

# Press Release

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**AchemAsia 2007  
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Trend Report No. 14: Efficient use of coal and biomass

## Focus on new technologies for efficient use of coal and biomass

- **Comeback for coal gasification and liquefaction**
- **Tailwind for bioenergy**
- **China to step up efficient use of domestic coal**

*The engineering community is hard at work, devising novel power-generation approaches that can be used to reduce society's dependence on traditional oil-, coal- and natural-gas-fired power generation, to reduce the environmental impact associated with traditional fossil-fuel-based methods for generating electricity and fuels, and to improve national security by encouraging energy self-sufficiency and reducing dependence on foreign oil. In particular, promising commercial-scale advances are being made in the areas of clean-coal gasification and liquefaction and biomass gasification to produce electricity and synfuels. At the 7th AchemAsia – International Exhibition Congress on Chemical Engineering and Biotechnology from 14 - 18 May 2007 in Beijing this will be in the focus of interest of both the exhibition and the international congress. More than 500 exhibitors and 20,000 visitors from 25 countries will take this opportunity to exchange ideas and experience and make new contacts.*

These non-traditional approaches to power generation are all aimed at helping to slow society's consumption of crude oil and natural gas. Fossil fuels are not only growing scarcer and more costly with every passing year, but they incur notoriously challenging and costly environmental issues, ranging from the production of SO<sub>2</sub>- and NO<sub>x</sub>-related emissions to the creation of CO<sub>2</sub> and other greenhouse gases. And, for many nations, the ability to reduce dependence on foreign oil imports - especially those coming from volatile, politically unstable regions of the world - is an important step towards increasing national security.

## Coal gasification and IGCC

There is increased global interest in coal-gasification processes and integrated gasification combined cycle (IGCC) power plants, and several commercial-scale facilities have been announced during the last few years. The goal is to take advantage of copious, relatively low-cost coal and to use it to produce electricity in a way that is intrinsically less polluting than traditional pulverized-coal-burning power plants.

According to the latest information from Deutsche Bank Research (January 2007), investments of up to US\$ 10 trillion are pending in low-emission technologies for the global power plant fleet, over US\$ 2 trillion of this alone in China.

Gasification technology works by injecting a solid or liquid feedstock (typically coal in slurry form) into a gasifier reactor, along with oxygen and higher-temperature steam. Under the high temperatures and pressures inside the gasifier, the feedstock reacts with the steam and oxygen in a reducing atmosphere, to yield syngas consisting of CO and H<sub>2</sub> with smaller amounts of CO<sub>2</sub> and methane. The enhanced sulfur- and mercury-removal capabilities of today's proven gasification technologies make IGCC an inherently cleaner alternative to conventional coal-fired power plants.

RWE (Germany) is currently planning to build the first commercial-scale power plant with integrated coal gasification, carbon capture and storage in Germany. The coal-fired plant with an expected gross capacity of around 450 MW and an efficiency of 40% could come on stream in 2014 if planning and implementation proceed smoothly. A decision on the plant site and the fuel used (lignite or hard coal) will be made in mid-2007. The CO<sub>2</sub> is intended to be compressed and transported via pipeline to the storage site. It is especially saline aquifers that would be suitable for storage.

With its subsidiary DEA, RWE intends to bring carbon capture to commercial maturity. The investment volume for the power plant and for transport and storage of carbon dioxide is estimated to be €1 billion. The world's first commercial-scale power plant with integrated gasification and downstream carbon capture and storage is not just a big step forward for advanced energy conversion that puts less stress on the climate. It is also meant to underscore RWE's claim to technological leadership, above all in coal-based generation. Using the key technology of coal gasification also creates a platform for coal-to-gas and coal-to-liquid technologies.

Prerequisites for this integrated project are not only successful technical implementation but also the necessary legal framework and approvals to be issued at a national and European level. Supplementing this, RWE is engaged in a parallel project to develop post-combustion CO<sub>2</sub> scrubbing for conventional power plants, which will offer a retrofit option for existing plants. Vattenfall Europe also plans to build a CO<sub>2</sub>-free pilot plant based on lignite.

GE Energy and Bechtel Corp. have formed an alliance to offer optimized IGCC projects in North America. The proposed GE-Bechtel Reference Plant will be based on the gasification technology GE acquired from ChevronTexaco in 2004.

ConocoPhillips also has a well-established coal-gasification process called E-Gas that can be used to convert coal and other hydrocarbon feedstocks into syngas that can then be used to produce IGCC power, chemicals or liquid fuels.

