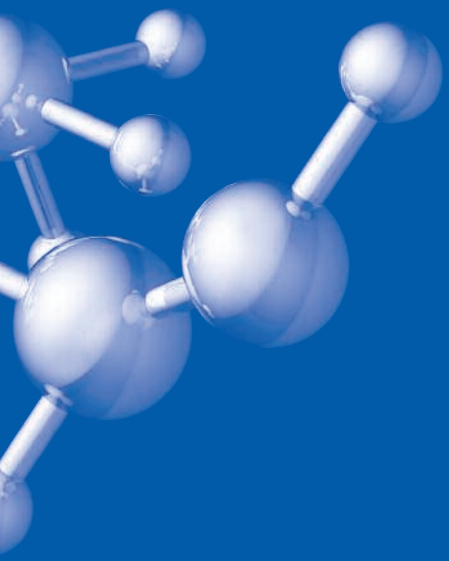
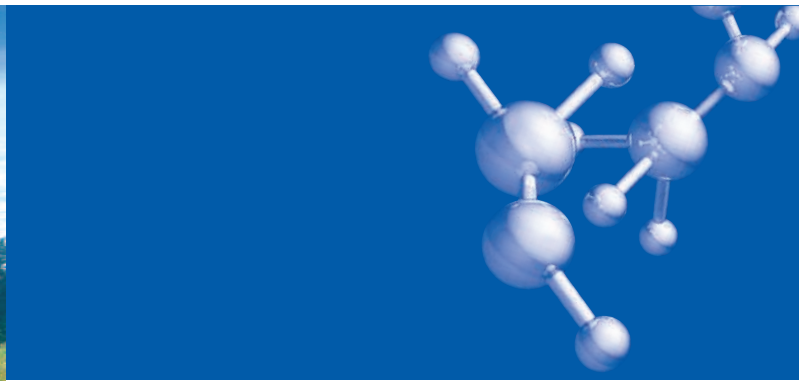
AIR LIQUIDE

Lurgi



# Solutions for $CO_2$ Reduction



# Curb $CO_2$ – Create Value

$CO_2$ has long since been identified as the main driver of global warming; therefore, the large majority of the world's leading economies agreed on strict requirements for the reduction of this greenhouse gas in the Kyoto Protocol. The actual implementation in international and national legislation is now taking shape. One thing has clearly transpired at this point: $CO_2$ emissions from the conversion of fossil energy resources are getting expensive!

On the other hand, the world's thirst for energy continues to grow fast. This thirst cannot be satisfied without fossil fuels. Even the intensive expansion of new technologies for the utilization of wind, sun or renewable resources is not sufficient to meet worldwide demand! Therefore, a three-step strategy is considered the optimum solution:

- Maximize energy efficiency
- Maximize renewable resources
- Maximize $CO_2$ recovery (carbon capture & storage)

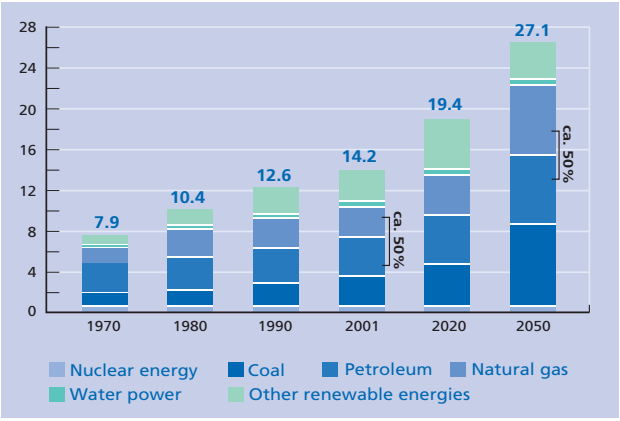
Those wanting to economically utilize oil, natural gas or coal for power generation will have to approach the subject matter with the future in mind. To this effect, Lurgi offers highly efficient separation processes that can drastically bring down $CO_2$ emissions.

## Worldwide energy consumption for different resources; forecast for the next 20 years

- In 2050, gas/oil will still cover around 50 % of the world energy demand,
- but coal consumption shows the strongest increase.

