

Rita D'Aquino

# Changes and Challenges China's New Five Year Plan


China's 11th Five Year Plan (FYP), chartered by the Central Committee of the Communist Party of China (CPC) in mid-October, has laid out a grandiose roadmap for the country's scientific development, a term used by the country's leadership for economic growth that takes into consideration the welfare of disadvantaged sectors as well as environmental concerns. Given the track record of China's burgeoning economy, there are relatively few who will doubt that China can attain its proposed gross domestic product (GDP) of \$4 trillion and a per capita GDP share of \$3,000, by 2020.

From 1978 to 2004, China witnessed an average economic growth rate of 9.4%/yr and became the world's sixth largest economy and the third largest trading nation, according to China news outlet *People's Daily Online* (http://english.peopledaily.com.cn). The problems generated by years of unrestrained and unfocused economic growth have been: a heavy reliance on foreign trade, which, according to government statistics, now constitutes 70% of the Chinese economy; a massive consumption of scarce, and increasingly imported, energy resources; and a widening gap between the rich and poor.

The central leadership also faces an uphill battle regarding the other major goal of the FYP — propagating more energy-saving, higher value-added industries as well as expanding the services sector. While accounting for only 4% of global GDP last year, China accounted for 12% of the global consumption of energy resources, 15% of water, 28% of steel, 25% of aluminum, and 50% of cement. The new FYP stipulates that the industrial sector must reduce energy use by 20%. Yet even the state media admitted last year that Chinese factories had to consume 2.6 tons of standard coal for the creation of every 10,000 yuanRenminbi (RMB) or \$1,237 worth of GDP — just 7% less than the comparable figure assessed five years ago. Clearly, more reforms are needed to achieve the FYP's objectives.

## Foreign investment in full swing

Under the FYP, China will attempt to control the use of foreign investment and pursue growth in a fair, balanced and sustainable way. This task will be challenging particularly in the resins market. In this sector, "the nation lacks the capital necessary to scaleup production to adequate levels to meet domestic demands," according to Beijing-based market researchers at chinaccm.com. "It is inevitable that foreign capital will enter the industry," they say. Further compounding the problem, China's past practices of encouraging foreign businesses to set up wholly owned or joint-venture enterprises with domestic companies have left the impression that homeland firms without a foreign business partner will not survive.

Today, numerous foreign investors are taking a big interest in the resins sector to enhance their portfolios and heighten their presence in the expanding Chinese marketplace. One of the more aggressive investment strategies is that of Royal DSM N.V. (Heerlen, Netherlands; www.dsm.com), which acquired coating resins producer Syntech, Inc. (Shunde, China; www.syntech.com), in October. The purchase of Syntech follows DSM's takeover of NeoResins (now DSM NeoResins) in February of this year and will enable DSM to become one of the leading industrial coating resins suppliers in China.

Meanwhile, BASF AG (Ludwigshafen, Germany; www.basf.com) commissioned its amino resins plant in Pudong, Shanghai, China. The company has particularly ambitious goals for China, notes Johnny Kwan, managing director of BASF Greater China. "By 2010, BASF plans to achieve 70% of sales from locally produced products. The amino resins plant will play an important role in realizing these goals," he says. BASF's amino resins are marketed under the trademark Luwipal and are used in the manufacture of baking finishes and paints.

Another case in point is Nanjing Yangzi Eastman Chemical Ltd. (NYEC; Nanjing, China), a joint venture between Eastman Chemical Co. (Kingsport, TN; www.eastman.com) and Yangzi Petrochemical Industrial Corp. (YPIC; english.sinopec.com). NYEC is boosting its hydrocarbon resin capacity by 30% to meet the growing demands for this product in the Asia Pacific region and most notably in China. When this expansion is brought on line in May 2006, it will increase NYEC's output of hydrocarbon resins from 40 million lb/yr to 52 million lb/yr.

Sino-Japanese tensions are not thwarting Japanese investments in China, which have reached "enormous levels" say analysts. This is evidenced by San-Dia Polymers Ltd.'s (SDP; Tokyo, Japan; www.sanyo-chemical.co.jp) opening of a $24 million chemical plant in the Nantong Development Area (Jiangsu province, China). SDP, a subsidiary, of Sanyo Chemical Industries, Ltd. (Osaka, Japan; www.sanyo-chemical.co.jp) launched the 20,000-ton/yr million operation through San-Dia Fine Chemical Products to produce and sell a strong water-absorbing resin, which can be used as a hygienic material for the production of paper diapers, as well as a raw material in the agricultural, construction and electronics sectors.

