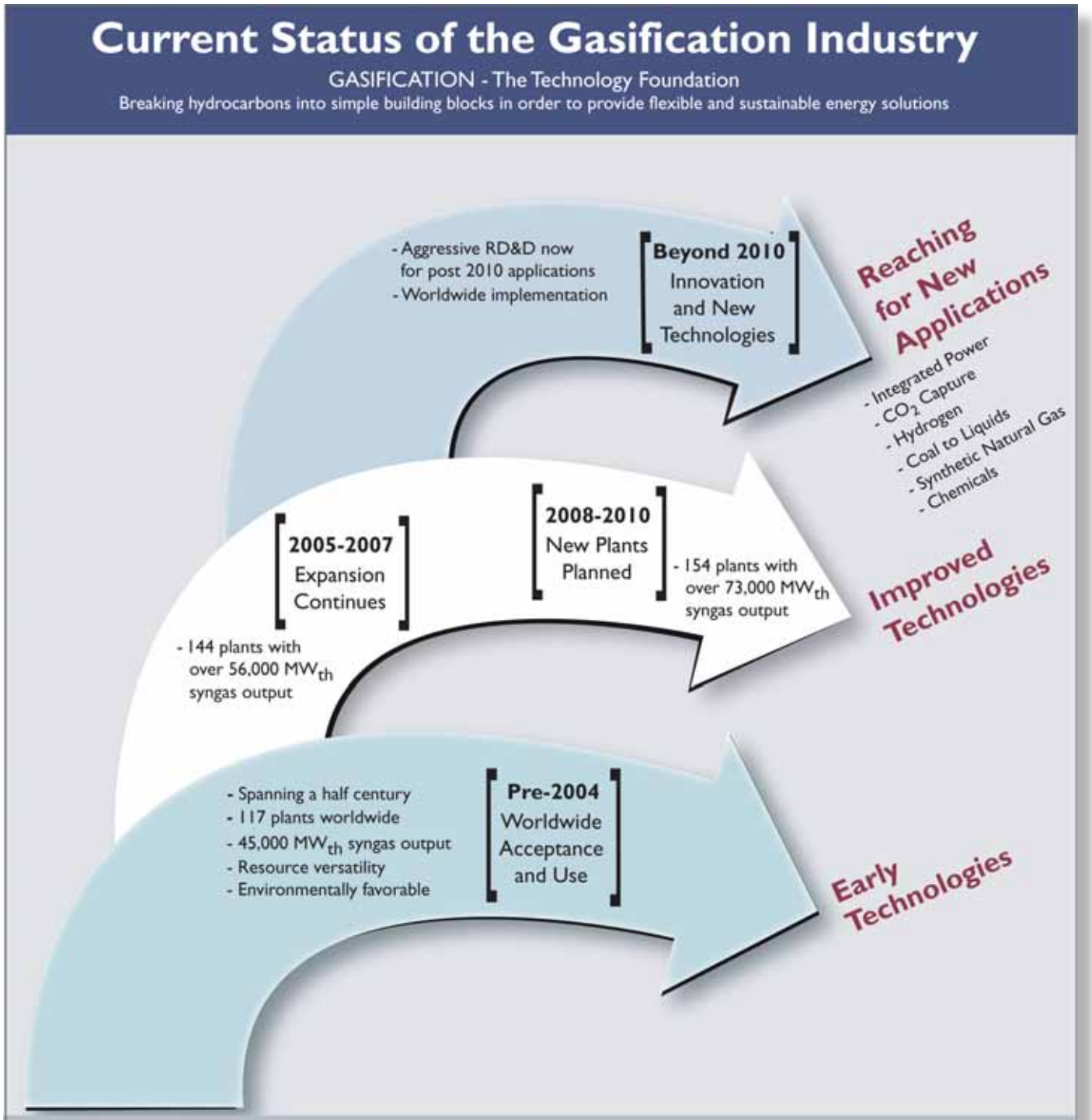
U.S. Department of Energy • Office of Fossil Energy
National Energy Technology Laboratory

# Gasification World Database 2007

## Current Industry Status

*Robust Growth Forecast*




The National Energy Technology Laboratory (NETL) within the United States Department of Energy (DOE) commissioned the first world gasification database in 1999, followed by updates in 2001 and 2004. This latest database updates those prior efforts and provides credible, timely information regarding the state of the world gasification industry today. Conducted in early 2007, the database provides a profile of current operating gasification plants, construction plans for new plants projected from 2008 to 2010, and information on trends and drivers affecting the growth of the industry.

# SUMMARY

*Upward worldwide growth trend continues for gasification.*

The United States Department of Energy (DOE) sponsored the 2007 World Gasification Database to accurately describe the current world gasification industry, to identify near-term planned capacity additions, and to keep the global gasification community apprised of current industry trends and drivers. This 2007 database builds on the initial 1999 worldwide database and the 2001 and 2004 updates.

## A Dynamic Global Marketplace

Gasification is being increasingly viewed as a technology foundation—a means to convert coal and other carbon feedstocks into clean hydrogen and carbon monoxide, which are in turn used to create a variety of value-added products for the global economy. Its use in over two dozen industrialized countries and the diversity of its products—electricity, chemicals, hydrogen, synthetic or substitute natural gas (SNG)—illustrate the enormous potential for the continued growth of the gasification industry.

Moreover, the global marketplace for gasification continues to be a dynamic, changing environment. Growth in gasification capacity is particularly high in China where 21 plants have come online during the past three years. Rapid economic growth there has driven huge demand for gasification to produce chemicals and fertilizers from that nation's vast coal reserves. The world's largest gasification plant fueled by natural gas is being built in Qatar to produce clean transportation fuel and will be 10 to 20 times larger than other facilities worldwide. All recent gasification plants built in Japan, Brazil, and the Czech Republic as well as plants planned near-term for Italy and Poland are focused on power generation. In India, a new gasification facility will be used for chemical production. Gasification capacity growth has been slow in the United States; however, the industry there is poised for substantial growth if construction of several new facilities occurs as planned over the next 5 to 10 years.

The continuing dominance of coal as the primary feedstock for gasification plants continues, evidenced by its use at 85 percent of the gasification plants built during the last three years and its planned use in roughly three-quarters of new plants during 2008 to 2010. Technology positions in the industry also continue to evolve, as Shell (15 plants) and GE Energy (8 plants) provided gasifiers for 23 of 26 plants over the last three years, although only Shell gasifiers are projected for the 10 new plants planned during 2008 to 2010.

## The 2007 World Gasification Industry

The 2007 World Gasification Database shows that current gasification capacity has grown to 56,238 megawatts thermal ($MW_{th}$) of syngas output at 144 operating plants with a total of 427 gasifiers (operating plus spares). This includes plants scheduled to start up by the end of 2007. Key characteristics of this global syngas capacity are described below:

- **Regional distribution:** Gasification plants are now operating in 27 countries. The Asia/Australia region, with 34 percent of the total capacity, is now the leading region in the world for syngas production. Rapid growth in China is fueling this surge. In the three-year period since the 2004 database, the Africa/Middle East region has moved to second position, declining from 34 percent to 27 percent of total capacity.

- **Feedstock distribution:** Coal has increased its leading position as the predominant gasifier feedstock, now accounting for 55 percent of syngas capacity generated from all feedstocks, compared to 49 percent in 2004. As Exhibit 1 shows, a total of 212 operating gasifiers—nearly 50 percent of the industry total—use coal as the primary feedstock. Petroleum now provides 33 percent of feedstocks, with the remaining 12 percent coming from natural gas, petcoke, and biomass/wastes.

- **Product distribution:** Synthesis gas is the primary product of operating gasification plants. However, other marketable products are generated from this "syngas," including chemicals (45 percent), Fischer-Tropsch (F-T) liquids (28 percent), power (19 percent), and gaseous fuels (8 percent). Chemicals improved its leading position from 37 percent in 2004 while F-T liquids declined from 36 percent.

- **Technology distribution:** Three commercially-proven technologies continue to dominate the 2007 world market: Sasol Lurgi technology accounts for 34 percent of the

*Exhibit 1. 2007 Summary of the Gasification Industry*

| Feedstock | | Operating 2007 | Planned 2008-2010 | Totals |
|---|---|---|---|---|
| Coal | $MW_{th}$ | 30,825 | 4,690 | 35,515 |
| | Gasifiers | 212 | 10 | 222 |
| | Operating Plants | 45 | 7 | 52 |
| Petroleum | $MW_{th}$ | 18,454 | 620 | 19,074 |
| | Gasifiers | 145 | 3 | 148 |
| | Operating Plants | 59 | 1 | 60 |
| Gas | $MW_{th}$ | 4,345 | 10,936 | 15,281 |
| | Gasifiers | 41 | 18 | 59 |
| | Operating Plants | 22 | 1 | 23 |
| Petcoke | $MW_{th}$ | 1,441 | 889 | 2,330 |
| | Gasifiers | 8 | 3 | 11 |
| | Operating Plants | 5 | 1 | 6 |
| Biomass/Waste | $MW_{th}$ | 1,174 | | 1,174 |
| | Gasifiers | 21 | | 21 |
| | Operating Plants | 13 | | 13 |
| **Total $MW_{th}$** | | 56,238 | 17,135 | 73,373 |
| **Total Gasifiers (Operating plus spares)** | | 427 | 34 | 461 |
| **Total Operating Plants** | | 144 | 10 | 154 |

reported production capacity, GE Energy is at 31 percent, and Shell is at 28 percent. The market share for Shell increased strongly from 19 percent in 2004, owing to its significant involvement in China.

## Planned Growth During 2008 to 2010

The current database shows an additional 10 plants with 34 gasifiers to become operational between 2008 and 2010. The majority of the plants—seven of 10—will use coal as the feedstock. The additional capacity from all new plants from 2008 to 2010 is 17,135 $MW_{th}$, an increase of over 30 percent. If this growth is realized, worldwide capacity by 2010 will be 73,373 $MW_{th}$ of syngas capacity, from 154 plants and 461 gasifiers (including spares).

- **Regional distribution:** From 2008 to 2010, the Africa/Middle East region will lead the world's regional growth with 64 percent of total planned capacity growth, all due to the Pearl gas-to-liquids (GTL) project in Qatar that will produce F-T liquid fuels from natural gas. Another 27 percent of the growth will originate from the Asia/Australia region, with China leading this increase. Plans for new gasification plants in North America—just 9 percent of the 2008 to 2010 total—have slowed due to factors such as high capital costs, legislative and regulatory uncertainty regarding carbon capture, natural gas prices, and the economy.

- **Feedstock distribution:** Natural gas will be the feedstock of choice for 64 percent of capacity growth planned for 2008 to 2010, due entirely to the one extremely large 10,936 $MW_{th}$ GTL plant Qatar plans to build. This natural gas plant with 18 gasifiers (Exhibit 1) reveals a significant anomaly regarding planned industry capacity growth. By contrast, coal will be the popular choice as feedstock for seven of 10 new plants, primarily due to the six coal-based plants to be built in China, five of which will produce chemicals.

