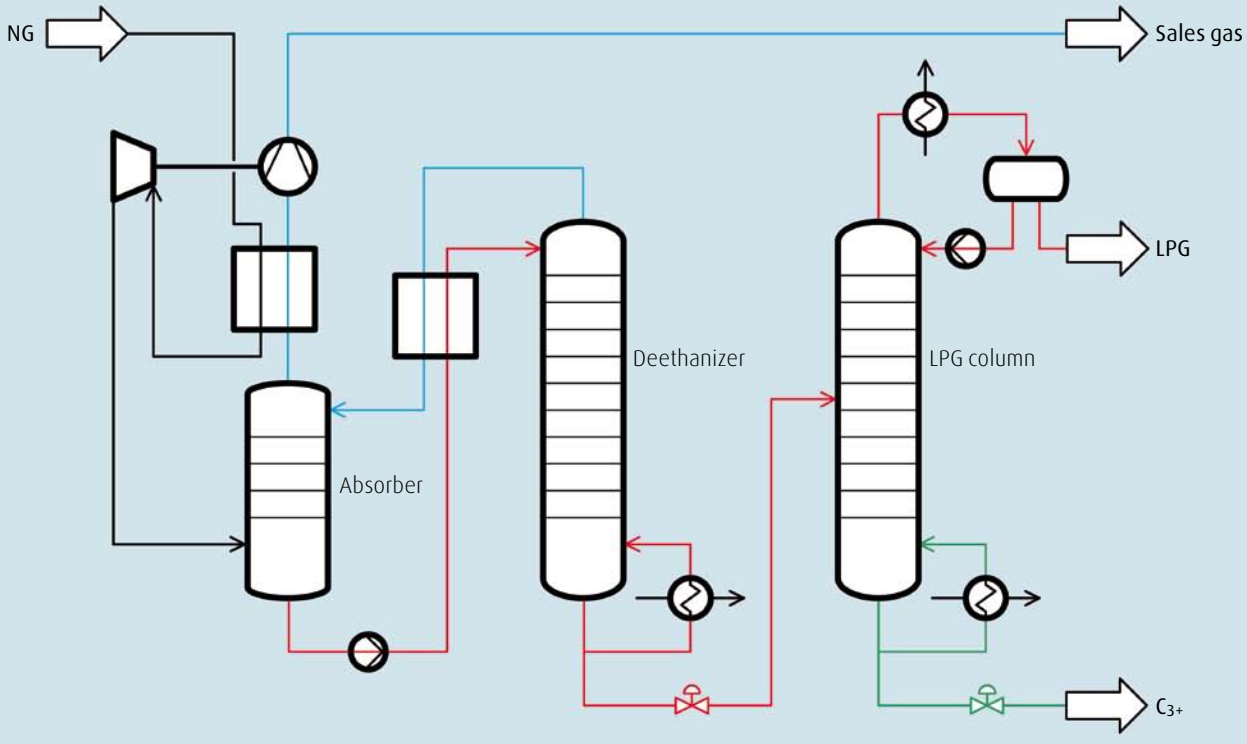
LPG plants

LPG (Liquefied Petroleum Gas) is widely used as alternative fuel for cars, but is also suitable as a chemical feedstock. It consists of propane and butane (C_3/C_4).

For the recovery of LPG/C_{3+} the Engineering Division offer an absorber process, which guarantees recovery rates as high as 99.9 %, while at the same time featuring low specific energy consumption. Furthermore the tolerable CO_2 content of the feed gas is higher than for conventional expander processes.

To achieve high C_3 recovery rates, Linde implements an absorber column upstream of the deethanizer. Here the feed gas is scrubbed by using a light hydrocarbon reflux coming from the top of the deethanizer. LPG is separated from the heavier hydrocarbons down-stream of the deethanizer using a destillation column.

Absorber process for C_{3+} recovery



C_{3+} recovery plant in Kollsnes, Norway
(Photo courtesy of STATOIL)

References for LPG/C_{3+} recovery plants.