Mitsui Chemical Co. (Tokyo; www.mitsui-chem.co.jp) is putting its stake in the ground by partnering with China's Sinopec Co. (Shanghai; www.sinopec.com). The new enterprise, a 50:50 joint venture called Shanghai Sinopec Gaoqiao Mitsui Chemical Co., has invested a total of $100 million to build a 120,000-ton bisphenol A (BPA) project in the Shanghai Chemical Industry Zone. BPA is the main ingredient used to produce epoxy resin and polycarbonate resin. For raw materials, the BPA plant will use all the phenol acetone produced at its 200,000-ton/yr dedicated installation, also located in the Shanghai Chemical Industry Zone.

**Innovation is key**

"In the next five years, China plans to place more emphasis on science and technology in policy and investment," says Ding Yuanzhu, a researcher at the economic and social development research institute under the National Development and Reform Commission. There are about 140 foreign-owned R&D centers in Shanghai now, and as many as 700 across the country. Meanwhile, the Chinese government, top research institutes like the Chinese Academy of Sciences, and Chinese businesses are combining forces to boost China's spending on R&D, which is presently about 1.3% of its GDP. The U.S., by contrast, spends about 2.6%, and Japan about 3.2%, notes the Organization for Economic Cooperation and Development. "That puts China in the game, but not as a dominant player, just quite yet," says Robert Haak, the Tokyo-based general manager of the Asian Technology Information Program. Haak estimates it will take about 10–20 years before China is a scientific powerhouse that dominates any area in the global market.

Laboratory by laboratory, China — and more specifically Shanghai — is proving to be a hot spot for polymer research and innovation. Bayer MaterialScience AG (Leverkusen, Germany; www.bayermaterialsscience.com) has just opened a new facility there to host technical development and research capabilities for its four regional business units, including polyurethanes; polycarbonates; coatings, adhesive and sealants; and thermoplastic polyurethanes. Another recent inauguration was Eastman's China Lab, which will support the development of new formulations and performance-enhancing applications for the firm's North Asia-based customers.

Shanghai is also where Ciba Specialty Chemicals (Basel, Switzerland; www.cibasc.com) debuted its $20 million R&D center in April to serve the paints, coatings, plastics and polymer industries, and DSM opened an R&D site this past September.

Meanwhile, Rohm and Haas Co. (Philadelphia, PA; www.rohmhaas.com) plans to build a $30 million R&D facility in Zhangjiang Hi-Tech Park. The project could cost up to $60 million upon expansion.

If there's one lesson to be learned from China's history, it's that economic growth is not necessarily equivalent to economic development. "The 11th FYP focuses on the construction of a balanced market economy," says Hu Angang, an expert on macroeconomics at Qinghua Univ. "This will represent a historic adjustment to the pattern of five-year plans since China began its market-oriented economic reforms in the 1970s," he adds. CEP

## Olympian Impact on Beijing's Environment

As China continues its transformation to becoming a global industrial powerhouse, environmental concerns are becoming a top priority. However, this was not always the case. The 11th Five Year Plan emphasizes pollution control. Adding to the urgency is Beijing's role as the host of the 2008 Olympics. In fact, the Beijing Municipal Government has invested 14.08 billion yuan RMB ($1.73 billion U.S.) toward environmental protection.

Since becoming the host of the 2008 Olympics, the Beijing Municipal Government has been carefully monitoring air quality. In 2004, the number of days that air quality was equal to or above the national standard in the urban area reached 229, or 62.5% of the year. This is a 14.4% increase from four years ago. Furthermore, $SO_2$ density met the national standard for the first time in 20 years.

Measures that were taken to achieve these impressive results included converting over 80% of urban coal-fueled boilers weighing below 20 tons to the use of clean energy (the total consumption of natural gas was 2.5 billion $m^3$). As incentives, the government offered 400–600 million yuan RMB ($49 million to $74 million) as subsidies on coal-fuel boilers conversion. As further encouragement, water and electricity consumption taxation was exempted for the enterprises using new clean energy.