Although the utilization of regenerative energy sources is advancing fast, we will need to convert fossil resources also in the future. To efficiently master the economic challenges ensuing from the agreements laid down in the Kyoto Protocol, adequate concepts for the reduction of $CO_2$ emissions are required to make such plants "future-proof".

Billion tons of coal equivalent




Source: BP (until 2001), World Energy Council

Reducing $CO_2$ emissions can pay off for many industries

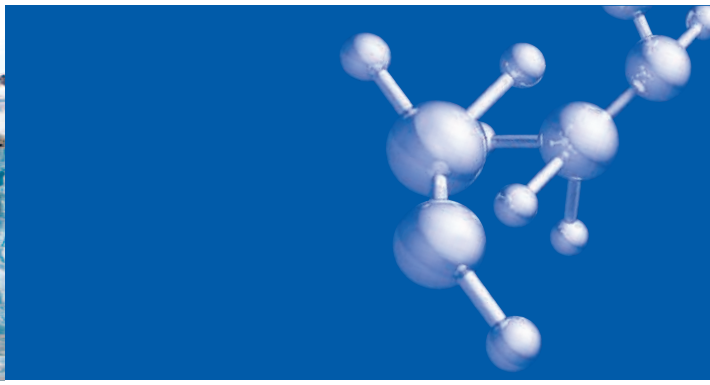
## For All Industries Using Fossil Resources

The restrictions stipulated in the Kyoto Protocol apply for all stakeholders that generate power from fossil fuels. The economic dimension of this measure became clear for the first time upon the introduction of emission certificate trading in 2005. The initial price rose as high as 35 USD/ton and has been moving up ever since.

Emission certificate trading does not only bear risks, however. Companies that use this opportunity and actively try to reduce their $CO_2$ emissions will gain a competitive edge. The extent is demonstrated taking a simple example. A modern, coal-fired power plant generates approximately 400 grams of $CO_2$ per kWh. A 1,000 Megawatt plant thus releases more than 3.2 million tons of carbon dioxide per year – of which more than 90 % can be captured with Lurgi technologies! Considering the fact that companies receive credit notes if they comply with specific threshold values, the reduction of $CO_2$ emissions pays off. The exact economic benefit and payback period depend on current emission certificate prices.

The potential of Lurgi's technologies can be used in many industries:

- Oil industry
- Gas industry
- Refineries
- Petrochemical industry
- Synthesis gas / natural gas plants
- Electrical power industry / utilities



## Maximize $CO_2$ Recovery – Clean Carbon Technology in two Steps

### Capture

Lurgi offers different processes for the capture of $CO_2$ from offgas, all of them affording a separation efficiency of at least 90 %. They yield pure anhydrous carbon dioxide in liquid or gaseous form. These technologies are not only suited for Lurgi's proprietary products, e.g. for synthesis gas and natural gas plants or refineries, but can also be integrated into many other plant complexes.

In view of the foreseeable legislative changes, $CO_2$ capture should form an integral part of the planning of new plants. A revamp of existing plants, too, can be profitable. This would require an individual analysis. Please contact us to this effect.

### Storage

The separation processes yield large quantities of carbon dioxide. At present, two alternatives are available for their final utilization and storage:

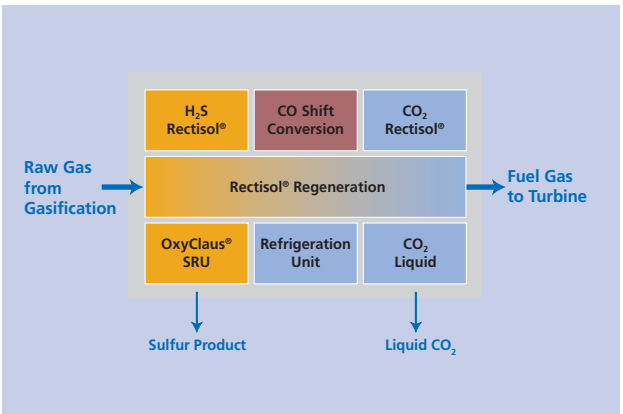
### Enhanced Oil Recovery

As the existing oil wells are subjected to an increasingly extensive exploitation, gas injection is required to maintain the pressure. Given the advantageous physical properties of carbon dioxide, this gas represents a particularly economic solution.