C_{3+} recovery plant
in Constanta, Romania

FEED gas capacity:	160,000 Nm³/h
Customer:	Petrom S.A. (member of OMV Group)
Start of production:	2009

C_{3+} recovery plant
in Kollsnes, Norway

FEED gas capacity:	1,100,000 Nm³/h
Customer:	Troll Group (Statoil)
Start of production:	2003

C_{3+} recovery and fractionation plant
in Rayong, Thailand

FEED gas capacity:	258,000 Nm³/h
Customer:	Petroleum Authority of Thailand
Start of production:	1995

C_{3+} recovery and fractionation plant
in Rayong, Thailand

NGL plants.

NGL plants

NGL consists of ethane and heavier hydrocarbons (C_{2+}) and constitutes an ideal feedstock for steam crackers producing olefins. It has a higher sales value compared to the pipeline gas itself, which justifies an extraction.

For the recovery of NGL/C_{2+} the Engineering Division offers a well proven expander process enabling recovery rates up to 98 %. The cryogenic process utilizes an expander to provide the refrigeration duty, which is necessary for the partial liquefaction of the natural gas upstream of the destillation process.

The process is characterized by the use of internal refrigeration to the maximum extent in order to minimize or even eliminate the necessity of external refrigeration. This ensures the lowest possible life cycle costs and investment costs for the customer.

References for NGL/C_{2+} recovery plants.

