

Making our world more productive



Linde EDHOX™ ethylene technology

New catalytic on-purpose ethylene
dehydrogenation concept with low emissions



Linde EDHOX™ technology

Alternative path for ethylene

The growing market for petrochemicals is driving demand for light olefins such as ethylene, which is mainly obtained by steam cracking technology. This mature and well established technology is considered state-of-the-art in this sector. However, it is relatively energy-intensive, requiring furnaces that operate at high temperatures (above 900 °C).

Linde's EDHOX technology for the oxidative dehydrogenation of ethane offers a high-performance and cost-efficient solution for ethylene production, operating at moderate temperatures (lower than 400 °C) and enabling comparatively low CO₂ emissions.

EDHOX is an excellent fit for ethylene producers, as well as processes requiring both ethylene and acetic acid such as VAM (Vinyl Acetate Monomer), EVA (Ethylene Vinyl Acetate) copolymer, PVOH (Polyvinyl alcohol products), PET (Polyethylene Terephthalate), ethyl acetate and similar derivatives.

*Scope 1 emissions are direct emissions from owned or controlled sources. Scope 2 emissions are indirect emissions from the generation of purchased energy (www.ghgprotocol.org)

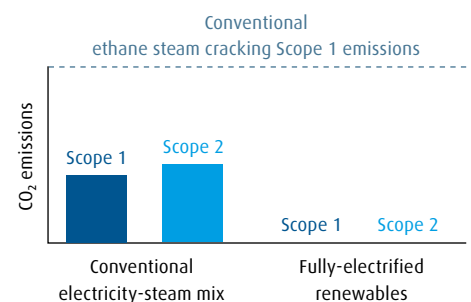
Technology highlights

- Catalytic conversion of ethane into ethylene and acetic acid under mild conditions
- Exothermic oxidative process with lower energy consumption than current state-of-the-art technologies
- Multitubular catalytic fixed-bed reactor (no steam cracking furnaces and decoking required)
- Catalyst developed in close cooperation with Clariant, the catalyst manufacturer
- Acetic acid co-product generates additional high value
- Optional combination with Linde's FlexASU® to accommodate fluctuating energy supplies from renewable sources by storing liquid oxygen
- Safe and reliable oxidative process operation

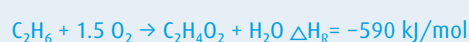
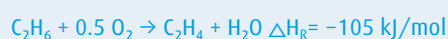
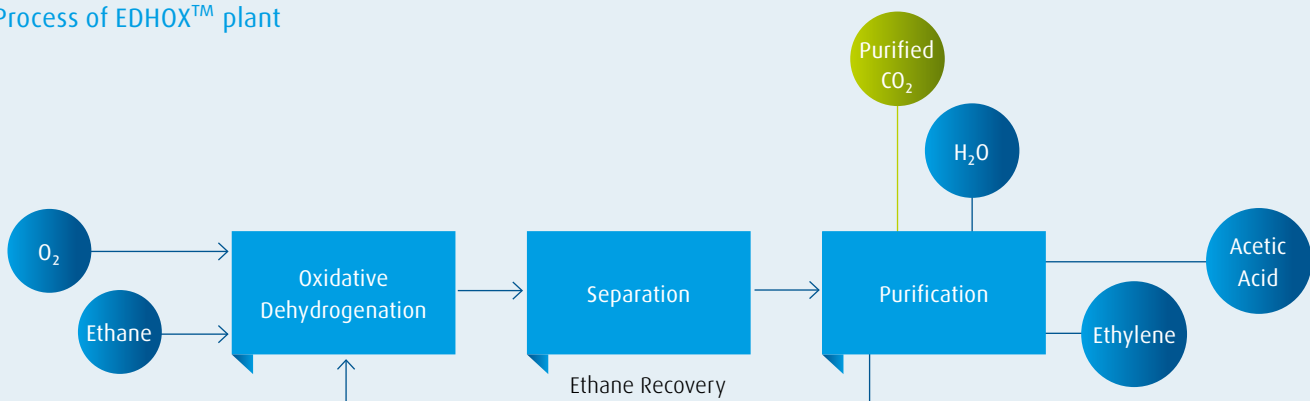
EDHOX with zero Scope 1 and 2* CO₂ emissions

- Significant Scope 1 CO₂ emission reduction relative to ethane steam cracking applying conventional energy
- Using renewable energy, net zero Scope 1 and 2 CO₂ emission achievable with low-cost impact
- Purified CO₂ inherently generated as by-product for storage or downstream processing

Scope 1 and 2 emissions*



Process of EDHOX™ plant



Gearing up for commercial readiness

- Successful demonstration plant operation since 2017 (Pullach, near Munich)
- Linde's EDHOX™ technology has completed the lab and pilot phases and has now been successfully validated in a demonstration plant for commercial use
- Confirmed commercial plant design by demonstration plant with reaction section, separation-purification and closed-loop operation to recycle ethane improving performance results from lab and pilot reactor phase:
 - High combined ethylene + acetic acid yield, with overall selectivity > 93% in demonstration plant
 - Applied catalyst and reactor tube dimensions correspond to commercial-scale geometry
 - Affirmed ranges of ethylene to acetic acid production ratio
 - Verified long-term catalyst stability

Benefits to your ethylene operations compared to ethane steam cracker

- Lower investment costs for the EDHOX ethylene plant
- Decreased production cost by additional cash generation provided by acetic acid co-production resulting in higher return on investment (ROI)
- Higher potential for reduction of CO₂ emissions, mitigating economic risks linked to emission taxes and supporting transition to a greener economy
- Attractive business case for adding ethylene capacity to existing ethane steam cracking facilities at low investment cost
- Integration with downstream ethylene and acetic acid consuming technologies allows for further cost reduction and increase of profitability
- Available renewable energy usage flexibility with Linde's FlexASU®, able to operate with a decentralized electric grid

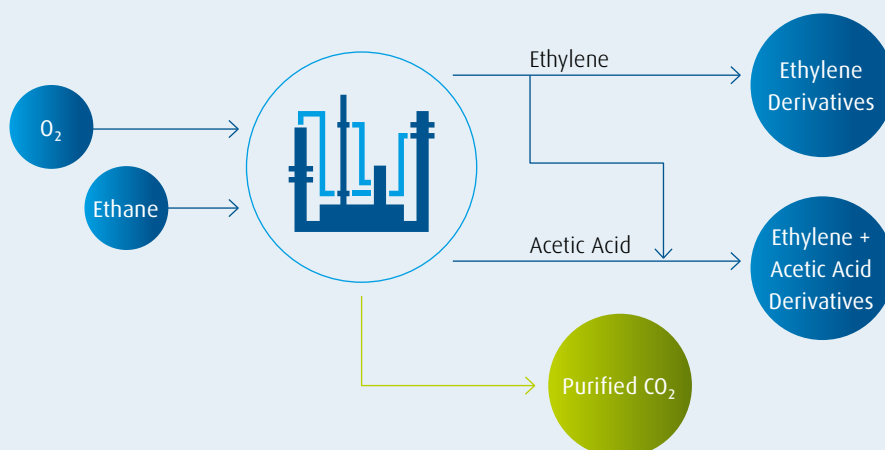


EDHOX™ demonstration plant

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Benefits of EDHOX™ plant



Polyethylene, EO derivatives, Ethylbenzene derivatives, EDC ...



VAM, EVA, PVOH product, Ethyl Acetate, PET ...

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

Get in touch with our petrochemical plant team:
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