# Wireless Technologies Take Center Stage at ISA Expo 2005

Wireless was the catch phrase at the ISA 2005 Expo (Chicago, IL; Oct. 24–26). A prime motivation for the incorporation of wireless sensor links or networks, is eliminating the cost of deploying cables (~$2,400/m in a chemical plant). Applications may involve simply replacing wired connections between sensors and control systems in an on-facility substation, or in an application such as retrofitting hazardous materials or combustible gas sensors.

But, for all its advantages, there are also drawbacks. "Of particular concern is the security of the information channel and the powering of the wireless devices," says Richard Caro, chief executive officer of CMC Associates. (Acton, MA; www.cmc.us). Another inhibiting factor is the response times of the wireless units. "Customers whose processes require response times in the order of milliseconds or microseconds prefer wired solutions," says Hector Barresi, line manager for industrial wireless products at Honeywell Inc.'s Industrial Measurement and Control Group (Phoenix, AZ; www.honeywell.com).

For these reasons, customers are more likely to move sensing rather than control functions to wireless, at least for now. For one thing, control devices such as motors and valves tend to need power lines, obviating some of the advantages of wireless control. Where more sensors give greater visibility into a process, there is no clear advantage to having more control devices. Perhaps most telling, however, is the fear among users that wireless control, still an emerging technology, might fail and bring a line to a sudden halt.

That fear, however, is diminishing with time, says Barresi, who notes that 15% of the applications he serves with wireless technology include some level of control. "Since last year, we have noticed a tremendous turnaround," he says. "We find the market much more open." That's a trend he attributes to users who are, first, increasingly informed about the technology and, second, aware of its cost-saving benefits.

## Setting standards

Indeed, those benefits are getting easier to earn as the wireless industry moves increasingly to develop specifications and promote standards — moves that will ensure simple and successful installations as well as afford interoperability among devices from different vendors. One radio specification being embraced by some vendors is dubbed 802.15.4 (named after the IEEE working group). Seen as an alternative to Wi-Fi and Bluetooth wireless standards, 802.15.4 combines low-cost and low-power consumption. In addition, the IEEE-1451.5 committee and a group called the ZigBee Alliance are pushing their versions of specifications that address higher levels of the familiar OSI network model. Other developments in the technology of wireless networks, include the emergence of so-called mesh topologies, which promise higher reliability than star or point-to-point configurations.

Accutech Instruments, a division of Adaptive Instruments, Inc. (Hudson, MA; www.adaptiveinstruments.com) is setting its own standard with the development of a new wireless protocol that it calls the next generation of industrial wireless products. Launched at the ISA Expo, "version 2.0 of the Multi Vendor Protocol (MVP) suits all applications, except for critical control," notes Paul Nielsen, Accutech's chief technology officer.

Unlike other protocols, the MVP allows for increased range (up to 2 miles compared to 30 ft for Bluetooth and 300 ft for Zigbee) and longer battery life (20-yr shelf life). Furthermore, it employs frequency hopping spread spectrum (FHSS), the backbone of the military's communication security technique, which offers added security and ensures that noise interference at any one frequency does not block the communications.

As is becoming popular with proprietary protocol technologies, an OPC server will be included as a standard interface accepted by almost all third party applications. "The inclusion of the OPC server means that Accutech doesn't have to wait for a wireless standard to be issued in order to move forward with new products. The base radio now supports up to 150 field units and more than 100 base radios in overlapping zones for almost unlimited sensors per installation. Nielsen says that existing base radios can be connected to new base units to ensure that 20 is compatible with all existing installations. New features and products to be available soon include a fully redundant system in which multiple base radios are listening to all field radios for bump-free redundancy. "This network topology will generate significant cost savings over traditional one-to-one or one-to-many systems," he concludes.