C_{2+} recovery and fractionation plant

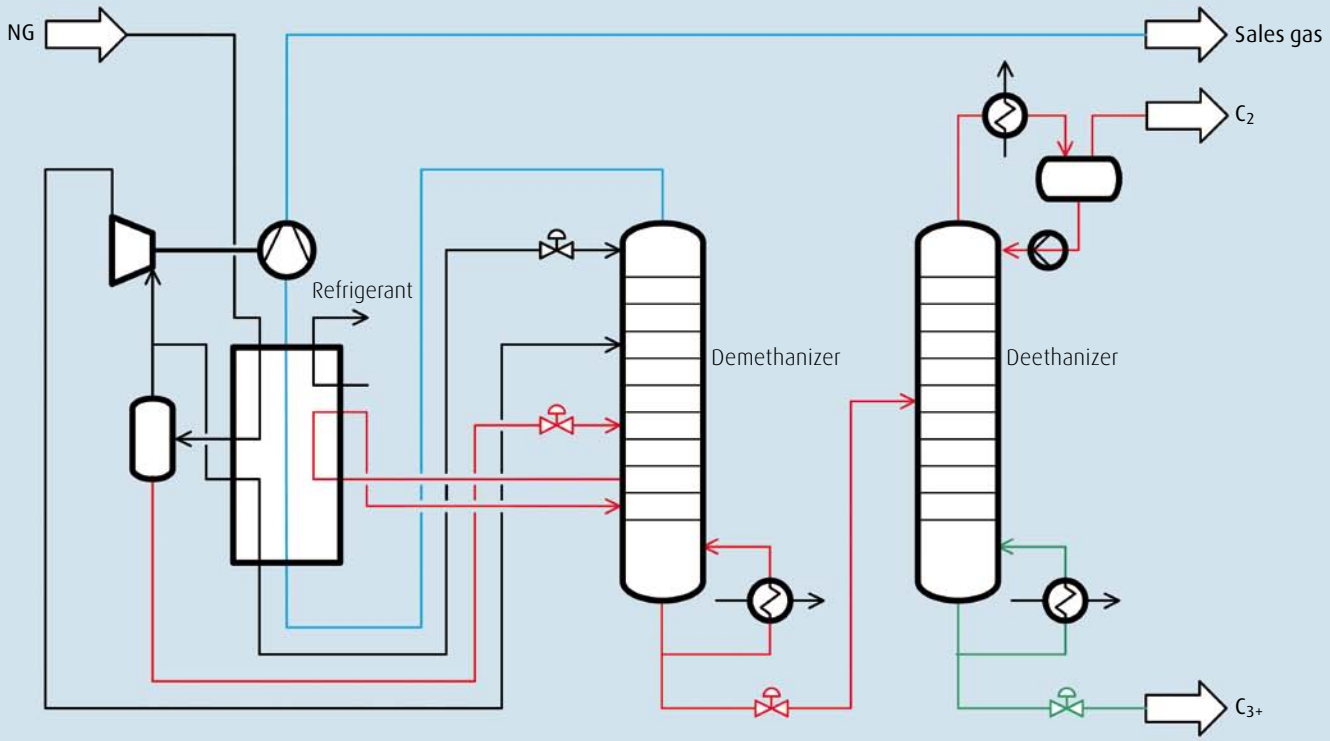
in Assaluyeh, Iran

FEED gas capacity:	3,000,000 Nm³/h
Customer:	Pars Petrochemical Company
Start of production:	2005

C_{2+} recovery plant

in Ahwaz, Iran

FEED gas capacity:	1,000,000 Nm³/h
Customer:	Marun Petrochemical Company
Start of production:	2005



Expander process for C_{2+} recovery

C_{2+} recovery and fractionation plant
in Rayong, Thailand

FEED gas capacity:	390,000 Nm³/h
Customer:	Petroleum Authority of Thailand
Start of production:	1997

C_{2+} recovery and fractionation plant
in Kårstø, Norway

FEED gas capacity:	670,000 Nm³/h
Customer:	Statoil for Statpipe Group
Start of production:	1986

Extraction of non-hydrocarbons.

Natural gas is a mixture of gases containing primarily hydrocarbon gases. It is colorless and odorless in its pure form. It is the cleanest fossil fuel with the lowest carbon dioxide emissions. Natural gas is an important fuel source as well as a major feedstock for fertilizers and petrochemicals.

Nitrogen rejection units (NRU)

Nitrogen is removed from natural gas to reduce transportation volumes and increase heating value. In some cases nitrogen rejection units are integrated within LNG plants to limit the nitrogen content in the fuel gas or to recover methane from tank return or end flash gas.

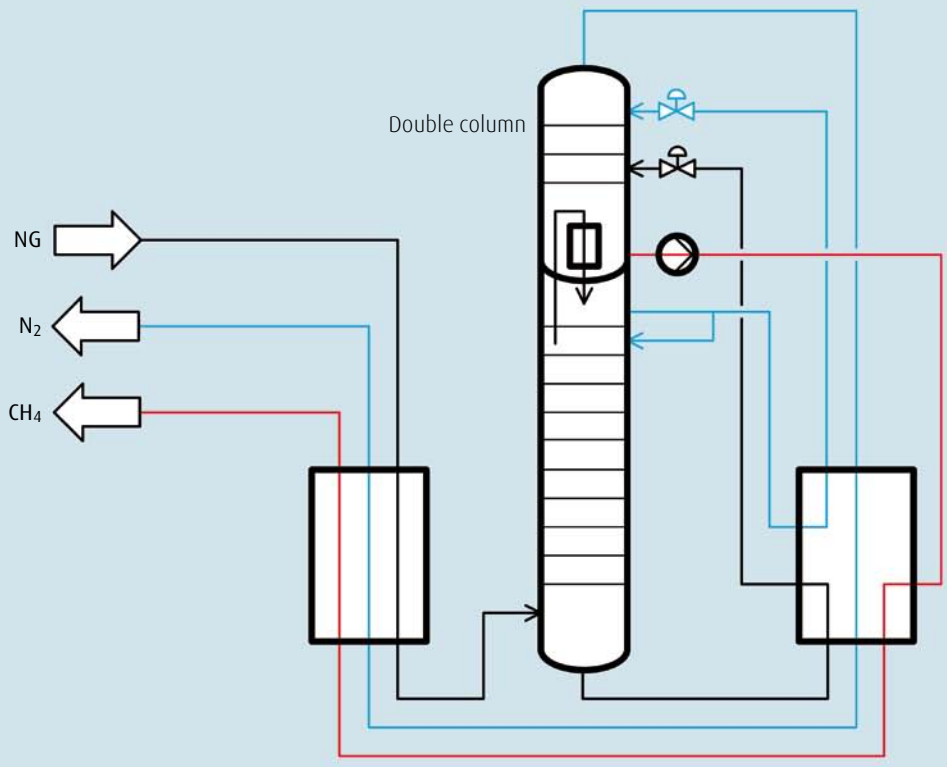
The Engineering Division is typically using a double column process for the removal of nitrogen. This maximizes the heat integration of the process. Depending on the nitrogen content of the feed gas, an additional enrichment column may be foreseen upstream of the actual removal process.

