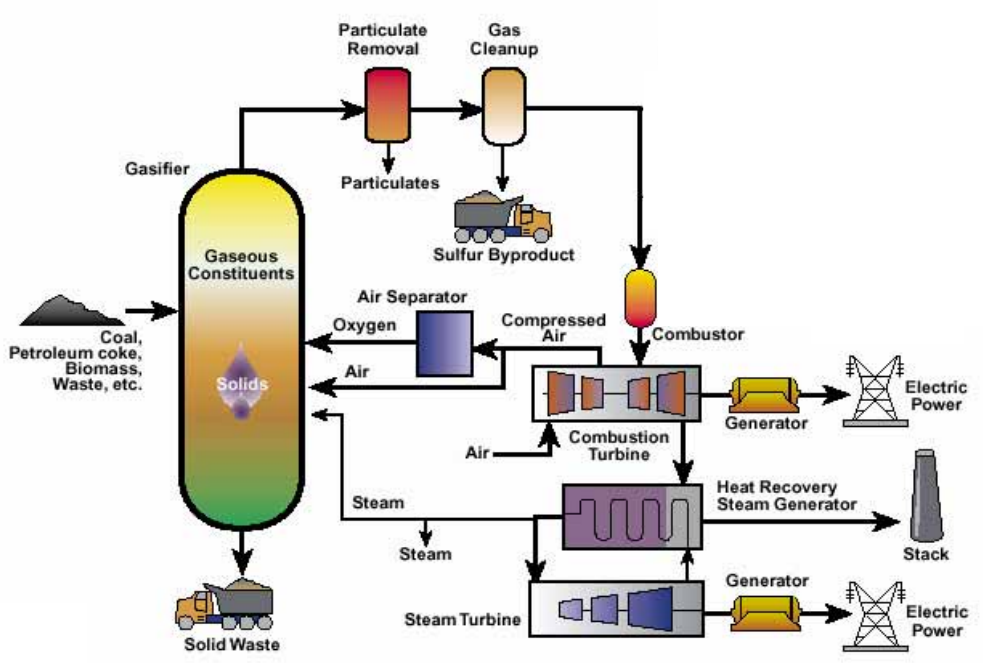
2.0. IGCC TECHNOLOGY AND OPERATING EXPERIENCE

IGCC is a power generation process that integrates a gasification system with a combustion turbine combined cycle power block. The gasification system converts coal (or other solid or liquid feedstocks such as petroleum coke or heavy oils) into a gaseous syngas, which is composed of predominately hydrogen (H_2) and carbon monoxide (CO). The combustible syngas is used to fuel a combined cycle generation power block to produce electricity. Figure 2-1 provides a simple diagram of the major components of an IGCC power plant.

Most of the components and the majority of the costs of IGCC power plants are associated with processes that are already in wide commercial use in the power, refining, or chemicals industries. For example, the combined cycle generation power block of an IGCC employs the same turbine and heat recovery technology that is used extensively around the world to generate electricity with natural gas. Only minor adjustments are needed when syngas is used as a fuel instead of natural gas.[73]

Similarly, the core process of gasification involves technology that has been used to create fuels since before World War II and has been deployed extensively around the

Figure 2-1. IGCC Power Plant



Source: NETL

[73] These adjustments are largely associated with the piping and control values that feed the syngas to the combustion turbine. Adjustment is required due to the larger volumetric flow of gas to the turbine when syngas is the fuel because it has a lower volumetric heating value than natural gas. See discussion in Section 2.15 below.

world in refining, chemical, and power applications. For example, in the 1930's Lurgi developed a dry-ash gasifier to produce Town Gas and later chemicals,[74] and during World War II, gasification was used extensively by Germany (as well as Britain and France) to produce fuel in the face of scarce oil supplies.[75]

Today, gasification remains a widely used commercial technology. A 1999 survey by the Department of Energy (DOE) and Gasification Technologies Council identified 161 commercial gasification plants in operation, under construction, or in planning and design stages in twenty-eight countries around the world.[76] These projects represented a total of 414 gasifiers with a combined syngas production capacity equivalent to 33,000 MW of power if it were all used to generate electricity.[77] Of these projects, 128 were identified as active-real projects (operating or under construction) that included 366 gasifiers.[78] There are at least fifteen suppliers of commercial gasification technology.[79] Table 2.1 lists the largest commercial gasification projects operating or under development around the world as of January 2000. China has recently ordered 10 new coal gasification plants from Shell to produce fuels and chemicals.