Sasol Lurgi Technology Company (ZA) and Lurgi AG (ZA/D) have been awarded a contract by Jindal Steel & Power Limited, New Delhi, India to build a coal gasification plant supplying 225,000 Nm<sup>3</sup>/h Syngas for a direct reduction steel plant at Angul, Orissa, India. The scope comprises basic engineering, detail engineering and supply of proprietary equipment. The technology applied will consist of "Sasol-Lurgi Fixed Bed Dry Bottom Gasification Process" in connection with diverse gas purification and desulfurization processes. The plant is scheduled to start operation in the fourth quarter of 2009. This gasification technology is considered to be most suitable for low grade Indian Coals.

In addition, favourable drivers within the energy landscape have seen the Sasol-Lurgi Technology Company forge ahead in extending its existing global footprint. In addition to four existing operating facilities, including the world's largest coal gasification facilities in South Africa, the company has recently concluded seventeen coal suitability analyses, contracted to perform six detailed feasibility studies and signed two new license agreements in the United States and India, respectively.

Tokyo-based Nippon Steel Corp. is also developing a process to convert low-value coal into light oil, synthesis gas and fuel for power generation. The heart of the new process is a two-stage, entrained-coal, partial hydro-pyrolysis reactor. A reformer section performs mainly hydrogenation of coal volatiles, and a gasifier section carries out partial oxidation of coal and char.

In terms of commercial-development efforts, several announcements in 2005 demonstrate the industry's renewed interest in developing commercial-scale IGCC facilities. For instance, ConocoPhillips and Excelsior Energy, Inc. signed a development and technology licensing agreement for 532-megawatt equivalent (MWe) IGCC facility to be located in northeastern Minnesota. The facility will use ConocoPhillips' E-Gas technology, and is destined for start-up in 2010.

In the U.S., the two longest-running commercial-scale IGCC plants are Tampa Electric's Polk Power Station in Tampa., Fla., and Global Energy's Wabash River IGCC Plant in Terre Haute, Ind., have been running since the 1995-1996 time frame, and each has a capacity of about 250 MW power. In Europe, several slightly larger IGCC plants have also been in operation in Italy, the Netherlands and Spain since the mid-1990s, as well.

After a 10-year hiatus in the construction of commercial-scale IGCC power plants, two new projects were announced in September 2005, and at 600 MW each, these two new IGCC facilities will be the largest to date, once they come onstream.

One of the new 600 MW IGCC power plants will be being developed by for a site in Indiana, by Cinergy Corp. in partnership with Vectren Corp., GE Energy and Bechtel Power. The other will be a 629 MW IGCC power plant slated for Meigs County, Ohio, that is being developed by American Electric Power (AEP), along with GE Energy and Bechtel Power. Target for commercial startup of that new IGCC plant is 2010. AEP, which is currently the largest electricity generator in the U.S., owning more than 36,000 MW of generating capacity, says it also intends to build at least another 600 MW of IGCC generation in its eastern operating area by 2013, to fulfill a 2004 commitment it made to add 1,200 MW of baseload IGCC generation capacity.

Meanwhile, in April 2005, ConocoPhillips and Fluor Corp. announced that work had begun on a front end engineering design (FEED) package for the Southern Illinois Clean Energy Center in Williamson County, Ill. That facility will use ConocoPhillips' E-Gas Technology to gasify coal to generate roughly 545 MW of electricity and 95 million std. cubic feet/day of pipeline-quality synthetic natural gas.

Another U.S. electric utility, Energy Northwest has also received Board approval to pursue the development of a 600 MW IGCC power plant for a site in western Washington state. Its goal is to have the plant up and running by 2011.

Meanwhile, to advance the state-of-the-art engineering concepts for clean, coal-based power generation, a non-profit group known as the FutureGen Industrial Alliance – a voluntary global coalition that includes American Electric Power (AEP); BHB Billiton, The China Huaneng Group, Consol Energy, Foundation Coal, Kennecott Energy, Peabody Energy and Southern Co., in partnership with the U.S. Dept. of Energy – is working to build the cleanest coal-fueled power plant in the world over then next 5 to 10 years. The group's goal is to design and build an IGCC power plant with "zero emissions," which will produce net byproduct hydrogen, and dispose of its byproduct CO<sub>2</sub> using underground sequestration. Members of the alliance have voluntarily committed more than US-\$ 250 million to help fund project development, while the U.S. government plans to invest about US-\$ 700 million in the project.