- **Product distribution:** With 69 percent of planned capacity additions during the next three years, F-T liquids will significantly improve its product position by 2010. The GTL plant in Qatar alone will produce 140,000 barrels per day of distillate liquids. As the former product leader in 2004, chemicals will still be produced from 22 percent of the capacity additions. Power will be produced from the remaining 9 percent of capacity additions.

- **Technology distribution:** The 2007 database indicates that Shell gasification technology will be used at all 10 plants (34 gasifiers) built between 2008 and 2010. If this growth is realized, Shell will then account for nearly 45 percent of the market syngas capacity by 2010 (largely on the basis of the natural gas conversion facility to be built in Qatar), compared to its 28 percent market share in 2007 and 19 percent share in 2004. With no new installations, Sasol Lurgi (dry ash) technology is projected to slip from a 34 percent market share in 2007 to 26 percent in 2010. While project orders are being announced, no new GE Energy or ConocoPhillips E-Gas gasifiers are projected for start-up from 2008 to 2010.

## Changes and Drivers

Current industry syngas output has increased by 25 percent since 2004—and by 32 percent since 1999. This growth is being driven primarily by new plants in China that are designed to convert coal and petroleum waste to chemicals and fertilizers. Additionally, current gasification plants in Italy, the Czech Republic, and Brazil as well as new plants planned for Poland and Italy are being built to generate power. Canada's first gasification-based facility began start-up operations in 2007 and will focus on oil sands production. Growth of gasification plants in the United States over the past three years has been hampered by high construction costs, comparatively higher costs for electricity generation, the uncertainty of environmental regulations mandating carbon capture and storage, and a resurgence of anti-coal sentiments, irrespective of the environmental benefits of clean coal technologies. However, 50 projects—including power generation, coal-to-liquids (CTL), chemicals, fertilizers, and coal-to-SNG facilities—are planned for U.S. operation beyond 2010.

*"Coal is our most abundant source of energy. It will help lead us to a stable, secure energy future at a time when we know our economy's appetite for electricity will grow. And it will help us safeguard our skies and rivers and other environmental treasures."*

— Samuel W. Bodman, Secretary of the U.S. Department of Energy

*Secretary Bodman participates in the 10th International Energy Forum in Doha, Qatar, in April 2006 to discuss energy security issues on a panel with other world energy leaders.*

*At 330 MW capacity, the Puertollano power plant in Spain is the world's largest coal-based IGCC plant. It is owned and operated by the ten-company ELCOGAS consortium.*

*The Nuon Power Buggenum IGCC plant gasifies a combination of coal and biomass/wastes using the Shell Coal Gasification Process. Located in the Netherlands, the 253 MW plant started up in 1993 as the Demkolec IGCC demonstration and completed that program phase in 1998. Nuon Power Buggenum purchased the plant in 2001 and began testing various coal/biomass feedstocks.*

*Sasol operates two gasification plants in South Africa that use low-grade coal to produce Fischer-Tropsch liquids and chemicals.*

# INTRODUCTION

*The 2007 World Gasification Database characterizes the current world gasification industry and describes near-term planned capacity additions.*

The 2007 World Gasification Database was completed by Childress Associates in collaboration with members of the Gasification Technologies Council and the DOE National Energy Technology Laboratory (NETL). Funded by DOE, this database provides easy access to an accurate, centralized source of information on the global gasification industry. Based on publicly available information, the database includes owners and/or operators of gasification-based power and manufacturing plants, major gasification technology vendors, and suppliers of supporting technologies. Consistent with prior databases, only commercial operating plants with a capacity exceeding 100 megawatts electric equivalent ($MW_e$) were included in order to avoid listing pilot test and temporary facilities as contributors to the commercial experience database. However, all feedstocks (i.e., coal, petroleum residues, secondary materials, biomass, and other carbonaceous materials) were included if the facility in question met the minimum capacity requirement.

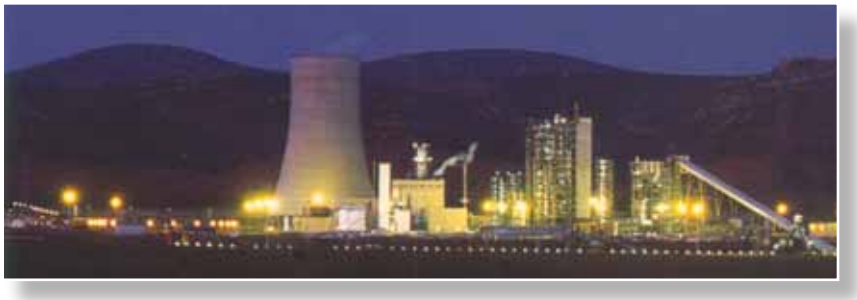
This database classifies plants based on their status as development, engineering, construction, start-up, or commercial operating. However, for purposes of summarizing and reporting industry syngas capacity, this brochure identifies two broad categories of plant capacity—Operating and Planned. Operating plants includes those projects in either start-up or commercial operating status. Planned projects are those that have been publicly announced; are in development, engineering, or construction stages; and have received some substantial commitment to the project. Non-operating plants are excluded from the industry syngas capacity figures. Minor adjustments were made to the database as appropriate to account for the closing and re-categorization of gasification plants.

Since gasification plants use a variety of feedstocks and generate several different types of products, a direct comparison of the facilities included in the 2007 database would have been difficult. To address this issue, megawatts thermal ($MW_{th}$) of syngas output—a measure of the production capacity of synthesis gas—is used as the common basis of reporting, accumulating totals, and comparisons. For purposes of comparison, the reported 2007 world syngas capacity of 56,238 $MW_{th}$ is roughly equivalent to 29,000 $MW_e$. Determining an equivalent product capacity generally depends upon differing assumptions for the variety of processing technologies used downstream of the gasifier. While English units are used throughout this brochure, the Glossary contains conversion factors for metric units.

This brochure is presented in four key sections:

- Syngas Production in 2007
- Growth Planned Through 2010
- Recent Industry Changes
- Beyond 2010—Strong Growth Anticipated in the United States

*Gasification has been important since the mid 1950s in South Africa when the original plant was built using fixed bed, dry bottom gasifiers.*



*The Puertollano power plant in Spain uses Uhde Prenflo technology to gasify a mixture of coal and petroleum coke feedstocks.*

# SYNGAS PRODUCTION IN 2007

*South Africa remains the dominant syngas-producing country in the world. Its Sasol plants account for 27 percent of world gasification capacity. However, with its substantial growth in recent years, China now has 44 operating gasification plants with about 24 percent of the worldwide capacity.*

The database results presented below show the state of the gasification industry in 2007 by geographical region, feedstock, product, and technology.

## Syngas Capacity by Region

The 2007 World Gasification Database found that existing world gasification capacity has grown to 56,238 $MW_{th}$ of syngas output from 144 operating plants and 427 total gasifiers (operating plus spares). Plants scheduled to start up by the end of 2007 are included. Based on current operating plants, Asia/Australia is now the leading region in the world, followed by Africa/Middle East. The European region—including both Western Europe and Eastern Europe (former Soviet block countries)—is the third largest, followed by North America. Central/South America has very limited existing capacity. In 2004, the size ranking was Africa/Middle East, European, Asia/Australia, North America, and Central/South America.

### Asia/Australia

As shown in the "Region" chart (Exhibit 2), the Asia/Australia region has a 34 percent share of the present world gasification capacity, with a syngas capacity of 18,864 $MW_{th}$. Countries with gasification-based capacity in the Asia/Australia region include:

- Australia—one natural gas plant produces chemicals.
- China—44 operating plants now convert coal and petroleum residues into a variety of chemicals, fertilizers, and gaseous fuels. Of these plants, 22 use GE Energy gasifiers, 18 use Shell, three use Sasol Lurgi, and one uses GTI. Also, 30 of these plants use coal as feedstock, 13 use liquid feedstocks, and one uses natural gas. No gasification-based power plants are currently operating in China despite the abundance of gasification facilities; however, the Fujian IGCC is now in construction.
- India—five petroleum-based plants produce chemicals and fertilizers and one lignite/petcoke plant produces electricity.
- Japan—five plants with petroleum, petcoke, and coal feedstocks produce chemicals. Two plants—one petroleum and one coal—produce power. Nippon Petroleum Refining Company built the first power-producing plant in 2003 at their Negishi refinery. Using coal as the feedstock and a Mitsubishi-designed gasifier, the Nakoso Integrated Gasification Combined-Cycle (IGCC) plant is now in start-up operations.
- Malaysia—one natural gas plant produces F-T liquids. This plant is a forerunner to the planned Qatar facility that will use natural gas and produce F-T distillate liquids.
- Singapore—two petroleum residue plants produce chemicals and power.
- South Korea—three petroleum residue and naphtha plants produce chemicals and fertilizers.
- Taiwan—two petroleum residue and naphtha plants produce chemicals.

*The Nippon Petroleum Refining Company Negishi IGCC plant began operations in 2003. This is the first IGCC plant in Japan and gasifies 2,000 metric tons per day from the Negishi refinery in Yokohama.*

*The Brisbane $H_2$ Plant in Australia has been operating since 2000 and employs two GE Energy gasifiers with natural gas as the feedstock to produce chemicals.*

## Africa/Middle East

The Africa/Middle East region has a syngas capacity of 15,173 $MW_{th}$, a 27 percent share of the present world gasification capacity. Using 97 gasifiers or 23 percent of the world total, Sasol plants in South Africa produce clean fuels from coal. In Egypt, the Suez ammonia plant with three gasifiers began operation in 1966 using refinery residues and off-gases.

## Europe

The European region has a syngas capacity of 13,763 $MW_{th}$, a 24 percent share of the world gasification capacity. With 50 operating gasification plants, the European region is the most diverse in terms of feedstocks, technologies, and products. The most recently built European gasification facilities primarily use petroleum-based feedstocks, with the exception of two biomass-based plants in Finland, the Nuon Buggenum coal-based IGCC facility in the Netherlands, and the Puertollano coal/petcoke-based IGCC plant in Spain. A number of older coal and/or lignite gasification plants, primarily in Eastern Europe, are also still operating. European capacity distribution in 2007 is as follows:

- Czech Republic—one petroleum-based plant produces chemicals and two coal-based plants produce power.
- Former Yugoslavia—two plants (one coal-based and one using natural gas) are in operation and produce chemicals.
- Finland—three plants that began operation between 1983 and 2001 produce gaseous fuels and power and use biomass/wastes as their primary feedstock. The Oulu syngas plant began operation in 1965 and gasifies petroleum to produce chemicals.
- France—two natural gas plants produce chemicals.
- Germany—twenty-one plants are in operation (one coal-based, five using biomass and/or wastes, 14 petroleum-based, and one using natural gas), with 14 producing chemicals, one producing gaseous fuels, and six producing power.
- Italy—six plants are operating, with four new plants built from 1999 to 2006 using refinery residues as feedstock to generate electricity in combined-cycle plants and to produce hydrogen for refinery use. Two older plants built in 1958 and 1963 use natural gas to produce chemicals.
- Netherlands—three plants are operating. The Nuon Buggenum coal-based IGCC plant began operations in 1994. The second plant is a petroleum residue facility at the Shell Pernis Refinery in Rotterdam that began operations in 1997 and produces power, steam, and hydrogen for use in the refinery.