Despite the worldwide commercial use and acceptance of gasification processes and combined cycle power systems, IGCC is not perceived to be a mature technology. Each major component of IGCC has been broadly utilized in industrial and power generation applications, but the integration of a gasification island with a combined cycle power block to produce commercial electricity as a primary output is relatively new. This integration for commercial electricity generation has been demonstrated at a handful of facilities around the world, but is not yet perceived to be a mature, commercial technology with clearly understood costs and risks. Overcoming this perception through deployment of an initial fleet of IGCC plants is an important objective of the 3Party Covenant proposal.

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[74] NETL, Major Environmental Aspects of Gasification-Based Power Generation Technology, Dec. 2002, p. 1-8.

[75] See ARTES Institute, University of Flensburg, "Biomass Gasification Technology and Utilization, Gasification History and Development," http://members.tripod.com. See also Becher, Peter W. PHD, "The Role of Synthetic Fuel in World War II Germany," Aug., 2001, http://www.airpower.maxwell.af.mil/airchronicles/aureview/1981/jul-aug/becker.htm.

[76] NETL/Gasification Technology Council, "Gasification: Worldwide Use and Acceptance," January 2000, p. 6.

[77] Id.

[78] Id.

[79] NETL, Major Environmental Aspects, p. 1-19.

Table 2.1. 30 Largest Commercial Gasification Projects by Syngas Output

Owner	Location	Gasification Technology	Syngas Output (MW_{th})*	Online Year	Feedstock	Products
Sasol-II	South Africa	Lurgi Dry Ash	4,130	1977	Subbit. Coal	FT liquids
Sasol-III	South Africa	Lurgi Dry Ash	4,130	1982	Subbit. Coal	FT liquids
Repsol/Iberdrola	Spain	GE Energy	1,654	2004[a]	Vac. residue	Electricity
Dakota Gasification Co.	U.S.	Lurgi Dry Ash	1,545	1984	Lignite & ref res	Syngas
SARLUX srl	Italy	GE Energy	1,067	2000[b]	Visbreaker res	Electricity & H_2
Shell MDS	Malaysia	Shell	1,032	1993	Natural gas	Mid-distallates
Linde AG	Germany	Shell	984	1997	Visbreaker res	H_2 & methanol
ISAB Energy	Italy	GE Energy	982	1999[b]	asphalt	Electricity & H_2
Sasol-1	South Africa	Lurgi Dry Ash	911	1955	Subbit Coal	FT liquids
Total France/ edf /GE Energy	France	GE Energy	895	2003[a]	Fuel oil	Electiricty & H_2
Shell Nederland	Netherlands	Shell	637	1997	Visbreaker res	H_2 & electricity
SUV/EGT	Czech Republic	Lurgi Dry Ash	636	1996	Coal	Elec. & steam
Chinese Pet Corp	Taiwan	GE Energy	621	1984	Bitumen	H_2 & CO
Hydro Agri Brunsbuttel	Germany	Shell	615	1978	Hvy Vac res	Ammonia
Global Energy	U.S.	E-gas	591	1995	Bit. Coal/ pet coke	Electricity
VEBA Chemie AG	Germany	Shell	588	1973	Vac residue	Ammonia & methanol
Elcogas SA	Spain	PRENFLO	588	1997	Coal & pet coke	Electricity
Motiva Enterprises	U.S.	GE Energy	558	1999[b]	Fluid petcoke	Electricity
API Raffineria	Italy	GE Energy	496	1999[b]	Visbreaker res	Electricity
Chemopetrol	Czech Republic	Shell	492	1971	Vac. residue	Methanol & Ammonia
NUON	Netherlands	Shell	466	1994	Bit Coal	Electricity
Tampa Electric	U.S.	GE Energy	455	1996	Coal	Electricity
Ultrafertil	Brazil	Shell	451	1979	Asphalt res	Ammonia
Shanghai Pacific Chemical Corp	China	GE Energy	439	1995	Anthracite coal	Methanol & Town gas
Exxon USA	U.S.	GE Energy	436	2000b	Petcoke	Electricity & syngas
Shanghai Pacific Chemical Corp	China	IGT U-Gas	410	1994	Bit Coal	Fuel gas & Town gas
Gujarat National Fertilizer	India	GE Energy	405	1982	Ref residue	Ammonia & methanol
Esso Singapore	Singapore	GE Energy	364	2000	Residual Oil	Electricity & H2
Quimigal Adubos	Portugal	Shell	328	1984	Vac residue	Ammonia

