

# KEPCO-Uhde Inc.

Company Brochure



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# 1. Company Profile / Company Description

KEPCO-Uhde Inc. is a technology company which offers ThyssenKrupp Industrial Solutions PRENFLO® PSG (PRENFLO® with Steam Generation) gasification process to the market. The main business areas are global gasification projects for Integrated Gasification Combined Cycle (IGCC), Synthetic Natural Gas (SNG) and polygeneration concepts of plants. KEPCO-Uhde offers licenses, Basic Engineering Packages (BEP) and technology services to its customers. Furthermore, KEPCO-Uhde is active in technology development of its process.

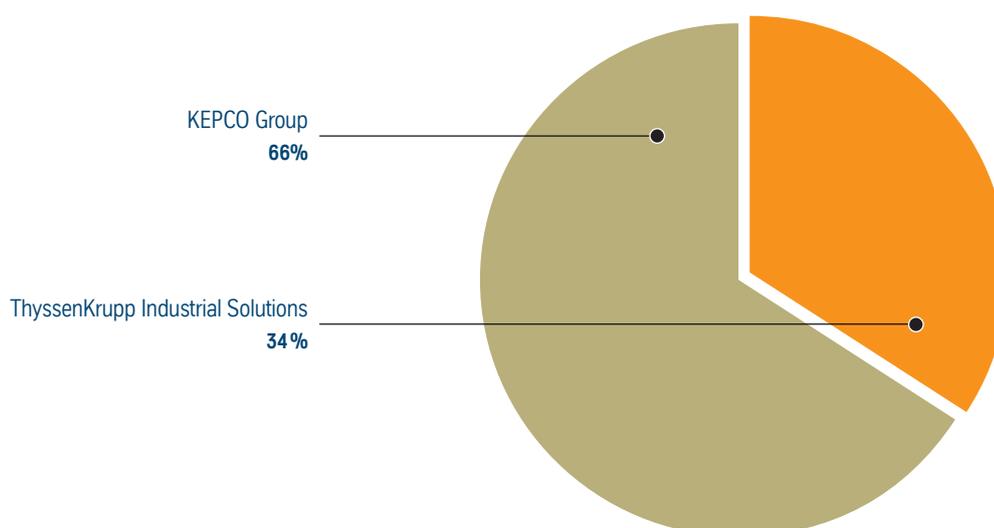
KEPCO-Uhde is a joint venture between KEPCO, the largest utility in South Korea, and Germany based ThyssenKrupp Industrial Solutions, one of the largest technology-driven EPC contractors. The company has been in operation since July 2011.

KEPCO-Uhde Inc. is poised to build together with KEPCO the largest IGCC power plant and become a global front runner in Integrated Gasification Combined Cycle, Synthetic Natural Gas, polygeneration and Carbon Capture & Storage which are strong in economics, efficiency and environment-friendliness.

## SHAREHOLDERS

KEPCO has 66% share of the joint venture which are distributed between KEPCO itself (45%) and the 5 power generation companies of KEPCO, KEPCO E&C as well as KEPCO KPS with 3% respectively. ThyssenKrupp Industrial Solutions is holding 34%.

KEPCO is a top class utility & engineering company in the world which is not only the largest electricity producer in South Korea but also strenuously expanding its business overseas. ThyssenKrupp Industrial Solutions is a globally recognized technology-oriented EPC contractor for the chemical industry which holds essential know-how in gasification technology.



## 2. Scope of Services

KEPCO-Uhde is dedicated to providing its customers with a wide range of services and to supporting them in their efforts to succeed in business. We place particular importance on interacting with our customers at an early stage to combine their ambition and expertise with our experience. Upon potential customers' requests, we are always willing to give them the opportunity to visit operating plants.

We aim to build our future business on the confidence our customers place in us. We remain in contact with our customers even after project completion. KEPCO-Uhde is committed to becoming a byword for partnership.

We would like to cultivate our business relationships and learn more about the future goals of our customers. Our aftersales services include regular consultancy visits which keep the owner informed about the latest developments or revamping options. KEPCO-Uhde and its partners stand for tailor-made concepts and international competence.

### LICENSING AND ENGINEERING

KEPCO-Uhde Inc. is the technology provider for the PRENFLO® PSG gasification process. It offers licenses of the PRENFLO® PSG process and corresponding engineering services such as Basic Engineering Packages (BEP).

Furthermore KEPCO-Uhde delivers services such as:

- commissioning of the plant
- feasibility studies
- training of operating personnel
- after-sales services

The major areas of activities are IGCC plants with and without Carbon Capture & Storage (CCS) technology as well as plants for the production of SNG.

### MARKETING & SALES

KEPCO-Uhde Inc. is part of the KEPCO group and is an essential part of the so-called KEPCO Fleet.