Finally, leaving no stone unturned in the quest to find cheaper, cleaner power, the Tokyo-based Hitachi Zosen Corp. is developing a way to use waste heat to make electricity without the need for any fuel. The use of ammonia as the working fluid in the Rankine thermodynamic cycle is well-known, but it has not yet been applied commercially. However, since 2004, Hitachi Zosen Corp. (Tokyo) has been testing a method that uses waste heat and an ammonia-based Rankine cycle at its power plant – a world's first, claims the firm. The equipment costs are estimated to be about 20-30 % less than those required for a water-based Rankine cycle driven by waste heat, says the firm. The simple process is said to be a good way to use waste heat to make electricity without generating additional CO<sub>2</sub>. The company is testing a 200 kW unit.

### **China discovers/turns to its domestic coal: Coal liquefaction and gasification to counter peak oil/oil shortfall**

China is the most highly populated country and ranks second after the USA in world energy consumption. To bolster its economic growth, besides oil and gas China is increasingly focusing on alternative energy sources, particularly coal-to-liquid (CTL) technology. China is the world's greatest producer and consumer of coal. Coal currently covers around 70% of China's energy demand and her immense coal reserves have triggered off a comeback for CTL fuels. It is estimated that within the next ten years it will be possible to replace around 1.2 million barrels of oil per day by coal-based liquid fuels; this figure represents over one sixth of current demand.

Coal being cheaper than oil, fuel based on the Fischer-Tropsch process used proprietarily by Sasol, South Africa, can already be produced for less than US\$ 20 per barrel, while oil prices have escalated to around US\$ 80 per barrel. The Chinese government, domestic coal producers and foreign investors are showing interest in investing in these new technologies.

According to a study by Festel Capital, Switzerland, in 2004 three companies, the Shenhua Group (80%), Shanghai Huayuan Group (10%) and the Shanghai Electric Group (10%), invested over US\$ 12 million in the China Coal Institute, China's first research center for coal liquefaction. Located in Shanghai, the center's key priorities are direct and indirect coal liquefaction technologies and also to provide technological support for China's first coal liquefaction project in Inner Mongolia and the relevant training for engineers in this field.

Interesting research into "Clean diesel production from coal based syngas via Fischer-Tropsch synthesis" is also being carried out by Synfuels China, State Key Laboratory of Coal Conversion, Institute of Coal Chemistry at the Chinese Academy of Sciences. The work focuses on the development of cheap, efficient synthesis catalysts and optimization of processes up to industrial application.

The Shenhua Group has ongoing projects in Shaanxi, Inner Mongolia, Ningxia and Xinjiang. It launched the first Chinese direct coal liquefaction project in Erdos, Inner Mongolia in 2004. This 3 billion US dollar investment is expected to produce an annual capacity of 5 million m.t. after completion. The first stage of expansion with a capacity of 3.2 million m.t. will go on stream in 2007, the second by 2010.

According to a statement by bfai (the German Office for Foreign Trade) in November 2006, a further project for indirect coal liquefaction (10 million m.t. per year) involving an investment of 3.1 billion euros will be implemented between 2006 and 2009. The Xinjian projects for direct coal liquefaction are still underway. In 2007 a plant producing 3.2 million m.t. per year will start operation. All in all the biggest Chinese coal producer is set to expand its coal liquefaction capacity in the four northern provinces up to around 30 million m.t. by 2020.

Shenhua is involved in several cooperation projects with international partners. In July 2006 Shenhua Ningxia Coal Industry signed an agreement with Shell for a feasibility study for a coal liquefaction plant with a capacity of 70,000 barrels of oil which would also produce additional petrochemical products such as petrol, diesel or naphtha. A similar deal was made with Sasol. The investment plan for the two projects amounts to 12 billion US dollars. Three further Shenhua projects are planned with Dow Chemical (methanol to olefin, methanol production, and coal to olefin).

According to bfai, the Shandong Yankuang Group in Shaanxi is embarking on a coal liquefaction and a methanol project, each with an initial capacity of five million m.t. and soaring to double that amount in a second phase; the plants will be supplied by Lurgi/Germany. South Africa's Sasol also sees considerable market potential for at least 12 plants for direct coal liquefaction using the Fischer-Tropsch process.