[a] Plant was in advanced engineering at time of survey.
[b] Plant was under construction at time of survey.
* MWth is a measure of syngas thermal energy.

Source: NETL/Gasification Technology Council, "Gasification: Worldwide Use and Acceptance," Jan. 2000, p. 7.

2.1. Major Components of IGCC Power Plants

The major components of coal-fueled IGCC power plants include: coal handling equipment, gasifier, air separation unit, gas cooling and clean-up processes, and combined cycle power block. The discussion that follows describes each of these components and provides an estimate of each component's share of total capital costs.

2.11. Coal Handling Equipment

Coal handling equipment provides for unloading, conveying, preparing and storing coal delivered to a coal power plant. The coal handling equipment used for an IGCC is largely the same as that used at PC power plants. Similar to PC plants, the primary preparation of the fuel is crushing or pulverizing prior to feeding it into the gasification system. Some gasification technologies use dry fed coal through lock hoppers, while others are fed fuel in coal-water slurry.[80] Coal handling equipment accounts for about 12 percent of the capital cost of an IGCC.[81]

2.12. Gasifier

Gasification is the partial oxidation of a solid or liquid fuel feedstock to produce a gaseous product (syngas) made up of predominantly H_2 and CO.[82] Gasifiers convert carbon-based feedstocks (such as coal, petroleum coke, heavy oils or biomass) into gaseous products at high temperature (2,000-3,000°F) and elevated pressure (400-1,000 psi) in the presence of oxygen and steam. Gasification occurs in a reducing (oxygen-starved) environment where insufficient oxygen is supplied for complete combustion of the fuel feedstock. Partial oxidation of the feedstock creates heat and a series of chemical reactions produce syngas.[83]

IGCC systems can incorporate any one of a number of gasifier designs, but all are based on one of three generic configurations:[84]

> *Moving-bed reactors (also called fixed-bed)*: In moving-bed reactors large particles of coal move slowly down through the gasifier while reacting with gases

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[80] SFA Pacific, Inc., "Evaluation of IGCC to Supplement BACT Analysis of Planned Prairie State Generating Station," May 11, 2003, p. 7.

[81] EPRI/NETL, Updated Cost and Performance Estimates for Fossil Fuel Power Plants with CO_2 Removal, Dec. 2002 (7-10 Cost breakdown based on cost estimates in Case 9A—IGCC without CO_2 removal, Appendix A, p. A-30).

[82] Syngas also contains some carbon dioxide (CO_2), moisture (H_2O), hydrogen sulfide (H_2S) and carbonyl sulfide (COS) as well as small amounts of methane (CH_4), ammonia (NH_3), hydrogen chloride (HCI) and various trace components from the feedstock. See SFA Pacific, Inc., "Evaluation of IGCC to Supplement BACT Analysis of Planned Prairie State Generating Station," May 11, 2003, p. 7..

[83] See EPRI/NETL, p. 7-11—7-15. See also SFA Pacific, Inc., p. 7. See also NETL, Major Environmental Aspects, Appendix 1A.