### Storage

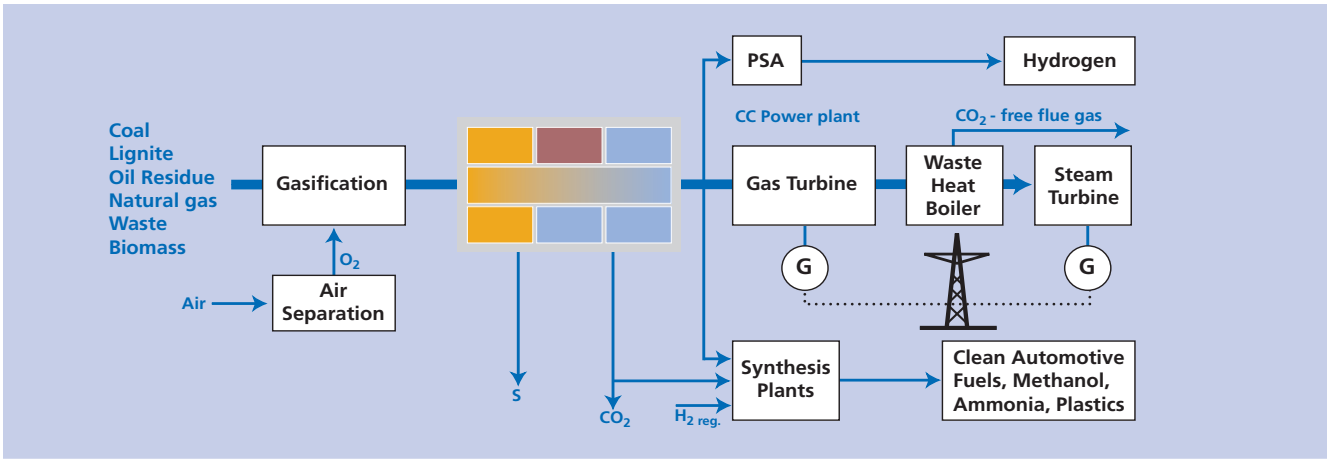
The storage of carbon dioxide in water-bearing layers deep within the earth appears to be exceptionally promising for the long-term storage of large $CO_2$ volumes. In addition, also the depleted oil and natural gas reservoirs or the deep sea could be used for the storage of carbon dioxide. Other options are currently being examined.

Carbon dioxide separated with the Lurgi processes can be smoothly routed to all these storage or utilization options.




Lurgi Gas Conditioning for Zero Emission Syngas Technology (ZEST)

## Typical applications:



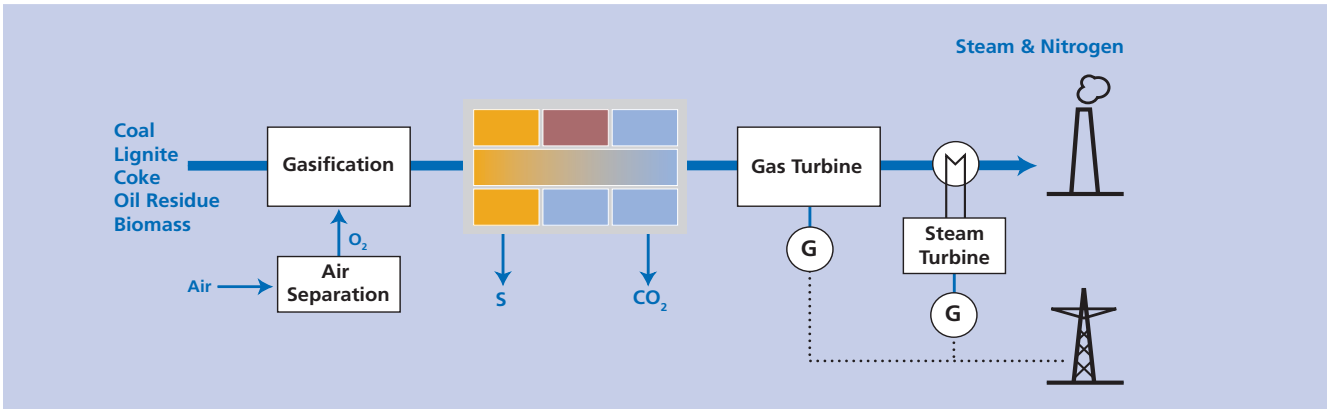
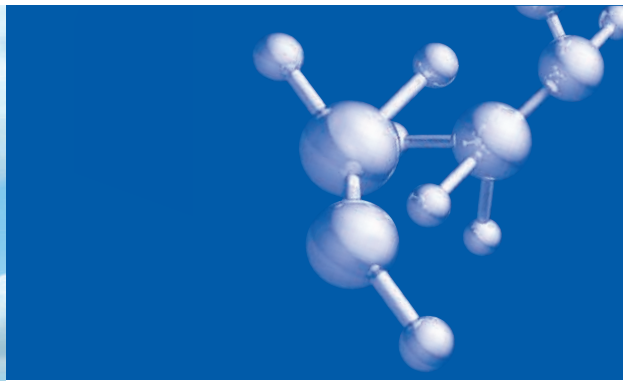