*The Sarlux IGCC at the Saras oil refinery in Sardinia is the largest operating IGCC to date, producing 550 MW of electric power. The plant also co-produces hydrogen and process steam from visbreaker tar. The plant completed start-up in 2000.*

*The Shell Pernis Refinery in Rotterdam uses the Shell Gasification Process to convert heavy refining residues into hydrogen for a hydrocracker as well as syngas for power generation. Three gasifiers process 1,650 tons per day of residues. First started in 1997, it has accumulated approximately 40,000 hours on syngas. This 115 MW IGCC plant automatically switches to backup fuels to maintain high reliability of the hydrogen and steam.*

- Portugal—one biomass plant produces gaseous fuels and one petroleum-based plant produces chemicals.
- Spain—one coal-based plant produces power and one natural gas plant produces chemicals.
- Sweden—two biomass plants produce power and gaseous fuels and one petroleum-based plant produces chemicals.
- United Kingdom—two natural gas plants produce chemicals.

### North America

North America currently has a syngas capacity of 7,722 $MW_{th}$, a 14 percent share of the world total. Virtually all of this activity resides in the United States, where 20 gasification-based plants are operating:

- Nine natural gas facilities primarily produce chemicals.
- Seven plants are fed by coal and/or petroleum coke. Four of these produce power, two produce chemicals and fertilizers, and one produces SNG. These include two IGCC power plants—Wabash River and Polk—built during the 1990s, the Eastman Chemical coal-to-chemicals plant, and the Basin Electric Great Plains plant, the only plant in the world producing pipeline quality gas.
- Four petroleum-based liquids plants produce chemicals or syngas for resale.

In Canada, the country's first gasification-based facility—the Long Lake Plant in Alberta Province, associated with oil sands production—began start-up operations in 2007. Hydrogen, steam, and power produced by the gasification plant will be used to produce and upgrade the synthetic crude oil extracted from the tar sands.

### Central/South America

The database results show that the Central/South American region significantly lags behind other world regions with a syngas capacity of just 716 $MW_{th}$, a 1 percent share of the world gasification capacity. Two petroleum-fed plants are currently operational in Brazil and the Dominican Republic, producing power, chemicals, and gaseous fuels.

## Syngas Capacity By Feedstock

Gasification facilities consume a variety of carbon-based feedstocks, including natural gas, coal, petroleum, petcoke, biomass, and industrial wastes. From the 2007 database, the "Feedstock" chart (Exhibit 3) shows that coal now dominates as the feedstock in 55 percent or 30,825 $MW_{th}$ of syngas capacity, which represents 45 plants. Petroleum (including fuel oil, refinery residue, and naphtha) is the second leading feedstock, with 18,454 $MW_{th}$ or 33 percent of total gasification capacity, representing 59 plants. Natural gas provides only 8 percent, with petcoke and biomass and/or waste offering about 2 percent each.

*Converted from natural gas in 2001, the Coffeyville Resources nitrogen plant in Kansas uses 1,000 tons per day of petroleum coke feedstock from an adjacent refinery to produce 700,000 tons of nitrogen fertilizer a year. Using the GE gasification process, the plant has remained competitive in the ammonia market while other U.S. ammonia plants have been shutting down due to high natural gas prices and foreign competition.*

*Operating since 2000, the ExxonMobil Baytown Syngas Plant in Texas is a 240 MW facility that produces both electricity and gaseous fuels. Petcoke is used as the feedstock for two GE Energy gasifiers at the plant.*

## Syngas Capacity by Product

The flexibility and versatility of gasification plants enable them to offer a wide range of products including F-T liquids, chemicals, fertilizers, power, steam, gaseous fuels, and various other products (e.g., ammonia and hydrogen). The "Product" chart (Exhibit 4) shows that, for operating plants identified in the 2007 database, chemicals and F-T liquids represent the leading products with 45 percent and 28 percent, respectively, of the world gasification capacity. Chemicals are generated at 103 plants and F-T liquids at four plants. Other products are power (19 percent) and gaseous fuels (8 percent). Power generation occurs presently at 26 gasification plants worldwide.

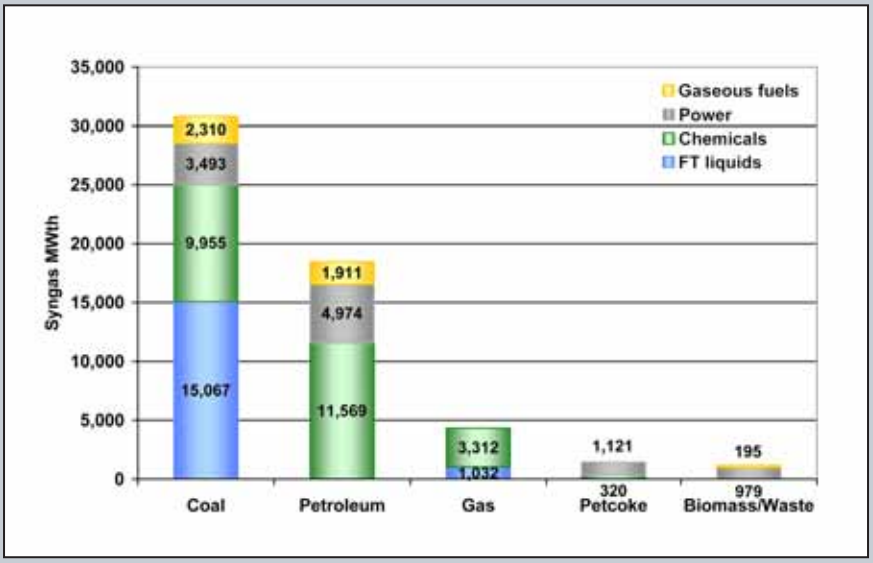
## Syngas Capacity by Technology

According to the 2007 database, at least 15 different gasification technologies are now in operation in plants around the world. However, three commercial technologies are currently dominant and hold 93 percent of the 2007 world market. As illustrated in the "Technology" chart (Exhibit 5), Sasol Lurgi (dry ash) gasifiers lead the way with 12 plants, accounting for 34 percent of world gasification capacity or 19,330 $MW_{th}$ of syngas output. GE Energy gasifiers are used at 72 plants, representing 31 percent (17,465 $MW_{th}$) of the total, and Shell gasifiers are used at 41 plants, representing 28 percent (15,637 $MW_{th}$) of total syngas output. The remaining 7 percent is spread among a dozen other gasification technologies.

### *The Relationship Between Gasification Feedstocks and Products*

As a diverse feedstock, coal is used to produce F-T liquids (49 percent) and chemicals (32 percent), for power generation (11 percent), and to produce gaseous fuels (8 percent). By contrast, petroleum is predominantly used to produce chemicals (63 percent) but also produces power (27 percent) and gaseous fuels (10 percent). Over 76 percent of natural gas production is used to provide chemicals, with the remainder going to F-T liquids. Petcoke and biomass and/or waste are primarily used for power generation.