For their part, users who want the advantages of wireless sensing and control are advised to work with vendors willing to lend their expertise by, for example, performing a site survey. Such a survey is needed to assess the impact of multipath, interference, and other radio effects. Other details that must be considered include cost, latency, application parameters, future changes to the factory floor layout, and even how often batteries will need replacement. In the meantime, those who wait too long for wireless technology to mature may find themselves behind the curve. CEP

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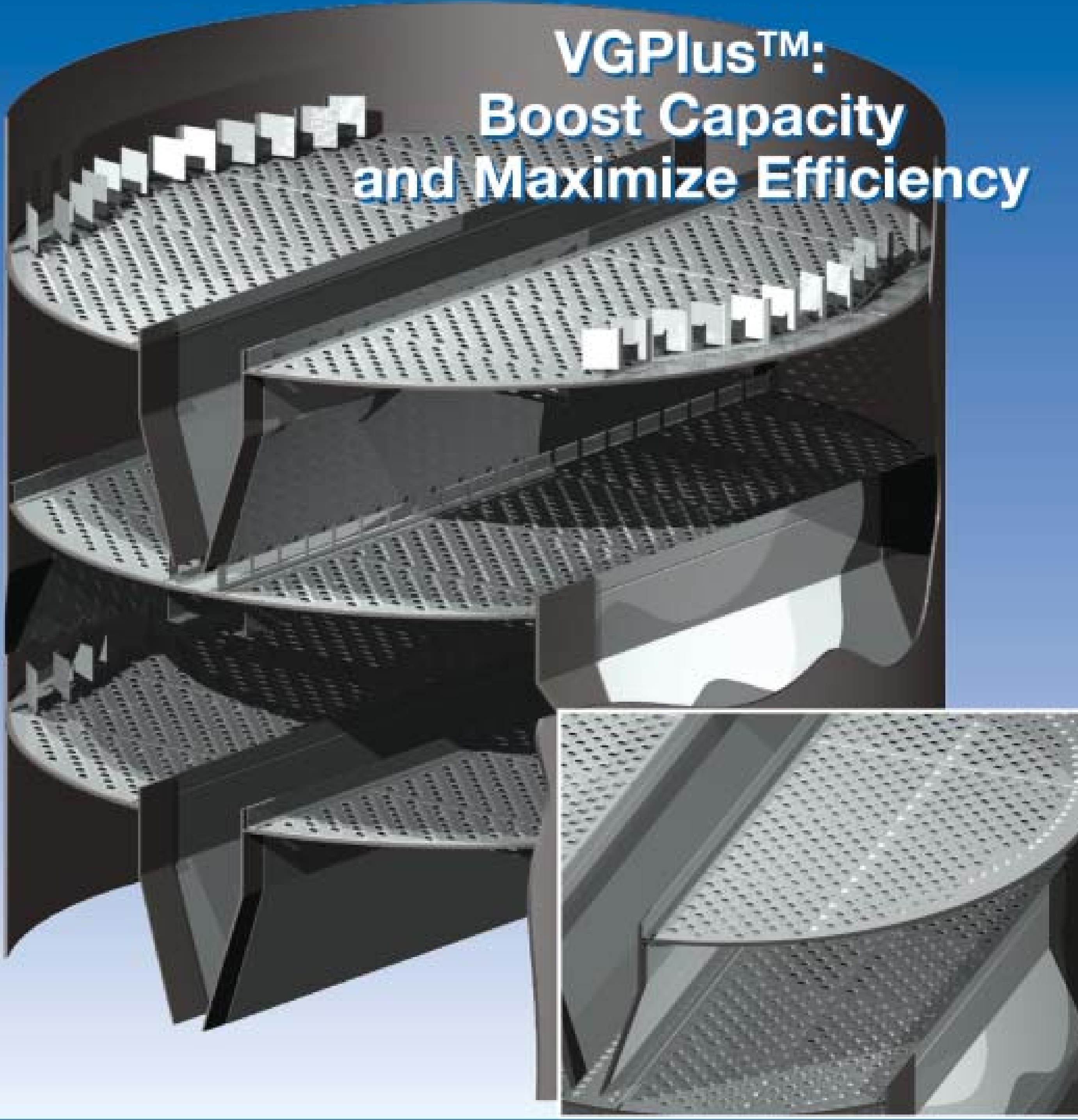

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# Renewed Interest in the Integrated Gasification Combined Cycle

The growing demand for electricity in the U.S. is fueling an interest in building new power plants. Although there is some activity in developing renewable resources, such as wind and solar energy, the more traditional energy sources are likely to be relied on for the majority of large increments in power generation. Yet, volatile natural gas prices, tightening emission regulations, and an abundant world coal supply provide an ideal backdrop for integrated gasification combined cycle (IGCC) to be a mainstream "clean coal" commercial offering.