Among the international suppliers, besides Shell and Sasol the German engineering company Lurgi and Texaco/USA are also working in the field of coal liquefaction. At the same time Chinese companies from the fields of coal production and petrochemistry are developing their own plants (maximum capacity 2000 m.t./day). However their production capacities come nowhere near those of the international players and the technology they use lags at least 5 to 6 years behind. International standards rate coal liquefaction projects with an output of less than 5,000 m.t. per day non-competitive.

The bfai also confirms that Sinopec, the China National Coal Group Corp., the Shenergy Group, China Yintai and the Inner Mongolia Manshi Coal Group in Erdos are collaborating on a 21 billion RMB methanol and methyl ether project with targeted capacities of 4.2 million m.t. and 2 million m.t. respectively. The plant will go on stream by 2010.

The Chinese Shanxi Jincheng Anthracite Coal Mining Co. Ltd. has contracted Uhde for the engineering and supply of a methanol-to-gasoline (MTG) plant. The new MTG plant will form part of a pilot-scale complex which is being built in Jincheng in the Shanxi province some 600 kilometres south-west of Beijing. The complex will also include a fluidised-bed hard-coal gasification plant and a methanol plant. Starting in 2008, it is planned to produce 100,000 (metric) tons of gasoline annually. Under the MTG contract, Uhde is responsible for the licence, engineering, supply of key process equipment and technical assistance right through to start-up of operation. The MTG process concerned has been licensed from the US company ExxonMobil Research and Energy (EMRE) and is suitable for the production of synthetic fuels.

In February 2007 Sinopec Corp. and Syntroleum Corp. (Tulsa, Oklahoma) signed a memorandum to establish joint technology development to advance natural gas-to-liquids (GTL) and coal-to-liquids (CTL) technologies, cooperation in verifying Syntroleum GTL technologies on an industrial scale, construction of a 700,000 tonne per annum (17,000 barrel per day) GTL plant and a 3,000 tonne per annum (100 barrel per day) CTL pilot plant in China using Syntroleum's technologies, and jointly marketing SSTC technology (Sinopec Syntroleum technology) in China through the most effective means.

This declaration of intent calls on Syntroleum to provide Sinopec with access to its complete set of proprietary GTL technologies including catalyst technology and Fischer-Tropsch technologies related to CTL for use in China on an exclusive basis during the period of cooperation. After signing a formal cooperation agreement, Sinopec agrees to provide Syntroleum with \$20 million per year over the next five years to support development of the technology. Sinopec and Syntroleum have already commenced relevant work on a legally binding cooperation agreement "Research and Development Cooperation Agreement".

## **Biomass gasification / Bioenergy**

Biomass gasification is also gaining renewed attention, as a way to use a renewable feedstock to produce a valuable synthesis gas that can then be used to generate electricity in a gas turbine, used as a feedstock to produce methanol, dimethyl ether, or, used in a Fischer-Tropsch system to produce diesel and other liquid fuels.

Traditional biomass gasification is carried out using partial oxidation, without a catalyst, at a temperature ranging from 900-1,400 °C, depending on whether oxygen or air is used. Besides the disadvantage of a high-temperature operation, considerable tar and char are produced.

Researchers at Japan's University of Tsukuba recently developed a new catalyst (1 % (w/w) rhodium supported on oxides of cerium and silicon) that allows biomass gasification to be carried out at lower temperatures – 650-700 °C, compared to 900-1,400 °C for conventional biomass gasification via partial oxidation without a catalyst. The resulting synthesis gas (a mix of CO, H<sub>2</sub>, CH<sub>4</sub>, and CO<sub>2</sub>, with solid carbon generation of only 1 % and no tar), is suitable to produce power in a gas turbine, or can be used as a chemical feedstock. The group is working to scale up the process.

Researchers at the University of Wisconsin (Madison) are also developing a milder process to make hydrogen, that contains less than 60 ppm carbon monoxide, from biomass-derived oxygenated hydrocarbons. Because it uses a nickel (not platinum) catalyst, and is carried out at milder conditions (225 °C, versus 600-1,000 °C), the process is being pursued as a less costly alternative to conventional steam reforming of natural gas to make CO-lean H<sub>2</sub> for fuel cells and other purposes.

A group of researchers at Japan's Shizuoka University has developed a one-step process for making hydrogen from biomass such as black liquor from the pulp-and-paper industry, municipal garbage, paper sludge and even pig excrement. The process takes place in supercritical water (SCW) and produces two to five times more hydrogen than conventional reforming and gasification processes, according to the group. The continuous process has been demonstrated at bench scale, and the developers are seeking commercial partners for scaleup.