*2007 Operating World Gasification Capacity – By Feedstock and Product*



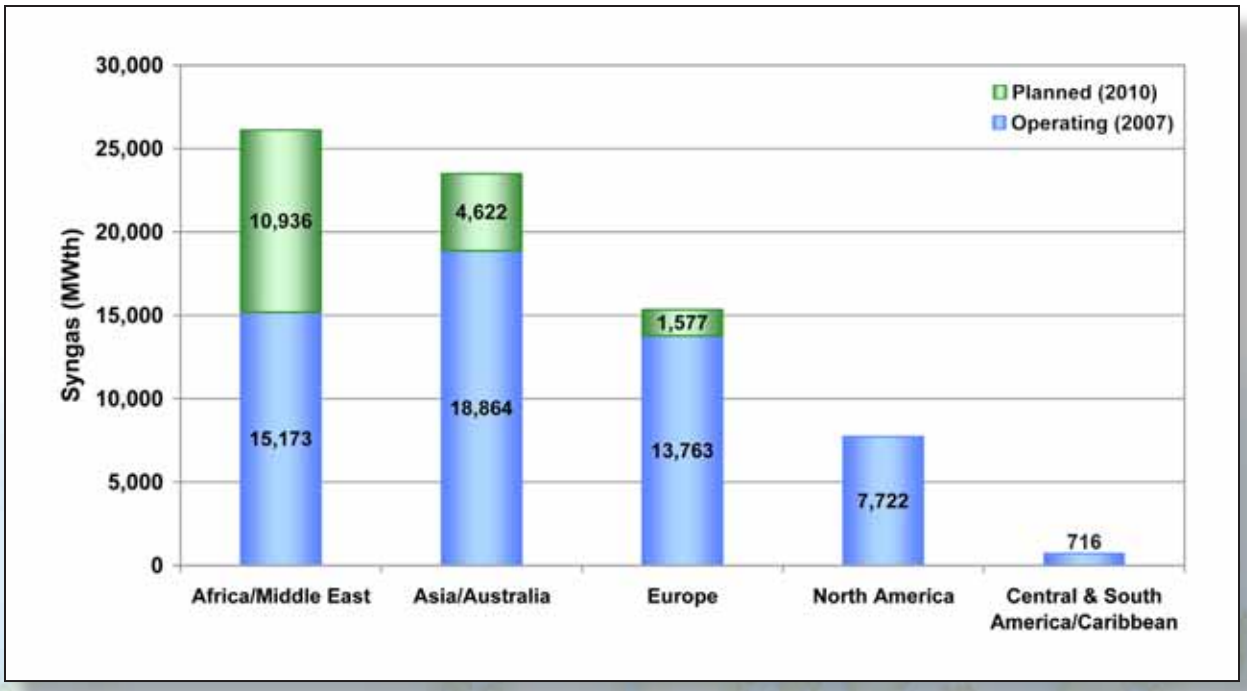



*Exhibit 2. World Gasification Capacity and Planned Growth – By Region*

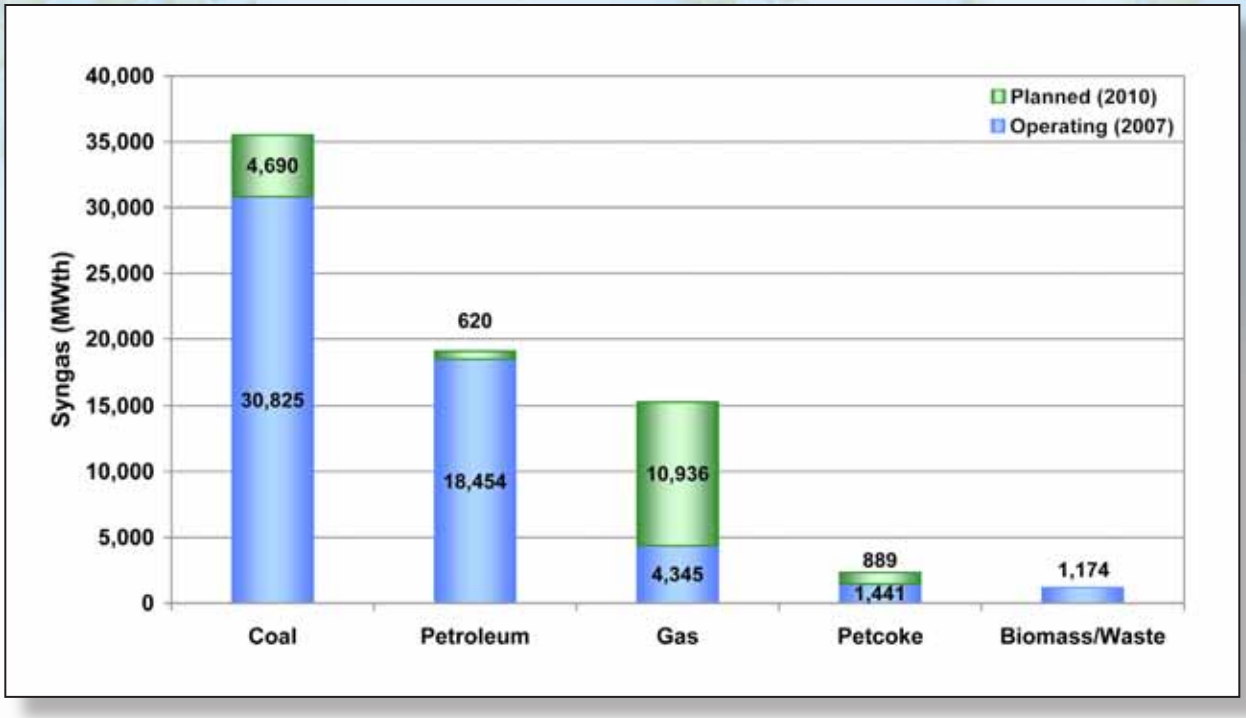



*Exhibit 3. World Gasification Capacity and Planned Growth – By Feedstock*

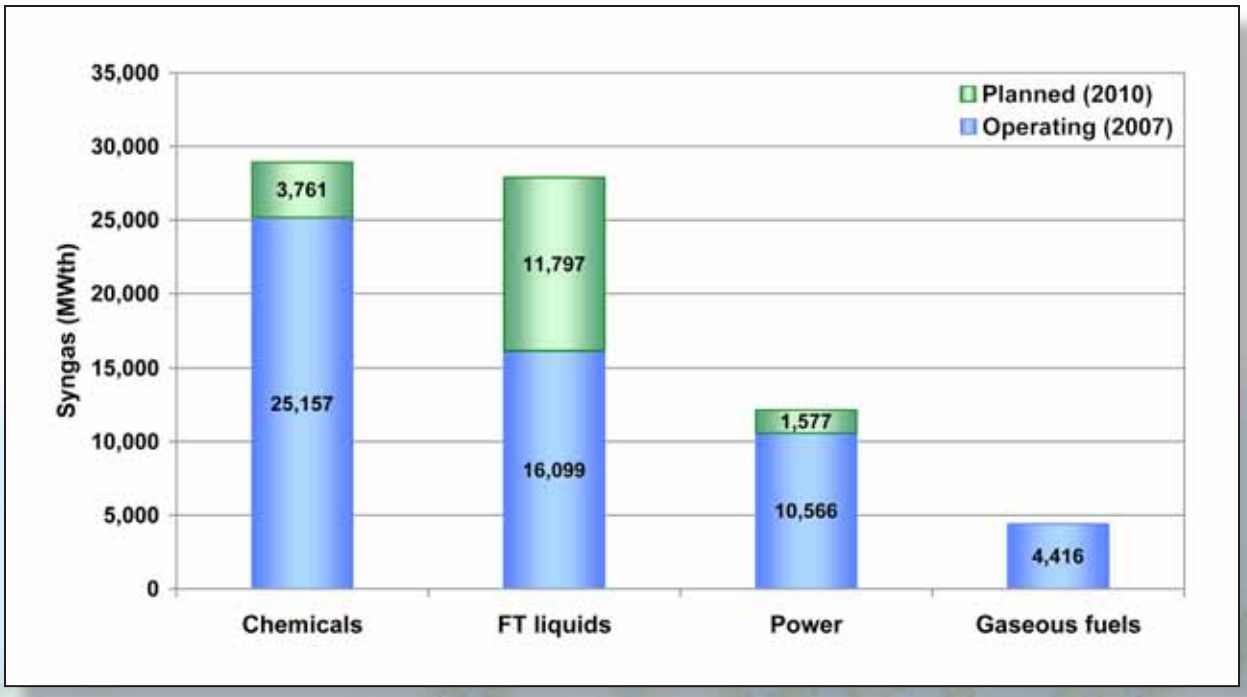



*Exhibit 4. World Gasification Capacity and Planned Growth – By Product*

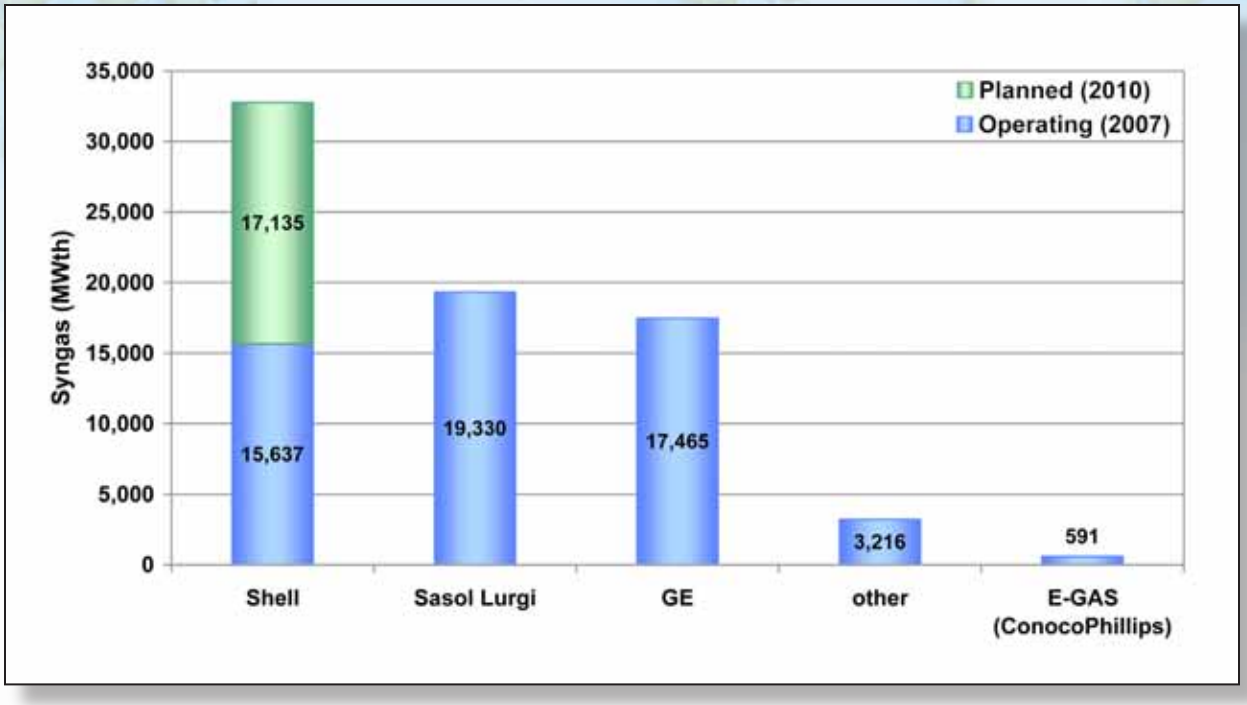



*Exhibit 5. World Gasification Capacity and Planned Growth – By Technology*

*The 262 MW Wabash River Repowering IGCC plant in Terre Haute, Indiana has been operating since 1995, initially as part of DOE's Clean Coal Technology Program. Using E-Gas technology, the plant has operated more than 15,000 hours, using both coal and petroleum coke feed during its demonstration stage.*

*"The IGCC plant here [at Wabash River] is the bigger of the two operating in America and demonstrates really where our future must be. We are going to actively pursue more plants like this that turn Indiana coal into natural gas that can be used in a state that is heavily dependent on natural gas for so many industrial purposes."*

Mitch Daniels, Governor of Indiana – August 2006

*"Coal gasification is central to our ability to offer Tampa Electric customers and the communities we serve a good balance of environmental responsibility, energy reliability, and economic sustainability."*

John Ramil, President and COO of
Tampa Electric Company – July 2007

*Operating since 1966, the Tampa Electric Polk Power Station is the second commercial U.S. IGCC plant built as part of the DOE Clean Coal Technology Program. In commercial operation since 2001, the Polk station generates 250 MW of electricity using GE gasification technology.*

*The Eastman Chemical Company "coal-to-chemicals" facility in Kingsport, Tennessee started up in 1983. With GE gasifiers that use 1,200 tons per day of Central Appalachian medium sulfur coal, the resultant syngas is used to make methanol, acetic acid, acetic anhydride, and methyl acetate. Sulfur compounds and ash are removed from the syngas.*

*"Our gasification technology is good for Eastman Chemical because it's an important part of our efforts to achieve a low cost position. It's good for the environment because the technology can minimize our carbon footprint when compared to traditional manufacturing processes. And it's good for the United States because we can use readily available domestic feed materials such as coal and petroleum coke which are less expensive and more stable when compared to oil or natural gas."*

Brian Ferguson, CEO of Eastman Chemical Company – July 2007

*Operating since 1984, the Dakota Gasification Great Plains Synfuels Plant uses Sasol Lurgi technology to gasify 14,000 tons per day of lignite to produce nearly 150 million standard cubic feet of substitute natural gas. The plant is the only commercial-scale facility in the United States to produce pipeline quality gas and is now also exporting up to 95 million cubic feet of $CO_2$ per day to Canada for enhanced oil recovery.*

# GROWTH PLANNED THROUGH 2010

*While six new plants out of the 10 planned worldwide will be in China, the largest regional growth rate occurs in Africa/Middle East, where a 72 percent syngas capacity increase is expected due to the exceptionally large Qatar facility. Fischer-Tropsch liquids, the specified product from the Qatar plant, will have the largest share of planned product growth at 73 percent.*

The 2007 database results show that, if all of the planned gasifiers are built, world syngas capacity is projected to grow by 17,135 $MW_{th}$, an increase of over 30 percent from 2008 to 2010. The nature of this increase is summarized below, broken down by region, feedstock, product, and technology.

## Syngas Capacity Growth by Region

The "Region" chart (Exhibit 2) shows planned growth in gasification capacity for each major region of the world from 2008 to 2010. Regional growth is led by Africa/Middle East, Asia/Australia, and Europe.

### Africa/Middle East

Capacity in the Africa/Middle East region is expected to grow by 72 percent from 2008 to 2010 based on the Shell GTL project in Qatar that will produce distillate fuel. Planned for operation by 2010, this project will use gasification technology to convert natural gas to synthesis gas and then use F-T conversion technology to produce clean diesel fuel. As a result of this exceptionally large plant in Qatar, the region will likely dominate gasification-based capacity in the near-term.