Gasification is a commercially proven method of efficiently converting coal and other hydrocarbons into a clean gaseous fuel called synthesis gas (syngas) through a noncombustion, partial oxidation reaction. IGCC is the combination of gasification with a combined-cycle system to generate electricity. The total plant consists of four major operating components: an air separation unit (ASU); a gasification plant; a gas clean-up system; and a combined-cycle power plant (Figure). The ASU separates air into its component parts and sends the gasifier a stream of high-purity oxygen. The gasification plant then produces the syngas from a variety of fuels. Afterwards, the syngas can be cleanly burned in a combined-cycle gas turbine.

Although this technology has been available and proven for many years, a number of barriers have prevented it from entering the commercial mainstream, including cost and perceived performance challenges relative to other technologies, such as pulverized coal and gas-turbine combined cycle. Additionally, in order to construct an IGCC plant, energy providers have had to do business with multiple parties, including power equipment suppliers, gasification technology providers, and, typically, an engineering procurement contractor, and a construction contractor. However, this is all changing.

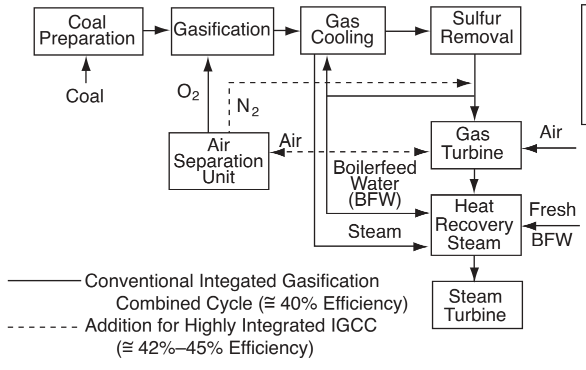



Figure. Schematic of an integrated gasification combined-cycle power plant.

## Turnkey IGCC

GE Energy, Inc. (Atlanta, GA; www.gepower.com), Bechtel Power (Frederick, MD; www.bechtel.com) and American Electric Power (AEP; Columbus, OH; www.aep.com) have taken critical steps toward construction of what would be "the first large-scale IGCC power plant built in the U.S. and the first IGCC plant to come online in the U.S. in nearly 10 years," says Dale Heydlauff, AEP vice president, New Generation. GE has formed an alliance with Bechtel to provide customers with a single-point responsibility for a turnkey IGCC plant providing everything from the coal feed to the power grid. GE will provide the technology design, development and system integration, while Bechtel will provide engineering, procurement and construction of the facilities. AEP, the plant owner and operator, has contracted with GE and Bechtel to conduct front-end engineering and design (FEED) for a proposed commercial, 629-MW IGCC facility slated for commercial startup in 2010.

The proposed GE-Bechtel Reference Plant will be based on the gasification technology GE acquired from ChevronTexaco in 2004. The combined-cycle-system model consists of two gas-turbine trains combined with a single reheat-steam-turbine generator. Each train comprises a 60-Hz gas-turbine generator and multipressure level heat-recovery steam generator (HRSG). Its performance when burning eastern U.S. bituminous coal at ISO conditions and zero feet elevation is given in the table above. "An important feature of the Reference Plant is its ability to handle a broad range of feedstocks," says GE engineer Allan Connolly. "An option to

**GE Reference Plant Design Basis**

| Source | Power Output, MW |
|---|---|
| Gas Turbine | 464 |
| Steam Turbine | 300 |
| Total Gross | 764 |
| Auxiliary Power | 135 |
| Net Power | 629 |
| Heat Rate (Btu/kWh, HHV ) | 8,844 |
| Coal Feed, ton/d (dry) | 5,372 |
| $O_2$ Feed, ton/d (pure) | 4,894 |

This data is based on an Illinois basin coal containing 3.23 wt.% sulfur and 12.25 wt.% ash, both on a dry basis. The coal heating value is 12,650 Btu/lb on a dry basis.

blend petroleum coke with coal is available to further broaden the range of IGCC feeds that are possible," he continues.