[84] NETL, Major Environmental Aspects, p. 1-7.

moving up through it. Several different "reaction zones" are created that accomplish the gasification process. The Lurgi dry-ash and the British Gas/Lurgi (BGL) gasifier employ this technology and are currently operating at several facilities.[85]

Fluidized-Bed Reactors: Fludized-bed reactors efficiently mix feed coal particles with coal particles already undergoing gasification in the reactor vessel. Coal is supplied through the side of the reactor, and oxidant and steam are supplied near the bottom. Commercial suppliers include the High Temperature Winkler (HTW) and KRW designs. Few of these systems are currently in operation.[86]

Entrained-flow Reactors: Entrained-flow systems react fine coal particles with steam and oxygen and operate at high temperatures. These systems have the ability to gasify all coals regardless of rank. Different systems may use different coal feed systems (dry or water slurry) and heat recovery systems. Nearly all commercial IGCC systems in operation or under construction are based on entrained-flow gasifiers. Commercial entrained-flow gasifier systems are available from GE Energy Gasification Technologies ("GE Energy"),[87] ConocoPhillips,[88] Shell, Prenflo, and Noell.[89]

The commercial gasification processes believed most suited for near-term IGCC applications using coal or petroleum coke feedstocks are the GE Energy,[90] ConocoPhillips, and Shell entrained-flow gasifiers.[91] Each of these technologies is currently deployed at an operating commercial IGCC facility.

In addition to incorporating an entrained-flow process, each of these gasification processes, and all of the gasification processes demonstrated to date for commercial IGCC use, are oxygen-blown systems.[92] Oxygen-blown gasification requires supplying a stream of compressed oxygen to the gasification reactor. The stream of oxygen is produced by a cryogenic oxygen plant commonly called an air separation unit (ASU). Cryogenic oxygen production is an established commercial process that is used extensively worldwide.[93]

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[85] Id., p. 1-8.
[86] Id., p. 1-10.
[87] GE Energy Gasification Technologies acquired the ChevronTexaco process July 1, 2004.
[88] ConocoPhillips acquired the patents and intellectual property rights to Global Energy's proprietary E-GAS gasification process in 2003. This technology was originally developed by Dow Chemical Company and later transferred to Destec, a partially held subsidiary of Dow Chemical. In 1997, Destec was purchased by Houston-based NGC Corporation, which became Dynegy, Inc. in 1998. In December 1999, Global Energy Inc. purchased the gasification technology from Dynegy and in 2003 ConocoPhillips purchased the technology from Global Energy (see DOE, Clean Coal Technology Topical Report Number 20, "The Wabash River Repowering Project—an Update," Sept. 2000, p. 4).
[89] NETL, Major Environmental Aspects, p. 1-10--1-11.
[90] See FN 65.
[91] SFA Pacific, Inc., "Evaluation of IGCC to Supplement BACT Analysis of Planned Prairie State Generating Station," May 11, 2003, p. 8.
[92] Id., p. 7.
[93] Id.

The compression of oxygen for oxygen-blown gasifiers requires costly compressors and utilizes substantial power. The auxiliary power requirements of the ASU account for the largest parasitic load on an IGCC facility utilizing an oxygen-blown gasifier.[94] One way to help reduce this parasitic load is to integrate the combustion turbine (CT) and ASU by extracting a portion of the air from the compressor of the CT to feed the ASU. However, because of reliability problems associated with 100 percent integration found at several demonstration facilities, current industry thinking in the U.S. is that about 50 percent integration is the maximum that should be used.[95]

The alternative to oxygen-blown gasification is air-blown gasification, which eliminates the need for the ASU. However, air-blown gasification results in the dilution of the syngas by nitrogen in the air, creating a syngas with a lower volumetric heating value.[96] As a result, air-blown gasification requires larger gasifiers, has lower fuel energy conversion efficiencies and creates additional technical challenges for the gas clean up and combustion turbine operation. Air-blown gasification also is less suited for cost-effective separation and capture of CO_2 emissions. For these reasons, the next generation of IGCC facilities are expected to be based on entrained-flow, oxygen-blown (rather than air-blown) gasification technologies.[97]

An entrained-flow, oxygen-blown gasification island, including the ASU and syngas cooling systems discussed below accounts for about 30 percent of the cost of a new IGCC facility.[98]

2.13. Syngas Cooling

Coal gasification systems operate at high temperatures and produce raw, hot syngas. Typically, the syngas is cooled from around 2,000°F to below 1,000°F (and the heat recovered). Cooling is accomplished using a waste heat boiler, or a direct quench process that injects either water or cool, recycled syngas into the raw syngas (a version of the GE Energy technology uses the quench method while Shell and ConcoPhillips have waste heat recovery systems). When a waste heat boiler is used, steam produced in the boiler is typically routed to the heat recovery steam generator (HRSG) to augment steam turbine power generation.[99]

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[94] Id., p. 14.
[95] Id.
[96] Id., p. 9.
[97] Id.
[98] EPRI/NETL, Appendix A, p. A-30.
[99] Id., p. 7-15.