### Asia/Australia

Syngas capacity growth in Asia/Australia will be the second largest of all world regions, with new plant capacity plans for 2008 to 2010 totaling 4,622 $MW_{th}$—a growth rate for that region of 25 percent from its 2007 level of 18,864 $MW_{th}$. This growth will be comprised of seven plants that will gasify coal or petroleum coke. Six of the plants will be in China, all processing coal to produce chemicals, fertilizers, and methanol. One additional plant in the Asia/Australia region will be in India at the Paradip refinery where petroleum coke will be gasified starting in 2010 to produce power and hydrogen—a configuration similar to the Shell Pernis refinery in the Netherlands.

### Europe

European capacity is expected to grow by 12 percent from 2008 to 2010 with the addition of 1,577 $MW_{th}$ from two plants producing primarily power. One plant in Poland planned for 2008 will use refinery residues and/or asphalt for polygeneration of power, steam, and hydrogen. One IGCC facility planned in Italy for 2009 will use coal to generate electricity. No new plants are planned during 2008 to 2010 for any other European countries.

### North America

No new gasification plants are projected to come online in the North American region from 2008 to 2010. This continues the trend from 2005 to 2007 where no new plants were started in the United States and only one plant, the Long Lake Plant, began operations in Alberta, Canada. The Long Lake facility is the country's first gasification-based plant. Other oil sands-related gasification projects are in preliminary analysis

### *New Gas-to-Liquids Plant in Qatar*

Qatar Petroleum and Royal Dutch Shell announced a new world-scale integrated Pearl gas-to-liquids (GTL) project in Qatar in July 2006. The project will produce 140,000 barrels per day (bpd) of GTL products as well as 120,000 bpd of associated condensate and liquefied petroleum gas. The project will be developed in two phases, with the first phase operational in 2010 and the second phase completed one year later. By comparison, the existing Oryx GTL plant in Qatar which is operated by Sasol has the capacity to produce 34,000 bpd.

and planning stages in Canada. Given the expected strong growth in demand for syn-crude from oil sands, this is expected to be a strong future market for gasification. Several gasification projects are in development in the United States beyond 2010.

### Central/South America

No new capacity growth is expected in the Central/South American region through 2010 from its 2007 level of 716 $MW_{th}$.

## Syngas Capacity Growth by Feedstock

The "Feedstock" chart (Exhibit 3) illustrates expected growth in world gasification capacity based on feedstock distributions. Natural gas leads all feedstocks with 64 percent of the total planned growth from 2008 to 2010, based solely on the GTL plant in Qatar. Coal is second with 27 percent. Major new coal-based power plants are being projected at several locations in the United States but are not expected to start commercial operations until beyond 2010. These new coal-based IGCC power plants are anticipated at both greenfield and brownfield sites as indicated in the following section.

Petroleum residues and petcoke will provide about 9 percent of new capacity planned by 2010, although prospects are strong for additional growth from the Canadian oil sands industry. Growth in natural gas feedstocks will be exclusively from remote gas in the Middle East.

## Syngas Capacity Growth by Product

For planned growth between 2008 and 2010, F-T liquids will continue to account for the largest share of worldwide growth in gasification capacity, with 69 percent (11,797 $MW_{th}$) of the total. The "Product" chart (Exhibit 4) shows that chemical production is expected to account for 22 percent (3,761 $MW_{th}$) of planned growth in capacity. Power generation remains third at 9 percent (1,577 $MW_{th}$). No growth is planned for gaseous fuels.

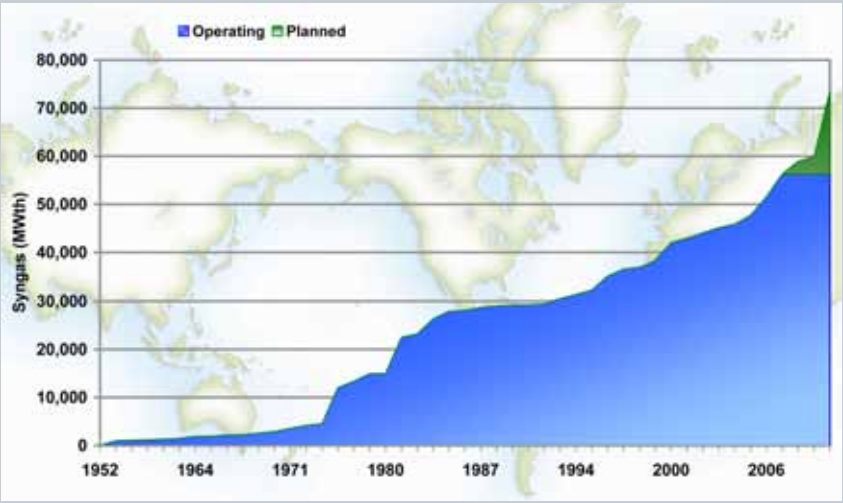
## Syngas Capacity Growth by Technology

As evident from the "Technology" chart (Exhibit 5), Shell is projected to achieve 100 percent (17,135 $MW_{th}$) of the planned growth in total syngas capacity during the period 2008 to 2010. Shell high-temperature, oxygen-blown, slagging entrained gasifiers will be used for the large F-T distillate liquids plant in Qatar, the coal-based chemical plants in China, and other power generation and chemical plants in Italy, Poland, and India. If this projected implementation of Shell technology occurs, Shell gasifiers will then account for 45 percent of the total world market by 2010, Sasol Lurgi will slip to a market share of 26 percent, and GE Energy gasifiers will decline to 24 percent of the world market.

### *More Than a Half Century of Growth for Gasification*

Gasifiers have been used since the early 1950s to produce fuels, chemicals, and fertilizers from a variety of low cost feedstocks, including coal and petroleum residues. The first significant increase in gasification use occurred in the 1970s and then again in the 1980s as a result of lower cost, less desirable feedstocks becoming more attractive alternatives to increasingly expensive petroleum and natural gas. Gasification saw even more robust growth in the 1990s as manufacturers and producers realized its innate capability to convert feedstocks into higher value products while meeting demanding environmental requirements.

*World Gasification Capacity and Planned Growth – Cumulative by Year*



# RECENT INDUSTRY CHANGES

*The 2007 database projects that 10 new gasification plants will start operations from 2008 through 2010. While the majority of these will be coal-based plants in China, the largest single contribution to syngas capacity will come from the very large natural gas facility in Qatar. Any new U.S. plants are projected for beyond 2010.*

## Recent Changes in World Syngas Capacity

The 2007 World Gasification Database shows that existing world gasification capacity has grown to 56,238 $MW_{th}$ of syngas output from 144 operating plants and 427 gasifiers (operating plus spares). This represents a 25 percent increase in syngas output compared to the most recent 2004 database level of 45,001 $MW_{th}$ and a 32 percent increase compared to the 1999 database level of 42,726 $MW_{th}$.

Since the 2004 database results of operating gasification plants, 13 more plants are operating commercially, 10 are in start-up, and three have planned start-up in late 2007. As Exhibit 6 shows, 12 of the 26 plants expected to come online by the end of 2007 are coal-fed Shell gasifiers producing chemicals in China—45 percent of the syngas output increase since the 2004 database. This trend is expected to continue in the near term. Excluding the Qatar plant, 46 percent of the syngas capacity planned to be online by 2010 is from a narrow subset of the feed, product, technology, and regions available—specifically from coal-fed, Shell gasification, chemical product in China.

### Syngas Capacity Changes by Region

The top three regions of the world in syngas output capacity have all exchanged places since the 2004 database. Asia/Australia (34 percent),

*Exhibit 6. Gasification Plants Started During 2005 - 2007*

| Year | Plant Name/Owner | Country | Feedstock | Product | $MW_{th}$ Output | Technology |
|---|---|---|---|---|---|---|
| **Operating** | | | | | | |
| **2005** | China 1 | China | Coal | Chemicals | 280 | GE |
| **2005** | China 2 | China | Coal | Chemicals | 174 | GE |
| **2005** | Liuzhou Chemical Industry Corp. Ltd. | China | Coal | Chemicals | 256 | Shell |
| **2005** | Shaanxi Shenmu Chemical Plant | China | Coal | Chemicals | 263 | GE |
| **2005** | Jinling | China | Coal | Chemicals | 287 | GE |
| **2005** | China 4 | China | Coal | Chemicals | 287 | GE |
| **2005** | China 3 | China | Coal | Chemicals | 287 | GE |
| **2005** | Sinopec, Zhijiang | China | Coal | Chemicals | 273 | Shell |
| **2006** | Shuanghuan Chemical | China | Coal | Chemicals | 197 | Shell |
| **2006** | China 5 | China | Coal | Chemicals | 284 | GE |
| **2006** | Sinopec, Yueyang | China | Coal | Chemicals | 509 | Shell |
| **2006** | Sinopec | China | Coal | Chemicals | 509 | Shell |
| **2006** | Agip IGCC | Italy | Petroleum | Power | 457 | Shell |
| **In Start-up** | | | | | | |
| **2006** | Dong Ting Ammonia | China | Coal | Chemicals | 466 | Shell |
| **2006** | Hubei Ammonia | China | Coal | Chemicals | 466 | Shell |
| **2006** | Sinopec Wuhan, Hubei | China | Coal | Chemicals | 509 | Shell |
| **2006** | Weihe Chemical | China | Coal | Chemicals | 395 | GSP |
| **2007** | Thermoselece Vresova | Czech Republic | Coal | Power | 787 | GE |
| **2007** | Long Lake Integrated Upgrading Project | Canada | Petroleum | Gaseous fuels | 1,025 | Shell |
| **2007** | Dahua Chemicals | China | Coal | Chemicals | 232 | Shell |
| **2007** | Yuntianhua Chemicals | China | Coal | Chemicals | 465 | Shell |
| **2007** | Yunzhanhua Chemicals | China | Coal | Chemicals | 465 | Shell |
| **2007** | Nakoso IGCC | Japan | Coal | Power | 455 | Mitsubishi |
| **Planned Start-up in Late 2007** | | | | | | |
| **2007** | Fujian Refinery Ethylene Project (FREP) | China | Petroleum | Power, Chemicals | 868 | Shell |
| **2007** | Brazilian BIGCC Plant | Brazil | Biomass/Waste | Power | 68 | TPS |
| **2007** | Yongcheng Chemicals | China | Coal | Chemicals | 424 | Shell |

the third largest region three years ago, is now the leading region in the world for gasification based on operating capacity, replacing the Africa/Middle East region (27 percent) which slipped to second position. Previously second, the European region (24 percent) is now the third largest region, followed by North America (14 percent) and Central/South America (1 percent) which retained their respective fourth and fifth place 2004 rankings.

## Syngas Capacity Changes by Feedstock

Coal continues to be the dominant feedstock for gasification plants, increasing its share from 49 percent of total world capacity in 2004 to 55 percent in 2007. Twenty-two of the 26 new plants expected to come online by the end of 2007 use coal as feedstock. Moreover, as shown in Exhibit 7, most new plants—seven of the 10 planned for the period 2008 to 2010—intend to use coal as the feedstock. Petroleum (including fuel oil, refinery residue, naphtha, etc.) is still the second leading feedstock with 33 percent of total gasification capacity in 2007 from 59 plants, but its share has declined from three years ago when it was at 37 percent based on 57 plants. Natural gas remains the third-ranking feedstock at 8 percent of current total capacity, nearly the same as the 9 percent level in 2004. Petcoke and biomass/waste also retained their fourth and fifth-place rankings with approximately 2 percent each.