Shell Deutschland Oil GmbH recently acquired a minority stake in Choren Industries GmbH. Together, the companies will construct the world's first commercial facility to convert biomass into a synthetic fuel called "SunFuel," which, according to the company, can be used without modification in any diesel engine. A 15,000-m.t./yr plant, planned for Freiberg, will use Choren's Carbo-V three-stage gasification technology to convert plant-derived biomass into synthesis gas, which can then be converted into methanol or diesel.

Neste Oil Corp. is constructing a €100-million biodiesel plant at its Porvoo, Finland, petroleum refinery. When the 170,000-m.t./yr plant starts up in mid-2007, it will be the first commercial plant to use Neste Oil's new NExBTL ("next generation biomass-to-liquid") process. The process produces diesel fuel from renewable raw materials, and, according to the company, can be adapted to use all kinds of vegetable and animal fats. Meanwhile, Neste Oil and Total S.A., have also signed a memorandum of understanding to evaluate the possibility of building a large-scale production plant for biodiesel fuel using the NExBTL process at one of Total's petroleum refineries.

The U.S. Dept. of Energy's National Renewable Energy Laboratory and Genencor International are also working to develop a process to convert the cellulose in biomass (such as agricultural waste) to ethanol.

While many biomass-conversion processes rely on partial oxidation reactors (using either air or pure oxygen), several groups are also developing biomass-conversion processes that rely on pyrolysis in an oxygen-depleted environment. For instance, DynaMotive Energy SystemCorp. has developed a fast pyrolysis-based process to produce "BioOil" from a wood-residue feedstock. In the process, pulverized biomass is pyrolyzed in a bubbling fluidized-bed reactor that operates oxygen-free at 450-500 °C.

Once it's operational, the pyrolysis plant will process 100 tons/d of plywood residue and produce 70 m.t./d of BioOil (along with 20 m.t./d of char and 10 m.t./d of non-combustible gases), which will be used to fuel a turbine to generate electricity in a cogeneration plant (up to 2.4 MWe) operating at Erie Flooring and Wood Products facility in West Lorne, Ont. DynaMotive Energy Systems is also in the process of developing a larger, 200-m.t./d pyrolysis plant for producing BioOil for other clients.

Forschungs-Zentrum-Karlsruhe (FZK) and Lurgi AG (Frankfurt) have embarked on a joint development for the pyrolysis of biomass. This represents the first step in a process converting biomass into liquid Fischer-Tropsch grade fuel. Flash pyrolysis utilises a proprietary retort producing biomass derived oils/hydrocarbons and char in decentralised units at the locations of biomass harvesting. These products forming a stable slurry will be transported to a central entrained flow gasifier to produce syngas which is converted after purification into Fischer Tropsch bio-synfuel. The first step in the development is the Flash Pyrolysis Pilot Plant (for 0.5 tph biomass feed) which is under current construction at FZK (mechanical completion December 2006).

## **Is biomass the alternative raw material source of choice?**

China is highly interested in processes for using biomass as an alternative to coal and oil. The international AchemAsia Congress and Partnering Events from 14 to 18 May 2007 in Beijing/PR China will highlight new perspectives and possibilities for cooperation with international partners.

## **Selected Topics of the international AchemAsia Congress Programme:**

- Synfuels & Renewables: Conversion of fossil fuels, clean coal technologies, syngas conversion
- Biorefineries: Biofuels, enzyme application, utilization of biomass, extraction
- Chemical process engineering: Hydrogen production, separation technologies, supercritical fluids, catalytic processes

### **High-ranking AchemAsia plenary speakers:**

- Humphrey Lau, Site President Novozymes China, Beijing, People's Republic of China
- Japie Scholtz, Sasol Technology R&D, Sasolburg, South Africa; President of the South African Institution of Chemical Engineers (SAIChE)
- Cao Xianghong, SINOPEC, Beijing, People's Republic of China, President of Chemical Industry and Engineering Society of China (CIESC)
- Philippe Tanguy, Ecole Polytechnique Montreal, Canada
- Ren Jianxin, President CHEMCHINA, Beijing, People's Republic of China
- Zhang Pei Zhang, Chairman of the Board, Shanghai HUAYI Group, Shanghai, People's Republic of China

**More information and the programme are available at:**

**[www.dechema.de](http://www.dechema.de)**

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