The KEPCO Fleet has been established to deliver to customers world wide a one stop package solution for gasification based IGCC, SNG and polygeneration plants. The KEPCO Fleet consists of KEPCO, the 5 power generation companies of KEPCO, KEPCO E&C (a reputable and experienced engineering company in the energy sector), KEPCO KPS (a reputable and experienced maintenance company), Korean

manufacturing and construction companies, ThyssenKrupp Industrial Solutions and last but not least KEPCO-Uhde itself.

Figure 1 on the right illustrates that the fleet delivers complete project solutions to customers. This includes EPC for the complete plants as well as solutions for the operation & maintenance of the plant. Financing assistance and equity investment by the KEPCO group are also possible. Furthermore, the KEPCO Fleet can offer packages including transmission and natural resource development. KEPCO-Uhde delivers the gasification technology for the projects and is the marketing and sales representative of the KEPCO Fleet.

### RESEARCH & DEVELOPMENT

KEPCO-Uhde Inc. is active in research and development in its field of technology. Together with its strong parent companies, KEPCO and ThyssenKrupp Industrial Solutions, the process is developed further.

KEPCO-Uhde, together with KEPCO, is currently executing its first R&D project with the goal of optimizing the overall flowsheet for IGCC and SNG plants based on its gasification technology. Through this R&D, KEPCO-Uhde is aiming at providing an optimized plant concept which suits customers needs to the maximum extent.

### KEPCO Fleet

## KEPCO-Uhde Inc.



ThyssenKrupp Industrial Solutions



Manufacturers

Construction Companies



### One Stop Package

Financing & Equity\*

EPC

Operation & Maintenance

Transmission and Natural Resource Development

### Customers Needs

IGCC

+

CCS

+

SNG

+

Polygeneration

Figure 1:  
KEPCO Fleet delivers one stop package to customers world wide.

\* Financing assistance as well as equity investment by the KEPCO group are possible.

## 3. Gasification



ELCOGAS S.A.,  
Puertollano, Spain.  
The world's largest  
IGCC power plant uses KEPCO-  
Uhde's  
PRENFLO® process.

### WHY GASIFICATION?

Gasification processes offer a number of upstream and downstream advantages to customers faced with rising oil and gas prices, dwindling energy reserves and a need to meet increasingly stringent environmental legislation. With proper preparation a variety of carbon-based materials can be easily gasified to produce synthesis gas (syngas) for the subsequent production of energy, chemicals and liquid fuels. Gasification is particularly clean and efficient.

Gasification is also flexible with respect to feedstock quality and the use of mixed feedstocks. The gasification of low-value or waste materials is also an attractive option. Even otherwise problematic materials can be gasified together with the main feedstock.

As coal is much more abundant than oil and gas and global availability ensures security of supply and relative price stability for the foreseeable future, coal will play an ever greater role in power generation, the chemical industry (e.g. in South Korea, India, China and Africa) and in the production of liquid fuels (gasoline, diesel, etc.). Coal gasification technology offers environment-friendly, efficient solutions for these applications. In power generation, for example, gasification can achieve high thermal efficiencies and also forms a basis for Carbon Capture and Storage (CCS).

KEPCO-Uhde's proprietary PRENFLO® with Steam Generation (PSG) technology provides an optimal gasification solution for a variety of applications.

### WHAT IS GASIFICATION?

Gasification is mainly a high-temperature partial oxidation process for converting carbonaceous materials into a synthesis gas composed mainly of carbon monoxide and hydrogen. A number of chemical reactions are involved, some exothermic and some endothermic:

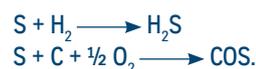
#### Exothermic:



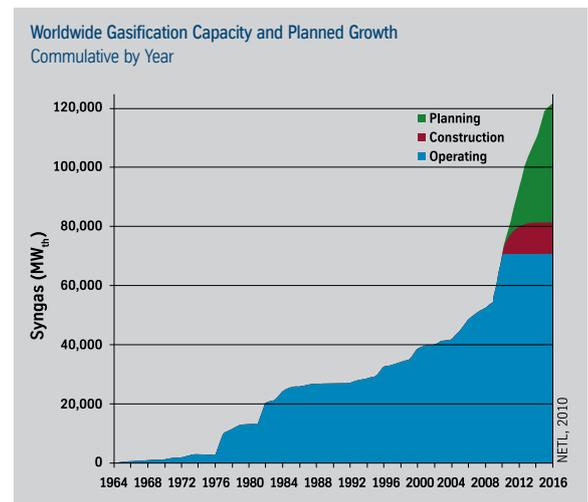
#### Endothermic:



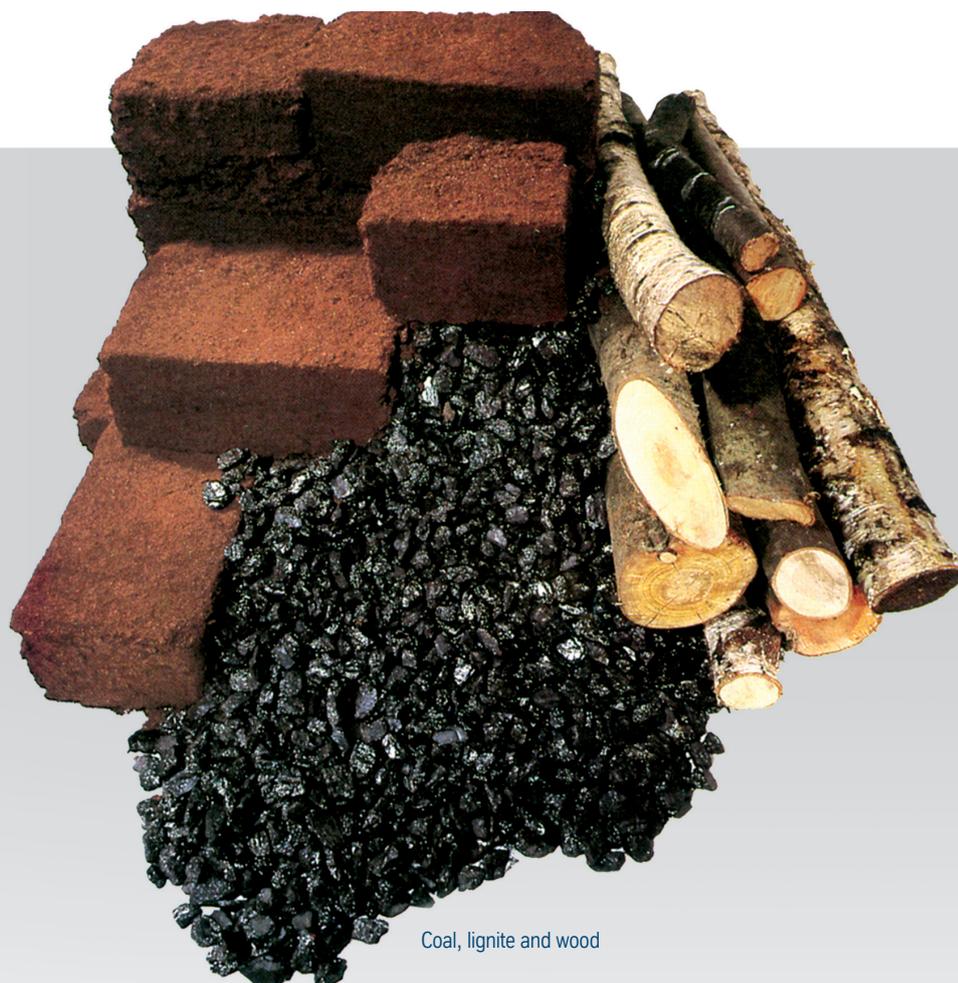
During the gasification process, the sulphur present in the feedstock reacts to produce mainly hydrogen sulphide (H<sub>2</sub>S) and carbonyl sulphide (COS):



Sulphur can therefore be readily recovered in its elemental form or as sulphuric acid, both marketable commodities.



## 4. Feedstocks and by-products



Coal, lignite and wood

PRENFLO® gasification with dry dust feed is able to handle all types of coal (hard coal, lignite, anthracite) as well as petroleum coke, char and biomass (e.g. chicken litter, sewage sludge, wood). In addition to the main product (syngas), gasification produces by-products of economic value. The

gasification of solids produces: slag, fly ash and, after subsequent gas treatment, elemental sulphur or sulphuric acid. Slag, a non-leachable product, can be used in road building or to manufacture bricks while fly ash is a base product of choice for the cement industry.