## Syngas Capacity Changes by Product

The 2007 database shows that chemicals remain the top product generated by gasification plants. In fact, 21 of the 26 plants expected to come online by the end of 2007 are chemical production plants, four will generate power, and one will produce gaseous fuels. The relative ranking for chemicals increased from 37 percent to 45 percent since 2004. On the other hand, F-T liquids declined its relative position from 36 percent three years ago to 28 percent. Power or electricity generation is still at 19 percent of total world syngas capacity, the same level as in 2004. Gaseous fuels also remained at its previous 8 percent level. New projects planned for 2008 to 2010 intend to produce chemicals and F-T liquids or generate power.

## Syngas Capacity Changes by Technology

Exhibit 8 shows a substantially improved market position of Shell gasifiers in the industry by 2007 due to the selection of Shell technology at 15 of 26 plants worldwide that came online during 2005 to 2007. The market share for Shell increased to 28 percent, compared to 19 percent in 2004. Both Sasol Lurgi and GE Energy declined in their relative market positions in 2007. Sasol

*Exhibit 7. Gasification Plants Planned for 2008 - 2010*

| Year | Plant Name/ Owner | Country | Feedstock | Product | $MW_{th}$ Output | Technology |
|---|---|---|---|---|---|---|
| 2008 | Shenhua | China | Coal | F-T liquids | 861 | Shell |
| 2008 | Kaixiang Chemical Plant | China | Coal | Chemicals | 257 | Shell |
| 2008 | Puyang Plant | China | Coal | Chemicals | 463 | Shell |
| 2008 | Lotos Reffinery Gdansk | Poland | Petroleum | Power | 620 | Shell |
| 2009 | Sulcis IGCC Project | Italy | Coal | Power | 957 | Shell |
| 2009 | Yongcheng Shell Plant | China | Coal | Chemicals | 466 | Shell |
| 2010 | Paradip Gasification $H_2$/Power Plant | India | Petcoke | Chemicals | 889 | Shell |
| 2010 | Pearl GTL | Qatar | Gas | F-T liquids | 10,936 | Shell |
| 2010 | Tianjin Chemical Plant | China | Coal | Chemicals | 1,124 | Shell |
| 2010 | Guizhou Chemical Plant | China | Coal | Chemicals | 562 | Shell |

*Exhibit 8. Changes in Market Position for Gasifier Technologies*

| Gasifier Technology | 1999 | 2004 | 2007 | 2010 |
|---|---|---|---|---|
| Shell | 21% | 19% | 28% | 45% |
| Sasol Lurgi | 28% | 41% | 34% | 26% |
| GE Energy | 39% | 34% | 31% | 24% |
| Other | 12% | 6% | 7% | 5% |

Lurgi went from 41 percent in 2004 to 34 percent and GE Energy declined from 34 percent in 2004 to 31 percent. Further, the collective position of these three commercial gasifier companies has continued to improve in the global marketplace. In 1999, these three gasifier providers held a collective market share of 88 percent; by 2007, this dominant position had reached 93 percent. While roughly a dozen other technology firms provide gasifiers to the industry, their collective share of the business has been nearly cut in half in the past decade.

This shift in technology use is likely to continue in the near term: 100 percent of the new plants planned for the next three years (including the Qatar GTL plant) are projected to use Shell gasifiers. If installation of these gasifiers is realized, Shell will increase its market position to a commanding 45 percent share.

## Comparison of Growth Projections

Exhibit 9 shows forecasts from the 2001, 2004, and 2007 databases. In general, the growth forecasted for the gasification industry has shifted two or three years—perhaps largely due to the worldwide economic decline in 2000 to 2003—but is still occurring and may continue at an even faster rate in the future. The 2004 forecast showed a clear shift to the right or delay in bringing additional syngas capacity online; this trend is also evident with the 2007 database. Thus, the 2007 forecast does not change the prior optimistic growth forecasts but simply defers them—and then shows an accelerated growth period beginning around 2009. This latter trend is also consistent with the renewed and increased growth of gasification anticipated in the United States beyond 2010.

Some historical gains have also been unexpected in the gasification industry. For example, in 1999 the Africa/Middle East region showed no expected growth for the next five years. However, by 2004 the reported capacity of the South African Sasol gasifiers had increased by over 40 percent. Some extraordinary gains are being realized in certain other countries as well. The rapidly expanding economy in China has resulted in associated energy and chemical feedstock demand increases, where three coal-based gasification plants making ammonia and two petroleum-waste fed ammonia plants began operations during 2000 to 2004 and were then complemented by an additional 22 plants—21 coal-based and one petroleum-based—during 2005 to 2007. This brings the total number of gasification plants in China to 44, over 30 percent of the worldwide total of 144. In Qatar, the exceptionally large plant forecasted to begin operations in 2010 will increase the syngas capacity for the Africa/Middle East region by 72 percent.

Many of the planned new gasification plants in Western Europe and North America have been postponed. As discussed in the following section, regulatory uncertainty, the increased cost of installing new plants, the influence from natural gas prices, the production of hydrogen, and carbon dioxide ($CO_2$) emissions reductions are all factors which are impacting the current and future growth prospects for the industry.

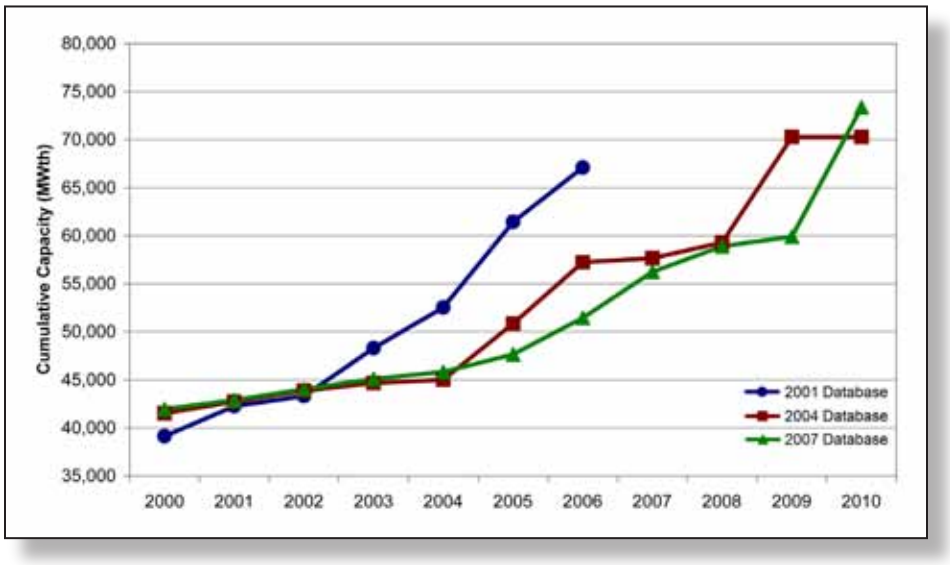



*Exhibit 9. World Gasification Planned Growth – Forecast Comparison*

## Trends and Drivers in the Gasification Industry

The ability to make clean power, chemicals, and fuels from low cost resources such as coal in an environmentally acceptable and economically competitive process is the key driver for the gasification industry. An additional driver is the innate capability of gasification technology to most effectively separate and capture $CO_2$ and thus effectively address

the problem of reducing greenhouse gas emissions. As the requirements for $CO_2$ capture become clearer, the pressure to use gasification-based technology will become increasingly important to new energy and industrial growth.

## Addressing $CO_2$ Emissions Reductions

One of the most important drivers for using gasification-based technologies is the need to capture the $CO_2$ and separate it for potential sequestration. Gasification is a technology that is uniquely capable of achieving this separation and capture. If carbon emissions become increasingly regulated, then long-lead time and long-life technology projects, such as electric power generation, as well as other projects directed to producing coal-based liquid fuels and SNG will be impacted by these regulatory controls. Numerous legislative initiatives have been proposed worldwide and particularly in the United States to establish specific targets for carbon emissions. Some states have initially targeted industrial and power technologies for reductions in emissions, including California, Maine, Massachusetts, New Jersey, New Hampshire, and Oregon. The technology being demonstrated as part of the FutureGen program is expected to show near-zero emissions capability.

## Regulatory Uncertainty

A major contributing factor in slowing the growth of gasification capacity, particularly in the United States, is the regulatory climate. This is especially true for the issue of carbon emissions controls as described above. This in turn introduces risk that makes the permitting, approval, and financing of plants more difficult. Some federal and state regulatory agencies have encouraged the development of gasification projects as they are seen to be attractive to meeting greenhouse gas emissions constraints while also reducing criteria pollutants. However, even with this encouragement, there have been some court actions that have negatively influenced the commitment for and growth of new gasification facilities. For example, the Mesaba project in Minnesota and the proposed IGCC plants in Wisconsin have been met with either regulatory board or court actions requiring that the plans for development of the projects be revisited to consider the relative capital costs and technology gains of their specific proposals. In contrast to this, Florida has recently approved a bill that will enable Tampa Electric to pass on costs to customers via rate increases for the design, licensing, construction, and interest for a new IGCC plant. Thus, there are both favorable and unfavorable actions that have contributed to the climate of uncertainty in the permitting and financing of new plants.

## Increased Cost of Installing New Plants

Cost estimates for gasification-based projects have recently faced significant increases in expected capital costs. These increases have re-ordered the thinking of some project developers and approving regulatory agencies regarding the desirability of gasification as a preferred option. As new projects have been proposed, the developers have completed several Reference Plant studies and Front-End Engineering Design (FEED) studies. All of these have shown significant increases in capital cost estimates. While some of the increases can be attributed to inflation and improved design features, the increasing demand for equipment and labor in the power and energy construction sector has increased the cost of original equipment and installation by as much as 20 to 30 percent.

One measure of the increase in the cost estimates is provided by the comparison of studies done for DOE in 1998 and again in 2007 using very similar cost estimating procedures, information resources, and assumed design bases. (See *Market-Based Advanced Coal Power Systems*, DOE Contract No. DE-AC01-94FE62747, Task 22/36, December 1998; *Cost and Performance Baseline for Fossil Energy Plants*, DOE/NETL – 2007/1281, May 2007.) This comparison of increasing costs is shown in Exhibit 10. Other studies show similar trends.