2.14. Syngas Clean-up

Syngas clean-up generally entails removing particulate matter, sulfur and nitrogen compounds from the syngas before it is directed to the CT.[100] Particulate removal is accomplished using either ceramic or metallic filters located upstream of the heat recovery device, or by "warm gas" water scrubbers located downstream of the cooling devices.[101] The particulate material, including char and fly ash, is then typically recycled back to the gasifier. When filters are used, they are cleaned by periodically back pulsing them with fuel gas to remove trapped material.[102]

Next the syngas is treated in "cold-gas" clean up processes to remove most of the H_2S, carbonyl sulfide (COS) and nitrogen compounds. The gas treating processes employed to remove these compounds are well established in the natural gas production and petroleum refining industries.[103] The primary processes (called acid gas removal (AGR) processes) are chemical solvent-based processes (using aqueous solutions of amines such as methyl diethanolamine (MDEA)) and physical solvent-based processes (such as Selexol, which uses dimethyl ethers of polyethylene glycol, or Rectisol, which uses refrigerated methanol).[104] The Selexol and Rectisol processes are better adapted to remove CO_2 in the future. Sulfur recovery processes recover sulfur either as sulfuric acid or as elemental sulfur. The most common removal system for sulfur recovery is the Claus process, which produces elemental sulfur from the H_2S in the syngas that can be sold commercially.[105]

The cost of these gas clean-up systems and associated piping accounts for about 7 percent of total plant costs.[106]

2.15. Combined Cycle Power Block

After clean-up, the syngas is sent to the combined cycle power block. In a combined cycle system, the first generation cycle involves the combustion of the primary fuel--which can be oil, natural gas, or, in this case syngas--in a combustion turbine (CT). The CT powers an electric generator, may provide compressed air to the air separation unit or gasifier, and produces hot exhaust gases that are captured and directed to a heat recovery steam generator (HRSG) to produce steam for a steam turbine to complete the combined power cycle.[107]

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[100] Additional clean-up processes could also be employed for mercury removal and carbon separation to significantly reduce mercury and carbon dioxide emissions. See Section 2.31 below.
[101] NETL, Major Environmental Aspects, p. 1-12.
[102] Id.
[103] SFA Pacific, Inc., p. 10.
[104] Id.
[105] NETL, Major Environmental Aspects, p. 1-12.
[106] EPRI/NETL, Appendix A, p. A-30.
[107] NETL, Major Environmental Aspects, p. 1-13.

Syngas fuel is essentially interchangeable with natural gas as fuel for modern combustion turbines (the Wabash IGCC plant in Indiana currently switches between syngas and natural gas), but there are some process differences when syngas is used. The primary difference is that the volumetric heating value of cleaned syngas is about 20-30 percent that of natural gas, so a much larger volume of fuel is required with syngas firing to provide the necessary energy input to the CT.[108] This large volume requires different piping, control valves, and burners and results in a larger total mass flow through the CT. As a result, the power output of the CT increases. For example, the GE Frame 7FA+e CT has an output rating of 172 MW on natural gas, but an output rating of 197 MW on syngas.[109]

The combined cycle power block, including the CT, HRSG and steam turbine generator accounts for about 33 percent of the cost of an IGCC.