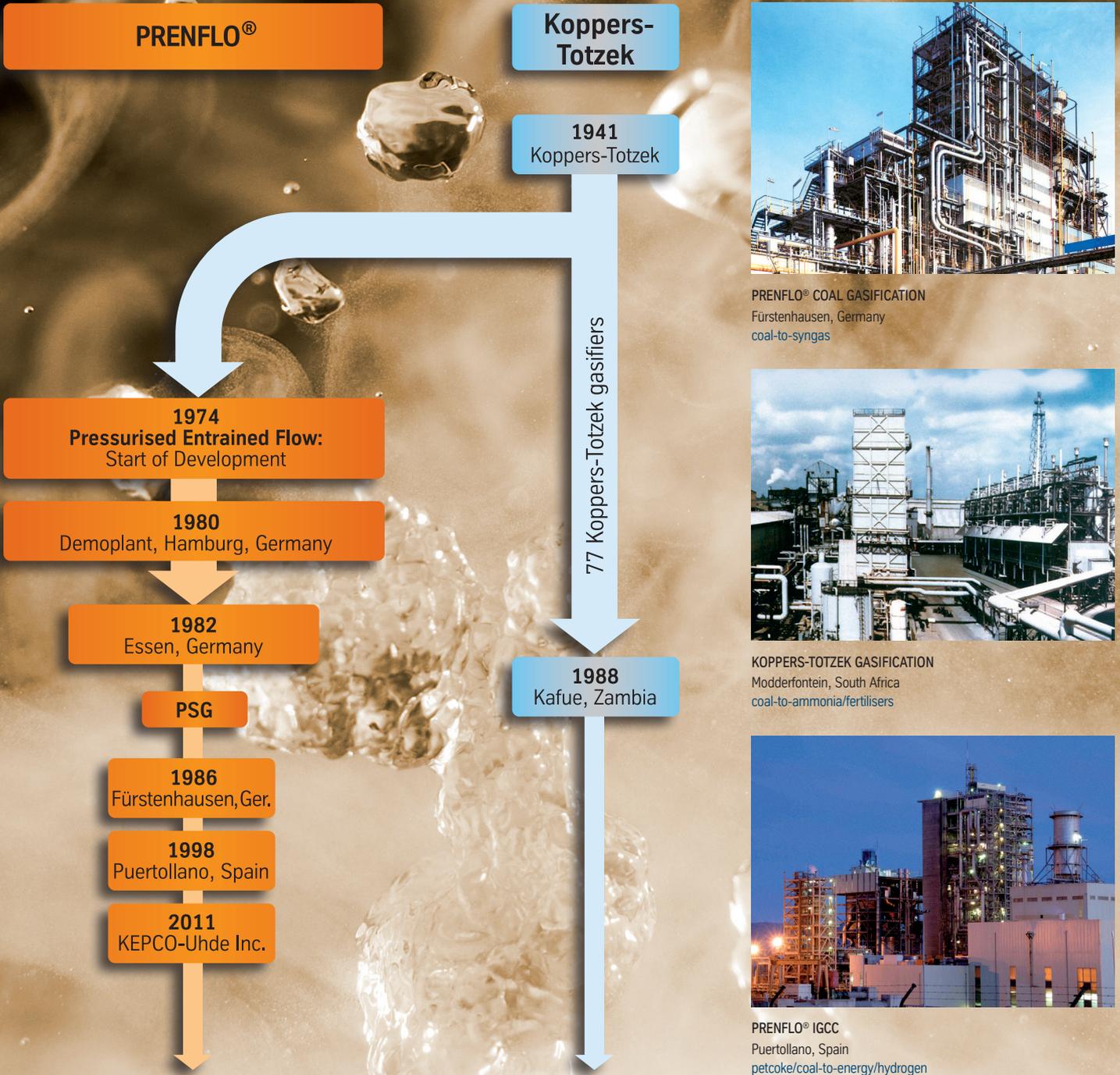


Products from PRENFLO® slag



Sulphur

# 5. History of gasification process



Development of KEPCO-Uhde's PRENFLO® PSG process with plants successfully completed.

KEPCO-Uhde builds on ThyssenKrupp Industrial Solutions' experience of over 65 years in the development, design and construction of gasification plants. ThyssenKrupp Industrial Solutions' list of references already includes over 100 gasifiers worldwide based on different gasification technologies covering a variety of feedstocks, and the expertise continues to grow.

Krupp Koppers, who merged with Uhde in 1997, developed the first entrained-flow gasification system (Koppers-Totzek process) in the early 1940s and built the first commercial Koppers-Totzek plants at the beginning of the 1950s. The German patent shown on the right was issued in 1952 for an uncooled refractory-lined Koppers-Totzek gasifier. The cooled gasifier was designed some years later.

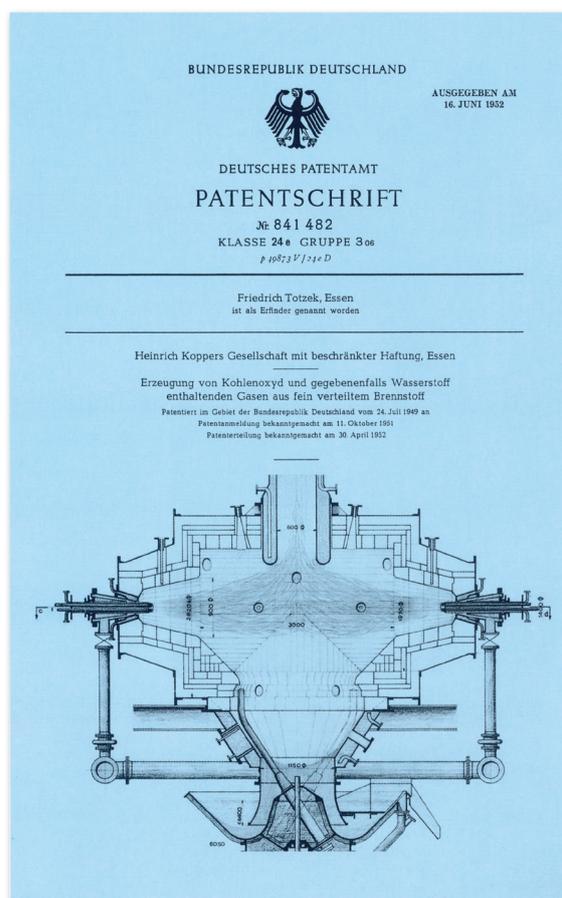
Most other entrained-flow gasification systems are refinements of the Koppers-Totzek process—for example, the Shell-Koppers gasification process, an entrained-flow gasification process at elevated pressure. This process was demonstrated at a plant in Hamburg, Germany, in the early 1980s.