*Exhibit 10. Cost Comparison of New Plants*

| | Total Plant Cost, ($/kW) | | Levelized Cost of Electricity, (cents/kWhr) | |
|---|---|---|---|---|
| **Study Year** | **1998** | **2007** | **1998** | **2007** |
| **IGCC** | 1,186 | 1,841 | 3.7 | 7.8 |
| **PC Supercritical** | 1,173 | 1,575 | 3.9 | 6.3 |
| **NGCC** | 524 | 554 | 3.6 | 6.8 |

## Influence of Natural Gas Prices on Gasification-Based Projects

Decisions to move forward with gasification projects depend highly on current and expected future prices of energy. Prior to 2000, prices for natural gas hovered below $2 per thousand cubic feet (mcf) at the wellhead and for the most part below $4/mcf delivered to industrial and power customers. Occasional spikes in prices, including the spike in 2001 to over $8/mcf, were reasonably considered to be aberrations. However, as Exhibit 11 shows, over the past five years the delivered prices to both industrial and power generation customers have consistently exceeded the level of $6/mcf, with extended periods running between $8 and $12/mcf.

With higher prices for natural gas, significant changes in the outlook for gasification have occurred. Substantial interest has been exhibited in three areas directly related to the expectations for higher natural gas prices. First is the competitive selection of technology for meeting expanding power generation needs. With higher prices for natural gas, the option of using gasification to convert lower-cost coal resources into usable gas for power generation with efficient gas-burning combined cycle plants is becoming more attractive. This shift in preference for resources has brought delays in decisions as electric utility companies and merchant plants reconsider the merits of using higher-priced natural gas for large-scale base-load plants operating at near full-load conditions. Second is the replacement of natural gas with a more stable and attractive gasification-based fuel gas. This can apply to replacement of natural gas in both the electric power sector (conversion of natural gas combined-cycle [NGCC] plants to IGCC plants) or in the industrial and chemical sectors where product costs (e.g., fertilizers) follow natural gas prices. Third is the use of coal-based gasification to directly produce liquid fuels or SNG that can be broadly distributed to industrial facilities that need such fuels or feedstocks. While CTL plants may face strong environmental opposition, $CO_2$ capture issues, and high capital costs, there are many announced CTL projects directed toward meeting new applications in liquid transportation

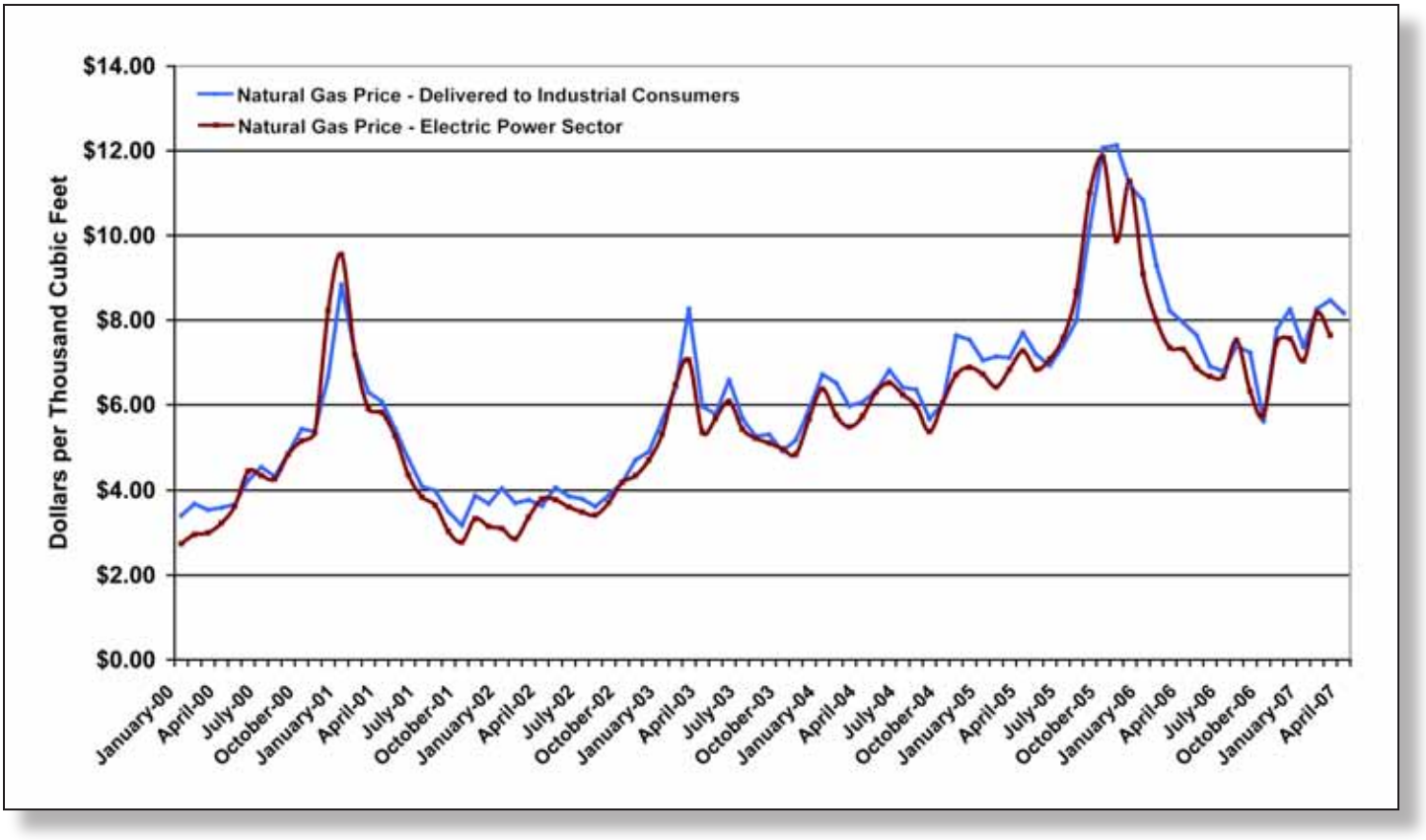



*Exhibit 11. U.S. Natural Gas Price*

fuels and single-battlefield fuels for military needs. Similarly, projects are being proposed for producing SNG for industrial as well as pipeline gas needs.

### Increased Interest in Production of Hydrogen with Focus on FutureGen

The 2007 database identified several developing projects that will produce hydrogen at gasification plants for applications in petroleum refining, chemicals, ammonia, and fertilizers. Hydrogen will be a product of the FutureGen plant, a Presidential Initiative designed to also produce clean power while sequestering carbon.

### The Energy Policy Act of 2005

The passage of the Energy Policy Act of 2005 provides significant federal financial incentives for a wide variety of gasification-based projects in the United States. Currently, DOE has $4 billion in loan guarantee authority. The FY 2008 budget requested $9 billion in loan guarantee authority. The new law authorizes direct federal outlays in grants, investment tax credits, loans, and cost-sharing that could help fund gasification-based plants.

*"Through new and innovative programs such as the Clean Coal Power Initiative and FutureGen demonstration, private sector partnerships, and use of tax credits and loan guarantees, the U.S. Department of Energy is advancing research to further develop and deploy advanced coal technologies to meet growing energy demand."*

Clay Sell, Deputy Secretary of the U.S. Department of Energy – June 2007

### *The FutureGen Project*

FutureGen is a $1.8 billion public-private partnership to design, build, and operate a near-zero emissions coal-fueled power plant. The approximately 275 MW IGCC plant will use cutting edge technologies to generate electricity while simultaneously capturing and permanently storing carbon dioxide deep underground. The project will convert a variety of coal types to hydrogen for power generation and other potential industrial uses and supports continued environmental improvement in the energy industry. FutureGen will lay the groundwork for developing similar power plants worldwide. Two sites in Illinois and two sites in Texas are being considered for the proposed facility. FutureGen is planned to be operational by 2012.

Projects listed in Exhibit 12 received awards in November 2006 from the first round of solicitations. (Two additional projects requested that their selection not be acknowledged publicly.) Authority was created for 80 percent loan guarantees for up to 17 additional gasification projects to be awarded by early 2008. This has significantly increased the interest in gasification projects and increases the likelihood of growth in capacity as well as new missions for gasification in the post-2010 period.

*"There is more energy available in U.S. coal than in nearly all of the oil in the world, and these tax credits will help us find ways to use coal in an environmentally sensitive way. The combination of government incentives and private sector innovation will harness America's technological strength to ensure clean, secure, affordable, and reliable energy."*

Samuel W. Bodman, Secretary of the
U.S. Department of Energy
– November 2006

*Tampa Electric Polk Power Station*

*Exhibit 12. First Round Tax Credit Projects in the United States from the Energy Policy Act of 2005*

| Technology | Recipient | Location | Output | Tax Credit |
|---|---|---|---|---|
| **IGCC Bituminous** | Duke Energy | Edwardsport, IN | 795 MW | $133.5M |
| **IGCC Bituminous** | Tampa Electric | Polk County, FL | 789 MW | $133.5M |
| **IGCC Lignite** | Mississippi Power | Kemper County, MS | 700 MW | $133M |
| **Gasification** | Carson Hydrogen Power LLC; Carson Hydrogen Power Project | Carson, CA | Hydrogen, 390 MW | N/A |
| | TX Energy, LLC; Longview Gasification and Refueling | Longview, TX | Syngas for chemicals | N/A |
| **Advanced Coal (non-IGCC)** | Duke Energy - Cliffside Modernization Projects | Cleveland and Rutherford Counties, NC | 1,600 MW | $125M |
| **Advanced Coal (non-IGCC)** | E.ON U.S., Kentucky Utilities & Louisville Gas and Electric | Bedford, KY | 1,744 MW | $125M |

# BEYOND 2010—STRONG GROWTH ANTICIPATED IN THE UNITED STATES

*Fifty gasification projects are in various stages of planning and preliminary engineering for future U.S. operation.*

With expanded demand for power plants, concerns over the availability and prices of oil and gas, and increased consensus regarding the needs for deployment of technologies providing for environmental protection, gasification-based projects are increasingly viewed as a technology option for future progress. The announcement of new gasification projects in the United States seeking partnerships, funding, and permitting illustrate this trend.

While four gasification plants began operations in the United States during 2000 to 2004, no new plants have been started during 2005 to 2007 and the database indicated that none are projected to start during 2008 to 2010. This absence of new U.S. capacity additions from 2005 to 2010 is understandable given that plants that would have been constructed and ready for commercial operation during this period would have had to be committed to during the late 1990s and early 2000s when natural gas prices were low, resources for industrial needs and transportation fuels were seemingly abundant, and the results from demonstrations of new generation gasification technologies (e.g., the Polk and Wabash IGCC plants) were not yet fully known.