Currently, the syngas is cooled below 100°C for conventional cleaning, and it is subsequently reheated before combustion, a process that requires substantial heat exchange capacity. The HRSGs remove the heat from the gas-turbine exhaust gases and use it to superheat the saturated steam and economize the boiler feed water to the gasification unit's radiant syngas coolers. The total superheated steam from both HRSGs is fed to the steam turbine to generate power. The gas turbine is specifically configured to combust the clean syngas and is also integrated with the ASU. A portion of the ASU air requirement (about 40%) is supplied by extracting air from the compressor and using byproduct nitrogen to increase output energy and reduce $NO_x$ emissions.

GE is also developing state of the art computational fluid dynamics (CFD) and reactive flow modeling tools to understand the breakup and flow of particulates, and the heat transfer process within the radiant cooler. These accurate and validated models are the key to improving the design of its next-generation radiant cooling system.

A related issue is the ultimate destination of water purged from the syngas scrubbing system within the gasification unit. Water must be purged from this system to control dissolved species such as chlorides. The design offers evaporation of the process water purged from syngas scrubbing to provide a water stream for recycle and to minimize the discharge from the plant. This zero-process-discharge option has already been commercialized at Tampa Electric Co.'s (TECO) Polk Power Station, which produces enough electricity to serve 75,000 homes.

"For the Reference Plant design, we targeted a deep-sulfur removal level from the syngas (as low as 20 ppmv) to allow the option of including a selective catalytic reduction (SCR) catalyst section in the HRSG," says Connolly. This deep-sulfur removal target was a leading driver for the final selection of a physical solvent for the Acid Gas Removal (AGR). In addition, an activated carbon adsorption bed will remove 90–95% of the mercury (Hg) contained in the syngas. An SCR system would further reduce $NO_x$ in the gas-turbine exhaust gas to single digit levels, well under the limits established by the New Source Emissions Standards for coal plants.

Energy Northwest (Richland, WA; www.energy-northwest.com) is developing the first IGCC power plant for the Pacific region. Project manager Tom Krueger says that "IGCC is not only the lowest cost energy option, but the realistic, environmentally responsible option for producing large quantities of base load power at affordable rates.

The proposed design gasifies coal or petroleum coke to fuel combustion turbines and generates 300–600 MW. The estimated design and procurement cost for the power complex, named the Pacific Mountain Energy Center, is approximately $1 billion, including $35 million to make the facility compatible with potential future technologies to remove and capture $CO_2$ from the feedstocks.

The reliability, capital costs and environmental results of modern gasification technologies have been extensively documented. There are now over 10 IGCC plants operating in the world with one to two years of operating experience. The syngas produced from coal, petroleum coke or heavy liquids can be used to produce hydrogen, steam, transportation fuels and chemicals, or as a direct replacement for natural gas to produce power.

Of particular interest is the fact that IGCC plants can be designed to capture $CO_2$ and make it available for disposal. In a coal- or gas-fired power plant, $CO_2$ can only be removed after combustion, which is not economically practical. However, $CO_2$ may be removed before the syngas is fed to the gas turbines in IGCC plants. This is currently being done at gasification plants operating in refineries that remove $CO_2$ to obtain pure hydrogen.

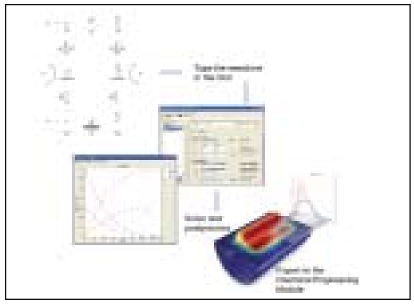
The next frontier for power generation technology will be to use gasification to produce hydrogen as the sole power plant fuel and capture $CO_2$ for disposal in deep underground reservoirs. It may be possible to use the hydrogen from an IGCC facility in fuel cells and have pure water as the only emission. This is the vision of FutureGen, a zero-emission coal-fueled power plant funded by the DOE. CEP

## SOFTWARE

### Speeding Up Complex Modeling

The intricacies of modeling drug delivery within the human body can result in long hours spent in front of a computer. Speeding the modeling process, Comsol unveiled its Reaction Engineering Lab software module at its Comsol Multiphysics Conference (Oct. 24–35; Cambridge, MA; www.comsol.com), which allows users to set up and solve such complex problems in a matter of minutes. "Enabling scientists to look at the 'big picture' and focus on the science, rather than on more routine mathematical calculations, the module performs the kinetics calculations that are often prone to human error," says Ed Fontes, product manager of Comsol. "By minimizing human error, it increases the speed of model development and encourages users to experiment more and try different variations on their processes," he continues.