Helium recovery and liquefaction plants

Helium is a rare gas, which is recovered from natural gas when present in sufficient concentrations. Linde Engineering offers a well-proven cryogenic process for the recovery of high purity helium (> 99.999 %). High purity helium is used for special applications such as space technology or the realization of superconductivity.

To attain high purity the raw helium is first recovered from natural gas in a cryogenic separation process. Down-stream of this process step it is purified in a pressure swing adsorption (PSA) unit and than liquefied for storage at temperatures of about -270°C. The Engineering Division has own technologies for each process step and is in a position to offer complete plants on a turn-key lumpsum basis.

Double column process for nitrogen rejection



LNG plant in Hammerfest, Norway

References for NRUs and helium plants.

NRU integrated in Pluto LNG plant
in Karratha, Australia
FEED gas capacity: 78,000 Nm³/h
Customer: Woodside Burrup Pty. Ltd.
Start of production: 2010

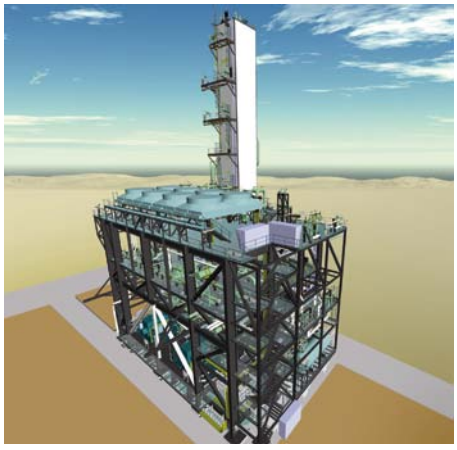
NRU integrated in Snøhvit LNG plant
in Hammerfest, Norway
FEED gas capacity: 71,400 Nm³/h
Customer: Snøhvit Group
Start of production: 2007

NRU integrated in a helium plant
in Skikda, Algeria
FEED gas capacity: 47,000 Nm³/h
Customer: Helison S.p.A.
Start of production: 2005

NRU
in Onslow, Australia
FEED gas capacity: 47,000 Nm³/h
Customer: BHP Petroleum
Start of production: 1994

Helium recovery and liquefaction plant
in Darwin, Australia
Production rate of liquid helium: 2,6 t/d
Customer: BOC Australia
Start of production: 2009

Helium recovery and liquefaction plant
in Skikda, Algeria
Production rate of liquid helium: 10 t/d
Customer: Helison S.p.A.
Start of production: 2005



Δ NRU integrated in Pluto LNG plant in Karratha, Australia

▷ Helium recovery and liquefaction plant in Skikda, Algeria

Designing processes – constructing plants.

Linde´s Engineering Division continuously develops extensive process engineering know-how in the planning, project management and construction of turnkey industrial plants.

The range of products comprises:
- Petrochemical plants
- LNG and natural gas processing plants
- Synthesis gas plants
- Hydrogen plants
- Gas processing plants
- Adsorption plants
- Air separation plants
- Cryogenic plants
- Biotechnological plants
- Furnaces for petrochemical plants and refineries

Linde and its subsidiaries manufacture:
- Packaged units, cold boxes
- Coil-wound heat exchangers
- Plate-fin heat exchangers
- Cryogenic standard tanks
- Air heated vaporizers
- Spiral-welded aluminium pipes

More than 3,800 plants worldwide document the leading position of the Engineering Division in international plant construction.