Based on information from public announcements, 50 projects have been identified for U.S. operation beyond 2010. The majority are not included in the database since they are not sufficiently advanced to be listed. Exhibits 13, 14, 15, and 16 tabulate these planned projects and

## U.S. IGCC Plants Gain Broad Support

*"With restrictions on carbon dioxide emissions expected in the future, IGCC technology represents an important advancement for power generation and for the coal industry. It's much less expensive to capture carbon dioxide pre-combustion in the gasification process than it is to capture it post-combustion from a pulverized coal plant."*

— Michael G. Morris, Chairman, President, and CEO of American Electric Power – June 2007

*"Illinois has among the largest reserves of coal in the world and being able to safely use this domestic energy source is a critical part of my energy plan. The Taylorville Energy Center, using cutting edge clean coal gasification technology, is a great example of how we can grow our economy and create good paying jobs while protecting our environment."*

— Rod R. Blagojevich, Governor of Illinois – June 2007

*"The investment [in the Cash Creek project] represents an opportunity to build a coal gasification facility that takes advantage of an abundant, locally produced natural resource in Kentucky, the nation's third-largest coal-producing state. This transaction is an anchor for our plans to grow by investing in gasification – a cleaner, more environmentally friendly power source compared to traditional coal-fired generation."*

— Dan Castagnola, Managing Director at GE Energy Financial Services – January 2007

*"The FutureGen initiative tackles some of the most pressing issues in the energy industry today — the use of our abundant coal resources, the control of greenhouse gases, and the development of new, clean, and reliable energy sources."*

— Stephen M. Johnson, Senior Executive Vice President of the Washington Group International — June 2007

*Exhibit 13. Gasification-based Power Plant Projects Under Consideration in the United States Beyond 2010*

| Project Name/Lead | Location | Feedstock | CT Fuel | Net ($MW_e$) |
|---|---|---|---|---|
| Orlando Gasification Project*/Southern Co., OUC | Orlando, FL | coal | syngas | 285 |
| Lima Energy IGCC/Global Energy | Lima, OH | coal/petcoke | syngas | 540 SNG $H_2$ |
| Cash Creek IGCC Plant/GE, MDL Holdings | Henderson County, KY | coal | syngas | 630 |
| Lockwood IGCC Plant/Hunton Energy, Cogentrix Energy Inc. | Sugar Land, TX | petcoke | syngas | 1200 |
| Mesaba/Excelsior Energy | Holman, MN | coal/petcoke | syngas | 600 |
| Carson $H_2$ Power Project/BP, Edison Mission Group | Carson, CA | petcoke | $H_2$ | 500 |
| FutureGen/FutureGen Alliance | Illinois or Texas | coal | $H_2$ | 275 |
| Mountaineer Plant/AEP | New Haven, WV | coal | syngas | 630 |
| Pacific Mountain Energy Center/Energy Northwest | Port Kalama, WA | coal/petcoke | syngas | 680 |
| Taylorville Energy Center IGCC/CCG LLC | Taylorville, IL | coal | syngas | 630 |
| Huntley IGCC Project/NRG Energy | Tonawanda, NY | coal | syngas | 680 |
| Tampa Electric, Unit 2 | Polk County, FL | coal | syngas | 630 |
| Wallula Energy Resource Center/Wallula Resource Recovery LLC | Wallula, WA | coal | syngas | 600-700 |
| Xcel Energy | Colorado | coal | syngas | 300-350 |
| TXU Corp. | Colorado City, TX | coal | syngas | 630 |
| TXU Corp. | Henderson, TX | coal | syngas | 630 |
| Clean Hydrogen Power Generation Project/Southern California Edison | California | coal | $H_2$ | 600 |
| Indian River IGCC Project/NRG Energy | Millsboro, DE | coal | syngas | 630 |
| Edwardsport IGCC Project/Duke Energy | Edwardsport, IN | coal | syngas | 630 |
| Great Bend/AEP | Meigs County, OH | coal | syngas | 630 |
| IGCC Demonstration Plant/Wyoming Infrastructure Authority, Pacific Corp | Wyoming | coal | syngas | TBD |
| Lower Columbia Clean Energy Center/Summit Power Group | Clatskanie, OR | petcoke/coal | syngas | 520 |
| Mississippi Power | Kemper County, MS | coal | syngas | 600 |
| NRG Energy | Texas | coal | syngas | 630 |
| Steelhead Energy/Madison Power | Williamson County, IL | coal | syngas | 620 SNG |

* DOE Clean Coal Demonstration Project

Note: Plant size for electricity generating facilities is reported as $MW_e$ in electrical output equivalent (unless otherwise noted), in contrast to size units of $MW_{th}$ syngas used elsewhere in this document.

*Exhibit 14. Coal-to-liquid Plants Under Consideration in the United States Beyond 2010*

| Project Name/Lead | Location | Feedstock | Products | Capacity (bpd) |
|---|---|---|---|---|
| American Clean Coal Fuels | Oakland, IL | coal | ultra-clean diesel and jet fuel | 25,000 |
| American Lignite Energy | North Dakota | coal | ultra-clean transportation fuels, power, petrochemical feedstocks, $CO_2$ for EOR | 32,000 |
| Baard Energy | Wellsville, OH | coal/biomass | ultra-clean diesel and jet fuel | 35,000 |
| Beluga CTL Plant/AIDEA | Cook Inlet, AK | coal | ultra-clean diesel fuel, naptha and LPGs | 80,000 |
| DKRW Advanced Fuels, Arch Coal, Bull Mountain Coal | Roundup, MT | coal | ultra-clean diesel fuel, 300 MW power | 22,000 |
| Gilberton Coal-to-Power And Clean Fuels Project/ WMPI PYT, DOE | Gilberton, PA | waste coal | ultra-clean fuels, power | 5,000 |
| Headwaters/Hopi Indian Tribe | Arizona | coal | ultra-clean diesel fuel, other liquids, power | 10,000-50,000 |
| Medicine Bow Fuel and Power/DKRW Advanced Fuels | Medicine Bow, WY | coal | ultra-clean diesel fuel, $CO_2$ for EOR, naphtha, 200 MW power, chemicals | 13,100 |
| Power County Advanced Energy Center/Southeast Idaho Energy | Pocatello, ID | coal | ultra-clean diesel fuel, ammonia, $CO_2$ for EOR | 1,400 |
| Rentech | Mingo County, WV | coal | ultra-clean transportation fuels | 30,000 |
| Rentech | East Dubuque, IL | coal | ultra-clean fuels, nitrogen fertilizers, power | 2,000 |
| Rentech | Natchez, MS | coal/petcoke | ultra-clean fuels, chemicals, $CO_2$ for EOR | 25,000 - 50,000 |
| Rentech, Peabody | Montana | coal | ultra-clean transportation fuels | 10,000 or 30,000 |
| Rentech, Peabody | Kentucky | coal | ultra-clean transportation fuels | 10,000 or 30,000 |
| Synfuels Inc | Ascension Parish, LA | coal | ultra-clean fuels, chemicals, power | N/A |
| Twin River Energy Center | Wiscasset, MN | coal/wood biomass | ultra-clean diesel fuel, 700 MW power | 214 |

*Exhibit 15. Commercial Coal-to-SNG Plants Under Consideration in the United States Beyond 2010*

| Project Name/Lead | Location | Feedstock | Products | Capacity (bcfy) |
|---|---|---|---|---|
| Cardinal Energy Center/ArcLight, Peabody | Illinois | coal | SNG, $CO_2$ | 35 |
| Indiana Gasification, LLC | Southwestern IN | coal | SNG, 630 $MW_e$ | 40 |
| Peabody, Conoco Phillips | Midwest | coal | SNG | 50 - 70 |
| Secure Energy, LLC | Decatur, IL | coal | SNG | 20 |
| Southern Illinois Coal-to-SNG Facility/Power Holdings, LLC | Rend Lake, IL | coal | SNG | 50 |
| TransGas Development Systems | Scriba, NY | coal | SNG | 3.9 |

*Exhibit 16. Other Gasification Plants Under Consideration in the United States Beyond 2010*

| Project Name/Lead | Location | Feedstock | Products |
|---|---|---|---|
| Kenai Blue Sky Coal Gasification Project/Agrium | Nikiski, Alaska | coal | nitrogen, power, $CO_2$ for EOR |
| Eastman Chemical | Beaumont, TX | petcoke | $H_2$, methanol, ammonia, $CO_2$ for EOR |
| Faustina Hydrogen Products/ Eastman Chemical | St. James Parish, LA | petcoke/coal | ammonia, methanol, sulfur, industrial-grade $CO_2$ |

provide information, respectively, on gasification-based power plants, CTL, coal-to-SNG, and other gasification plants under consideration. Many of the power plant projects in Exhibit 13 have indicated that they will be designed to be carbon-capture ready. In fact, many projects are being designed for carbon capture. While the gasification projects in Exhibits 13 through 16 are illustrative of those in development, not every project in planning goes to construction and start-up. Moreover, press releases often revise planned start dates as plant owners contend with many issues that affect the start of commercial operation.

In summary, gasification provides a versatile technology option to satisfy environmental and carbon policy requirements and is increasingly becoming the technology of choice. In an environment of increasingly favorable energy market conditions and strong public policy support, significant additions to gasification capacity in the United States in the coming years for the production of clean power, fuels, and chemicals are viewed with greater certainty.

# GLOSSARY

| | |
|---|---|
| AEP | American Electric Power |
| bcf | billion cubic feet |
| bcfy | billion cubic feet per year |
| bpd | barrels per day |
| CT | combustion turbine |
| CTL | coal-to-liquid |
| EOR | enhanced oil recovery |
| FE | Fossil Energy |
| FEED | front-end engineering design |
| F-T | Fischer-Tropsch |
| GTC | Gasification Technologies Council |
| GTL | gas-to-liquids |
| IGCC | integrated gasification combined-cycle |
| mcf | thousand cubic feet |
| mmcf | million cubic feet |
| $MW_e$ | megawatt electrical |
| $MW_{th}$ | megawatt thermal |
| NETL | National Energy Technology Laboratory |
| NGCC | natural gas combined-cycle |
| PMEC | Pacific Mountain Energy Center |
| RDS | Research and Development Solutions |
| scf | standard cubic feet |
| SNG | synthetic or substitute natural gas |
| tpd | tons per day |

## CONVERSION FACTORS

1 short ton (U.S.) = 2,000 pounds = 0.9072 metric ton (tonne)

2,204.6 pounds = 1 metric ton (tonne)

1 barrel (U.S., petrol) per day (bpd) = $1.84013 \times 10^{-6}$ cubic meters per second ($m^3/s$)

1 cubic foot ($ft^3$) = 0.02832 cubic meter ($m^3$)

37.326 standard cubic feet (scf) = 1 normal cubic meter ($Nm^3$)

0.622 scf per minute = 1 $Nm^3$ per hour

## Front Cover Photos

*ELCOGAS Power Plant; Puertollano, Spain*

*Dakota Gasification Great Plains Synfuels Plant; North Dakota, United States*

*Sasol Synfuels Plant; Secunda, South Africa*

*Tampa Electric Polk Power Station; Florida, United States*

*Coffeyville Resources Nitrogen Plant; Kansas, United States*

The database that is the basis for this brochure was compiled by Childress Associates and involved owners/operators of gasification-based power and manufacturing plants, major gasification technology vendors, and suppliers of supporting technologies. The database is available at the DOE NETL website:

**www.netl.doe.gov/technologies/coalpower/gasification/database/database.html**

The database is available in different formats:

- A Microsoft Excel® spreadsheet containing all data fields for all records contained in the original Microsoft Access database.
- An Adobe® PDF file that is bookmarked for sections sorted by technology vendor, feedstock, country, region, and product.
- A Microsoft Access® database file that allows searches for records by the following criteria: plant ID number, region, country, year of start-up, gasification technology, main feed(s), plant capacity, and main products.

This searchable database is also available on the website of the Gasification Technologies Council.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