The new software module features a state-of-the-art solver (DASPK) developed by Professor Linda Petzold of the Univ. of California, Santa Barbara). Its easy-to-use graphical user interface enables users to describe problems in a straightforward manner by simply entering the chemical-reaction formulas as they would write them on a piece of paper. The software then sets up the corresponding kinetics, material and energy balances using the mass-action law or user-defined expressions. During this process, thermodynamic and transport properties of reacting mixtures can also be calculated. The end result of these computations is a plot or tabular output of the system behavior (Figure).



The Reaction Engineering Lab module can be used in applications including chlorine removal from off-gas, pharmaceutical development, chemical vapor deposition, and more. It can be used as a standalone package, or used in combination with Comsol's Multiphysics and Chemical Engineering software modules.

## R&D UPDATE

### Biocatalytic Route to 'Sweet Silicones'

Organosilicon-sugar conjugates (OSC), also known as "sweet silicones," can be used as surfactants, adhesion promoters, and chiral templates, according to researchers at Polytechnic University (Brooklyn, NY; www.poly.edu). The synthesis of OSCs often requires an acid or base catalyst, protection-deprotection steps, and activation of carboxylic acid terminal groups on the siloxane starting material, but uncontrolled side reactions and poor regioselectivity have impeded the ability to control the structure of the resulting compounds, says project leader. Richard A. Gross. Working with colleagues at Dow Corning, Polytechnic researchers considered that enzyme catalysis might circumvent these problems. To test their hypothesis, they used *Candida antarctica* lipase B immobilized on acrylic beads (Novozyme 435) to catalyze esterification of dimethylsiloxane oligomers containing carboxylic acid end groups with ethyl glucoside. The resulting conjugates were prepared in a solventless one-pot reaction at 70°C for 36 h with high regioselectivity and in moderate yields. "This greener, simplified route should allow a more diverse set of sweet silicones to be prepared," says Gross.

## OPEN ENERGY FORUM HIGHLIGHTS THE AICHE ANNUAL MEETING

More than 200 chemical engineers took time on Sunday, October 30th, to share their ideas for the ways in which AIChE and their profession can address the world's energy challenges. Suggestions covered technologies from biomass to nuclear to hydrogen to photovoltaics, and covered topics from education to advocacy to research. These views were expressed at an open forum on energy held in Cincinnati in conjunction with AIChE's Annual Meeting. The forum was co-hosted by AIChE's Commission on Energy Challenges, chaired by Amos Avidan of Bechtel Corp., and AIChE's Assembly of Fellows, chaired by John O'Connell of the University of Virginia.

Members of AIChE's Commission on Energy Challenges (left to right) James Smith, Amos Avidan, John Chen, Jeff Siirola and Dale Keairns express opinions on critical energy issues.

One over-riding theme to emerge was that AIChE, with its technical expertise, should provide a neutral ground for methodically exploring energy options, and for sifting through the conflicting analyses that sometimes characterize the energy debate. Another idea that surfaced was for AIChE to adapt its model of the Center for Chemical Process Safety or Design Institute for Physical Properties and launch a research effort on behalf of a consortium of companies. The focus of such research could be optimizing the companies' energy usage and identifying potential feedstock alternatives.

There were a number of international attendees on hand, and they felt that there is a perception abroad that the U.S. is not doing much to address energy and global climate concerns. One attendee reported on European advances in biomass, and said that U.S. engineers rarely participate in conferences there. Some U.S. attendees questioned whether the world has the wherewithal to grow both food and fuel, with one quipping that, "if we reduce the number of cattle, we can free up land for biomass, but we'll all have to become vegetarians."

There was a great deal of sentiment that AIChE should do more to educate the public about energy issues. Speakers pointed to nuclear and waste-to-energy options as ones that face perception obstacles, instead of technical ones. There was also a sense, however, that AIChE is not equipped to undertake, on its own, any major educational initiatives that would have broad public impact. One student attendee said that we should also educate engineers about policy, as well as policy-makers about technology.

Avidan wrapped up the meeting by assuring attendees that the Commission will look at supply and demand equally, use a systems approach, address global issues, and look at unconventional energy sources and renewables.