The PRENFLO® technology marks a further development of this process in the late 1980s. Tests at a demonstration plant in Fürstenhausen, Germany, proved that PRENFLO® can accommodate coals from all over the world as well as petroleum coke without the need for modification. In addition, extensive tests were performed to determine suitable materials of construction.

In the late 1990s the world's largest solid-feed-based IGCC with PRENFLO® technology started operation in Puertollano, Spain.

The above entrained-flow processes are based on dry dust feed.

ThyssenKrupp Industrial Solutions has additional experience with a variety of gasification process such as fluidized bed technologies as well as slurry technologies. This experience is used to offer the most competitive gasification technology to the market.



German patent for Koppers-Totzek process issued in 1952



## PROCESS DESCRIPTION

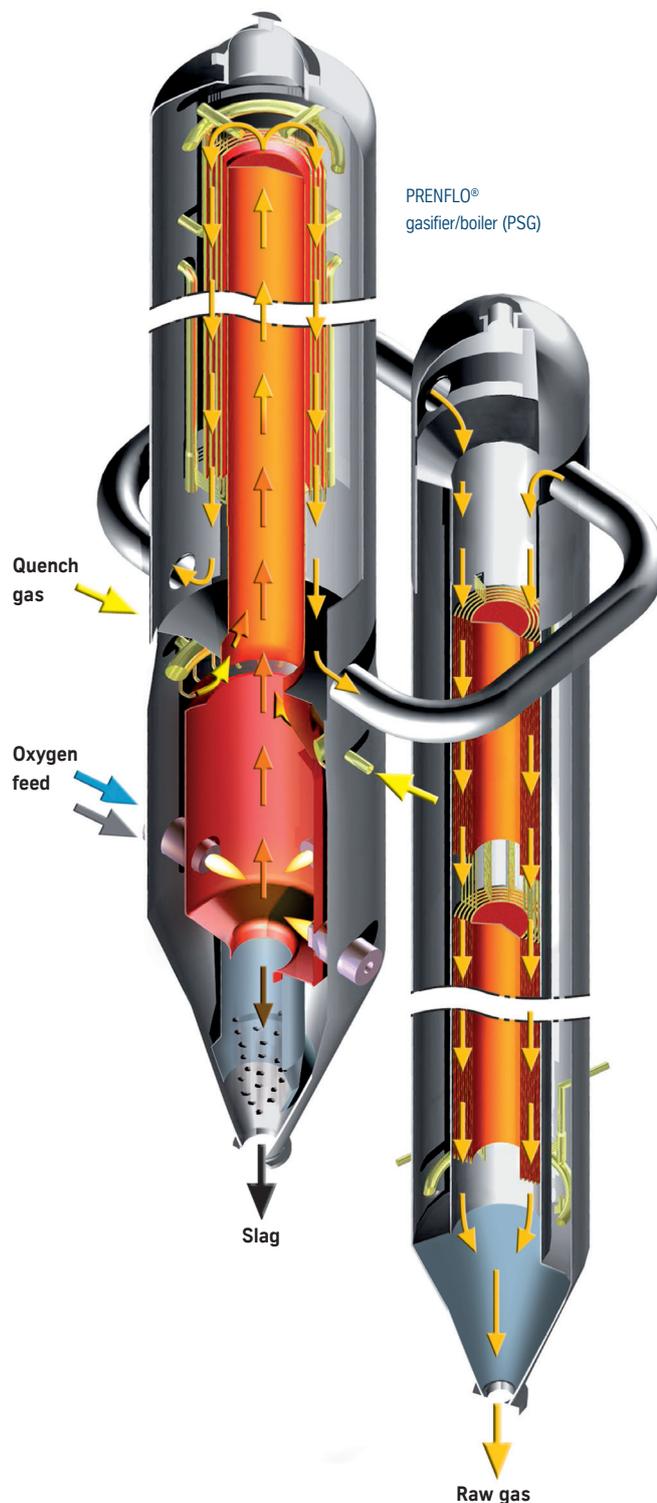
First, the feed dust is prepared in the feed preparation unit. Approximately 80% of the dust is smaller than 0.1 mm and has a water content of approx. 1-2 wt.% in the case of hard coals and approx. 8-10 wt.% in the case of lignite. This feed dust is then gasified in the PRENFLO® gasifier using oxygen and steam as gasification agents. The gasification temperature is higher than the ash melting temperature, which allows the coal ash to be removed as slag. The cooled-type gasifier is equipped with multiple, horizontally arranged burners.

In the PRENFLO® Process with Steam Generation (PSG), the raw gas produced, which contains mainly carbon monoxide and hydrogen, is cooled in the waste heat boiler, generating steam. The gas is then dedusted in a candle filter and further treated in a Venturi scrubber.