2.16. Balance of IGCC Plant

Other components of an IGCC facility include cooling water systems, ash and spent sorbent handling systems, electric plant accessories, instrumentation and control systems, on-site buildings and structures and site improvements.[110] Together these typically account for about 18 percent of plant costs. Table 2.2 summarizes the major components of an IGCC power plant and their approximate share of construction cost including contingencies.[111]

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[108] SFA Pacific, Inc., p. 12.
[109] Id.
[110] EPRI/NETL, Updated Cost and Performance Estimates, p. 4-72.
[111] Estimated share of plant costs based on a conceptual plant design and may be substantially different depending on the processes used, location of the facility and other plant or process-specific factors. In addition, IGCC power plants may include additional processes for removing mercury, separating and capturing CO_2, or producing various chemical outputs that are not included in the estimated breakdown in Table 1.2.

Table 2.2. Major IGCC Components and Approximate Share of Construction Costs

Process Description	Function	Share of Construction Cost
Coal Handling Equipment	Receive, prepare and feed coal feedstock into gasifier	12%
Gasifier, ASU and Syngas Cooling	Gasify coal into syngas; produce pure oxygen stream for gasification process, and cool raw syngas	30%
Gas Clean-up and Piping	Remove particulates, and acid gases from syngas	7%
Combined-Cycle Power Block	Generate electricity with syngas using a CT and steam turbine cycle	33%
Remaining Components and Control Systems	Cooling systems, spent ash and sorbent handling, controls and structures	18%
		100%

2.2. Operating IGCC Facilities used for Commercial Electricity Production

Five IGCC facilities designed for commercial electricity production are described below, including two in the U.S., two in Europe, and one in Japan. Four use coal and/or petroleum coke feedstocks, and one uses asphalt feedstock. Table 2.3 summarizes operating information for each facility.

2.21. Wabash Power Station, Terre Haute, Indiana

The Wabash Power Station IGCC plant began operation in 1996 and has been operating for more then eight years. The project was initiated in 1991 as a DOE Clean Coal Technology (CCT) program demonstration project. Construction began in July 1993 and was completed in November 1995. The project repowered an existing coal power plant by adding a gasification island and CT, and by refurbishing a steam turbine at the facility to extend its life and enable it to withstand the increased pressure and steam flow associated with combined cycle operation.[112]

The project was undertaken as a joint venture between Destec Energy Inc. of Houston (owner of the E-gas gasification process prior to ConocoPhillips) and PSI Energy, an investor owned utility in Indiana (now Cinergy). The plant is a 262 MW (net) facility utilizing the ConocoPhillips gasification process based on an entrained-flow, oxygen-blown, two-stage gasifier that uses natural gas for start-up. The facility was designed for and utilized bituminous coal for its first three years of operation, but later switched to petroleum coke for economic reasons. The total plant investment was $438 million ($1,680/kW in mid-2000 dollars), half of which was contributed by DOE.[113]

[112] NETL, Major Environmental Aspects, Appendix 1B-9.
[113] DOE, Clean Coal Technology Topical Report Number 20, p. 12.

The plant operating performance has generally improved over time as systems have been modified and optimized. From 1998-1999, during the plant's demonstration period, availability (including both the gasification island and the power train) was 62.4 percent, which improved to 73.3 in 2000, 72.5 percent in 2001, 78.7 percent 2002, and 82.4 percent in 2003.[114]

2.22. Polk Power Station, Polk County, Florida

The Polk Power Station is an IGCC plant built by Tampa Electric Company based on the entrained-flow, oxygen-blown GE Energy gasification technology. Like Wabash, it was built as part of the DOE CCT program, with a 50 percent cost share from DOE. Unlike Wabash, the Polk Station was built on a greenfield site, rather than being a repowering of an existing coal plant. Construction on the facility began in October 1994 and operation began in September1996.[115]

Polk Power Station is a 250 MW (net) facility that has utilized a variety of bituminous coals as well as a petroleum coke/coal mixture. The total direct cost of the project in 2001 dollars was $448 million ($1,790/kW). Tampa Electric estimates that incorporating the lessons learned and changes made at the plant, a plant of the same design could be built in 2001 dollars for $412 million ($1,650/kW).[116]

Like Wabash, the Polk Stations operating performance has been reliable. The availability of the gasification island steadily improved from just over 60 percent in 1998 to 80 percent in 2000. In 2001, two unplanned outages decreased the availability to 70 percent, but it increased back to 74 percent in 2002. Since 1998, the power block of the facility has had an availability of about 90 percent, because the turbines can be run on either syngas from the gasifier or distillate fuel.[117]

2.23. Willem Alexander IGCC Plant, Buggenum, The Netherlands

The Willem Alexander plant in Buggenum was commissioned in 1994, making it one of the first commercial IGCC plants in the world. The project was built and operated by Demkolec BV and is today owned by NUON.