Engineering Division
Schalchen Plant
Tacherting, Germany
Phone +49.8621.85-0
Fax +49.8621.85-6620
plantcomponents@linde-le.com

Linde-KCA-Dresden GmbH
Dresden, Germany
Phone +49.351.250-30
Fax +49.351.250-4800
lkca.dresden@linde-kca.com

Selas-Linde GmbH
Pullach, Germany
Phone +49.89.7447-470
Fax +49.89.7447-4717
selas-linde@linde-le.com

Cryostar SAS
Hésingue, France
Phone +33.389.70-2727
Fax +33.389.70-2777
info@cryostar.com

Linde CryoPlants Ltd.
Aldershot, Great Britain
Phone +44.1.252.3313-51
Fax +44.1.252.3430-62
info@linde-lcl.com

Linde Impianti Italia S.p.A.
Rome, Italy
Phone +39.066.5613-1
Fax +39.066.5613-200
r.tikovsky@lindeimpianti.it

Linde Kryotechnik AG
Pfungen, Switzerland
Phone +41.52.3040-555
Fax +41.52.3040-550
info@linde-kryotechnik.ch

Cryo AB
Göteborg, Sweden
Phone +46.3164-6800
Fax +46.3164-2220
gunnar.lenneras@cryo.aga.com

Linde Process Plants, Inc.
Tulsa, OK, U.S.A.
Phone +1.918.4771-200
Fax +1.918.4771-100
sales@lppusa.com

Selas Fluid Processing Corp.
Blue Bell, PA, U.S.A.
Phone +1.610.834-0300
Fax +1.610.834-0473
john.mcdermott@selasfluid.com

Linde Engenharia do Brasil Ltda.
Rio de Janeiro, Brazil
Phone +55.21.3545-2255
Fax +55.21.3545-2257
jaime.basurto@linde.com

Linde Process Plants (Pty.) Ltd.
Johannesburg, South Africa
Phone +27.11.490-0513
Fax +27.11.490-0412
lindepp@global.co.za

Linde-KCA Russia Branch
Moscow, Russia
Phone +7.495.646-5242
Fax +7.795.646-5243
dirk.westphal@linde-kca.com

Linde Arabian Contracting Co. Ltd.
Riyadh, Kingdom of Saudi Arabia
Phone +966.1.419-1193
Fax +966.1.419-1384
linde-ksa@linde-le.com

Linde Engineering Middle East LLC
Abu Dhabi, United Arab Emirates
Phone +971.2.4477-631
Fax +971.2.4475-953
linde@emirates.net.ae

Linde Engineering India Pvt. Ltd.
Vadodara, Gujarat, India
Phone +91.265.3056-789
Fax +91.265.2335-213
sales@linde-le.com

Linde Engineerig Far East, Ltd.
Seoul, South Korea
Phone +82.2789-6697
Fax +82.2789-6698
hanyong.lee@linde.com

Linde Engineering Division
Bangkok, Thailand
Phone +66.2636-1998
Fax +66.2636-1999
anuwat.krongkrachang@linde.com

Linde Engineering Co. Ltd.
Dalian, P.R. of China
Phone +86.411.39538-800
Fax +86.411.39538-855
jochen.nippel@lindeleh.com

Linde Engineering Co. Ltd.
Hangzhou, P.R. of China
Phone +86.571.87858-222
Fax +86.571.87858-200
hangzhou.leh@lindeleh.com

Linde Engineering Division
Beijing Representative Office
Beijing, P.R. of China
Phone +86.10.6437-7014
Fax +86.10.6437-6718
linde@public.bta.net.cn

Linde AG Taiwan Branch
Engineering Division
Taipei, Taiwan
Phone +886.2.2786-3131
Fax +886.2.2652-5871
bernhard.puerzer@linde-le.com

Linde Australia Pty. Ltd.
Chatswood N.S.W., Australia
Phone +61.29411-4111
Fax +61.29411-1470
willy.dietrich@linde.com.au

Linde AG
Engineering Division, Head office, Dr.-Carl-von-Linde-Str. 6-14, 82049 Pullach, Germany
Phone +49.89.7445-0, Fax +49.89.7445-4908, E-Mail: info@linde-le.com, www.linde.com

HE/1.1.e/10