The slag from the gasifier can be used as a construction material and the fly ash from the candle filter as a base product in the cement industry.

PRENFLO® technology is used at the world's largest solid-feedstock-based IGCC power plant in Puertollano, Spain.

This plant operates with a mixture of petroleum coke and coal. The following tables show the feedstock composition and an analysis of the raw gas produced.



Ultimate analysis				Raw gas analysis PSG			
	Coal	Petcoke	Mixture				
C	wt.%	36.3	82.2	59.2	CO <sub>2</sub>	vol.%	2.9
H	wt.%	2.5	3.1	2.8	CO	vol.%	59.9
N	wt.%	0.8	1.9	1.4	H <sub>2</sub>	vol.%	21.7
O	wt.%	6.6	--	3.3	N <sub>2</sub> + Ar	vol.%	14.4*
S	wt.%	0.9	5.5	3.2	CH <sub>4</sub>	vol.%	< 0.1
Ash	wt.%	41.1	0.3	20.7	H <sub>2</sub> S + COS	ppmv	1.1
Water	wt.%	11.8	7.0	9.4	Total:	vol.%	100.00
Total:	wt.%	100.0	100.0	100.0	LHV, dry	MJ/m <sup>3n</sup>	10.16
LHV	MJ/kg	13.1	32.6	23.1			

\* based on oxygen purity of 85 vol.% for gasification

## MAIN FEATURES OF THE PSG PROCESS:

- Entrained-flow
- Dry dust feed for high efficiency
- Multiple burners with high availability and long lifetime
- Horizontally arranged burners for high carbon conversion
- Membrane wall with long lifetime
- Waste heat boiler for efficient heat recovery
- Operates above ash melting point

## 7. Syngas application

The raw gas produced by gasification needs to be treated before it can be used for the production of downstream products, such as SNG, electricity, hydrogen and other chemicals.

There are various process routes available for obtaining the desired syngas composition, which may be a mixture of carbon monoxide and hydrogen or either pure hydrogen or carbon monoxide alone.

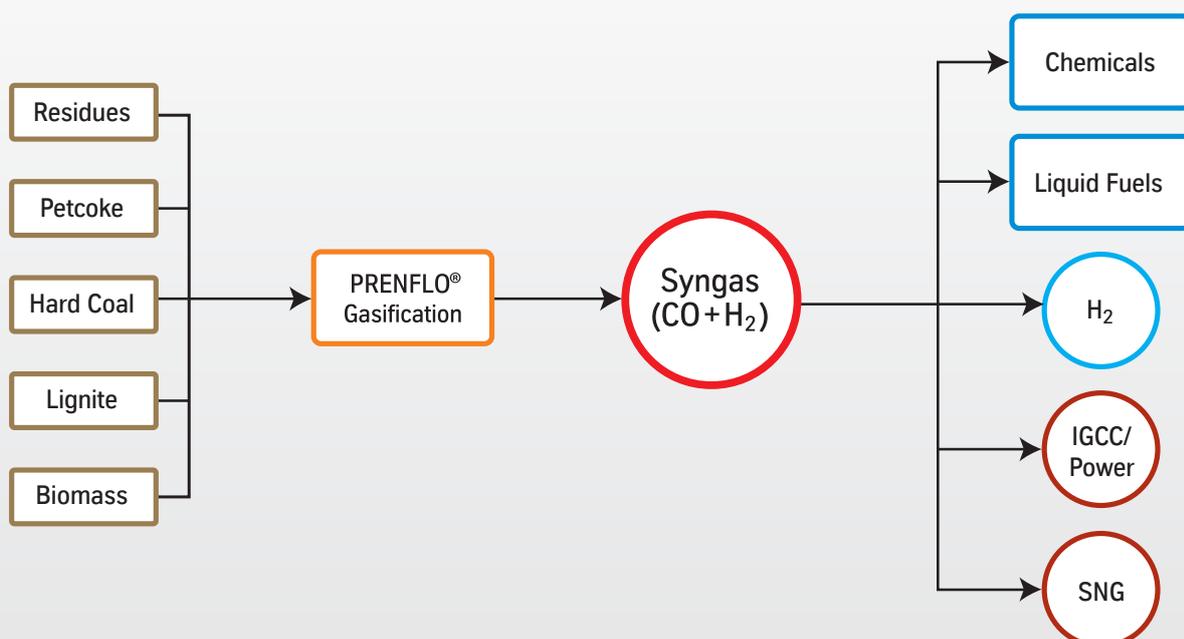
Hydrogen, for example, can be used in the refinery industry to achieve lighter and cleaner liquid fuels or for new applications such as fuel cells for power generation or cars.

Hydrogen-rich syngas can be produced via the "sour" CO shift process. In this case, the CO in the raw gas produced by gasification is shifted with steam to form hydrogen and carbon dioxide before the sour gas components are removed.

A number of processes are available for desulphurisation and carbon dioxide removal, such as Genosorb, MDEA, aMDEA,

Rectisol.