Diagram 1: ZEST – Zero Emission Syngas Technology
Diagram 2: Zero emission IGCC



## Working with Strong Partners

In the framework of the post-Kyoto activities, Lurgi ranks among the drivers for many activities in Germany and Europe. We are a partner to various projects and initiatives working side-by-side with governments and strong corporations.

COORIVA – Sponsored by the German Ministry of Economy and Labor, several leading German technology companies are collaborating with Lurgi on the development of a process for zero-emission power generation. The so-called COORIVA Zero Emission IGCC process allows for a $CO_2$-free combustion of coal for power generation.

COORIVA
$CO_2$-Reduktion durch Integrierte Vergasung und Abtrennung

ENCAP – Promoted by the EU, this project targets the development of emission-free technologies for power generation from fossil resources. Besides Lurgi, the cooperation includes Siemens, RWE, Vattenfall, Statoil and Total, among others.

encapco2

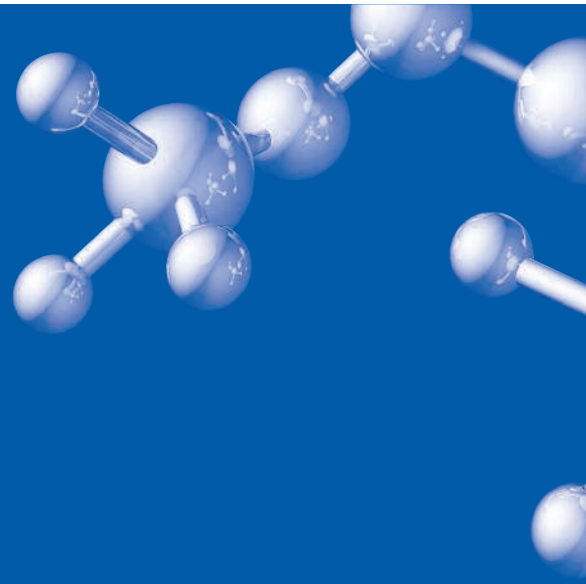
COORAMENT – Sponsored by the German Ministry of Economics and Technology, this project involves the operation of a Lurgi HP-POX (High-Pressure Partial Oxidation) pilot plant. The plant converts natural gas and oil heavies to synthesis gas under high pressure and with an appreciably enhanced yield. Here, too, the objective is to optimize the energy utilization.


Lurgi takes the role of an initiator, partner and driver of numerous initiatives for the implementation of the Kyoto Protocol. Our contributions include technical solutions for the reduction of $CO_2$ emissions or the economic utilization of regenerative resources.

Lurgi is a leading technology company operating worldwide in the fields of process engineering and plant contracting. Based on syngas, hydrogen production and clean conversion technologies for fuels or chemicals Lurgi offers innovative solutions that allow the operation of environmentally compatible plants with clean and energy-efficient production processes.
Its technological leadership is based on proprietary and exclusively licensed technologies which aim to convert all carbon energy resources (oil, coal, natural gas, biomass, etc.) in clean products.

Lurgi is a member of the Air Liquide Group.

306e/01.11/10



**Lurgi GmbH**
Lurgiallee 5 · 60439 Frankfurt am Main · Germany
Phone: +49 (0) 69 5808-0 · Fax: +49 (0) 69 5808-3888
E-mail: communication@lurgi.com · Internet: www.lurgi.com