KEPCO-Uhde's gasification business is focused on SNG and electricity production via IGCCs with and without carbon dioxide capture. For the downstream processing KEPCO-Uhde and ThyssenKrupp Industrial Solutions work closely together using ThyssenKrupp Industrial Solutions' vast experience in syngas-based chemicals plants.



## 8. SNG production

### BACKGROUND ON SNG POTENTIAL

In 2013, the International Energy Outlook (IEA) projected that the world energy consumption will grow by 56 percent between 2010 and 2040. Much of the growth in energy consumption occurs in non-OECD countries, where demand is driven by strong long-term economic growth.

Fossil fuels will continue to supply almost 80 percent of world energy use through 2040. Natural gas is the fastest-growing fossil fuel in the outlook. Global natural gas consumption increases by 1.7 percent per year.

This increased demand for natural gas will have a significant impact on natural gas pricing.

It is thus expected that the price and demand of gas will go up gradually regardless of additional sources such as shale gas and this makes it attractive to produce natural gas based on alternative fuels such as low rank coal.

Synthetic Natural Gas (SNG) has essentially the same properties like natural gas and LNG. With a strong demand for LNG e.g. in Asia, SNG is a valuable alternative which is based on resources such as low rank coal and thus is looking more and more attractive. This product is especially attractive in locations where natural resources are scarce.

SNG can be easily produced e.g. mine mouth and then transferred with the existing natural gas pipelines to industrial and private customers. Essentially the same products produced from natural gas can be also obtained from SNG such as electricity and chemicals (e.g. ammonia, methanol etc.).

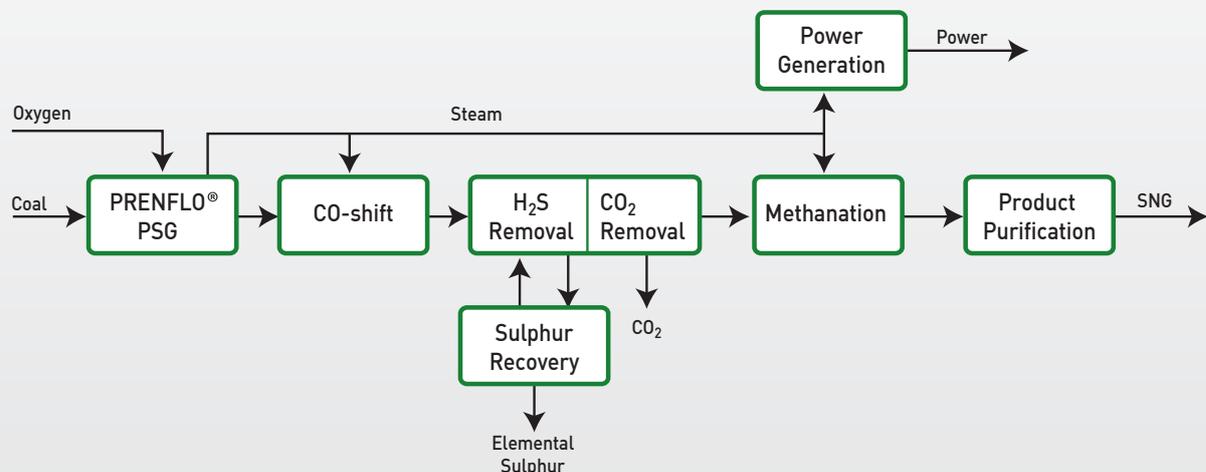
The production steps for SNG are shown in a block flow diagram. After the gasification process a shift reaction to produce additional hydrogen is needed to satisfy the boundary conditions for the methanation process. Subsequently the sulphur is removed from the process with a gas treatment process. Downstream of these units, the main reaction to SNG takes place. The product is then purified and is shipped to battery limits. It is worth noting that the process chain is overall exothermic and it is recommended to use the heat produced to generate electricity as shown in below Figure.

The PRENFLO® PSG process is very well suited for this application since it is a highly efficient process reducing the feedstock amount to a minimum. The steam produced in the gasification section is used for electricity production as well and makes the SNG plant power independent. Even power export is possible.

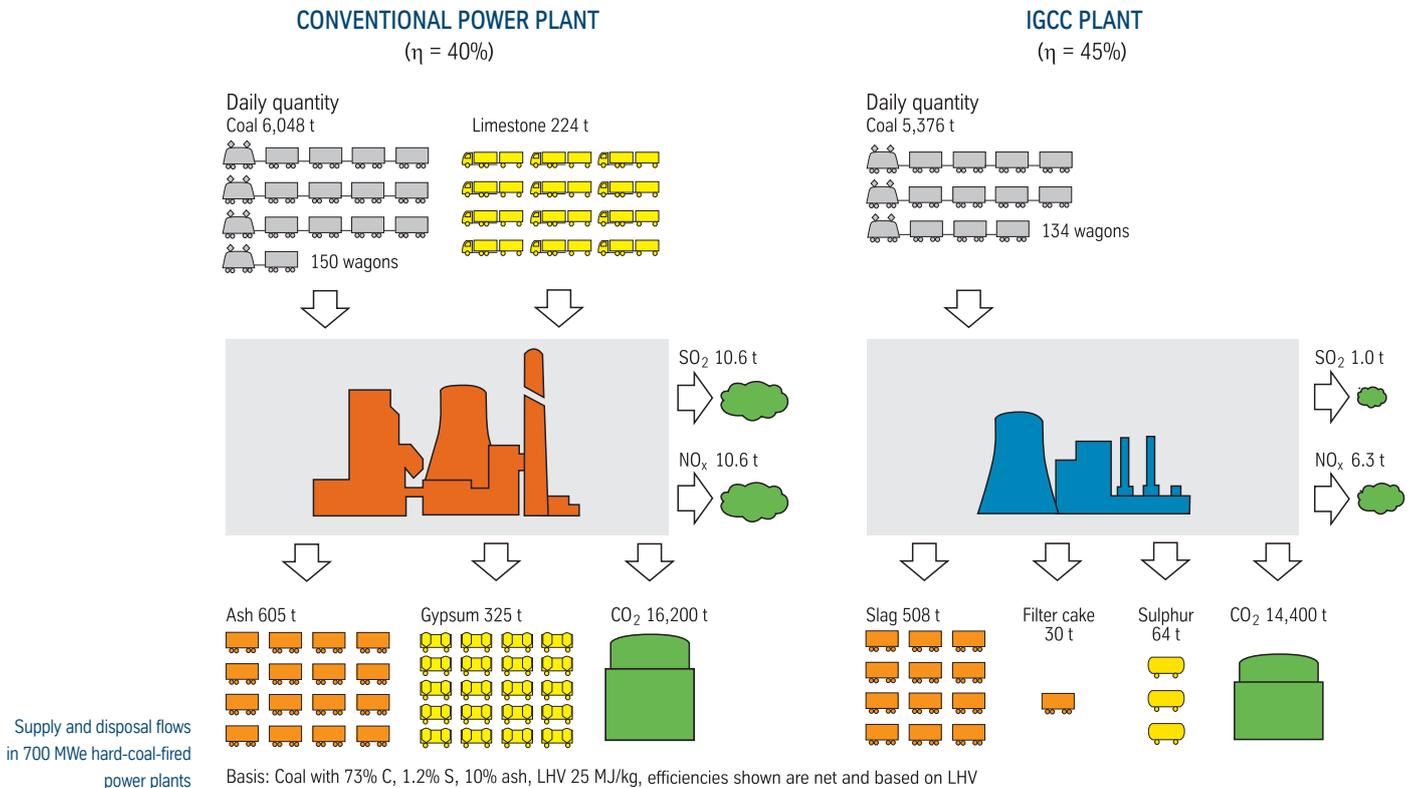
To give an impression of the size of the production plants, please note that SNG production from one gasifier of over 350,000 t/y is possible. One promising plant scheme is the production of over 1.000.000 t/y of SNG using 3 PRENFLO® PSG gasifiers and two trains of gas treatment processes. This set-up is using the optimal economy of scale of all needed process units.

As described in the Scope of Services, the optimization of this SNG plant concept is one goal of the currently executed R&D task.

### PRODUCTION PROCESS



## 9. IGCC plants for electric power generation



Solid feedstocks, such as coal, will continue to play an important role in power generation for the foreseeable future. Integrated gasification combined-cycle (IGCC) technology offers an ideal method for cost effectively producing power from these feedstocks while offering substantial environmental benefits over other power generation technologies, such as reducing  $\text{CO}_2$ ,  $\text{SO}_x$ ,  $\text{NO}_x$  and particles emissions. The environmental benefits can be improved even further by adding biomass materials to the feedstocks.

The supply and disposal flows of a conventional power plant are compared with those of an IGCC plant (see above). This comparison clearly shows how efficient and environment-friendly IGCC plants are.

ThyssenKrupp Industrial Solutions has designed and built

PRENFLO® (PSG) gasification technology using a mixture of high-sulphur petroleum coke and high-ash Spanish coal as the feedstock at the world's largest solid-feedstock-based IGCC plant in Puertollano, Spain.

This IGCC plant is based on a highly integrated system in which the total air for the air separation unit is taken from the gas turbine compressor. The plant can be divided into three main parts:

- the gasification island, comprising the feed preparation unit, the PRENFLO® gasification unit, the gas treatment unit and a sulphur recovery unit
- the power block, comprising the gas turbine, the heat recovery steam generator and the steam turbine
- the air separation unit (ASU).





## CONTACTS

KEPCO-Uhde is dedicated to providing its customers with a wide range of services and to supporting them in their efforts to succeed in business.

Together with ThyssenKrupp Industrial Solutions, KEPCO and the KEPCO Fleet members, we form a strong team to deliver first-class solutions to our customers.

If you have any interest, please contact us at the following numbers and e-mail address. We are looking forward to hearing from you.

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