The plant is a 253 MW (net) IGCC utilizing a Shell entrained-flow, oxygen-blown, dry feed gasifier. The plant, which was built to utilize a number of different imported coals, differs significantly from its counterpart in the U.S. in that it includes full integration of the gas turbine and ASU. This integration means that the turbine supplies all of the air to the ASU, which helps increase efficiency (the plant design efficiency is 43 percent LHV,

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[114] Keeler, Clifton, *"Operating Experience at the Wabash River Repowering Project,"* Presentation at the 2003 Gasification Technologies Conference, San Francisco, CA, Oct. 2003.
[115] NETL, "Tampa Electric Polk Power Station Integrated Gasification Combined Cycle Project Final Technical Report," Aug. 2002, p. I-1.
[116] Id., p. 4-1—4-2.
[117] Id., p. ES-5.

which is proven in practice), but makes it more complex and difficult to start, which affected its initial availability. After encountering operating problems mainly related to turbines in its initial years, design changes were made in 1997 that significantly improved plant performance. The plant operated at 84 percent availability in 2002 and 87 percent in 2003. The year-to-date May 2004 availability is over 95%

The plant served as an IGCC demonstration plant during initial years of operation and had been used to test different operating conditions and various feedstock with commercial scale. 14 types of coal, including 6 types of blend coal (ash content > 16%wt.; sulfur > 1%wt), have been successfully gasified. Because of the dry feed system, the plant consumes less water than slurry based systems and has no water discharge.

After the change of ownership to NUON, the plant management decided to operate the plant for commercial purpose and conducted programs aiming at achieving stable operation. As a result, the availability of the gasification system and thus the number of operating hours on syngas production has been increased significantly since 2001. The lifetime of the gasifier burners has proven to be well over 20,000 operating hours; and the lifetime of the filter candles in the HPHT filter has exceeded 25,000 operating hours. The thin refractory lining at the inner side of the gasifier membrane wall has not been replaced nor repaired since the plant started operations in 1994.

2.24. Puertollano IGCC Plant, Puertollano, Spain

The Puertollano plant is a 298 MW (net) IGCC owned and operated by Elcogas, a consortium of eight major European utilities and three technology suppliers. The plant utilizes a Prenflo gasifier, which is an entrained-flow, oxygen-blown system with dry fuel feeding.[118]

Similar to the Willem Alexander plant, the Puertollano plant has full integration of the gas turbine and ASU, which enables it to operate at a high efficiency (45 percent LHV basis), but has reduced the operating performance of the facility. In 2000 and 2001, the plant availability was around 60 percent, substantially below what is generally required of a commercial coal generating facility in the U.S.[119]

2.25. Negishi IGCC Plant, Negishi, Yokohama Japan

The Negishi IGCC facility is owned by Nippon Petroleum Refining Co. and started commercial operation in June 2003. At 342 MW (net) it is the largest IGCC plant currently in operation. The facility is based on a GE Energy Direct Quench Type gasifier and is designed to utilize a variety of feedstocks. As of August 15, 2003, the facility had 1,128 hours of commercial operation with a 99.3 percent power block availability and

[118] NETL, Major Environmental Aspects, p. 1B-12.
[119] Id.

96.1 percent gasification syngas availability. The facility employs an advanced sulfur recovery system that removes 99.8 percent of sulfur from the syngas.[120]

Table 2.3. Summary Statistics for Commercial Electricity Generation IGCC Plants

	Wabash Power Station	Polk Power Station	Willem Alexander	Puertollano	Negishi
Owner	Cinergy/ ConocoPhillips	Tampa Electric	NUON	ELCOGAS	Nippon Refining
Location	Indiana, US	Florida, US	Netherlands	Spain	Japan
Capacity (MW net)	262	250	253	298	342
Gasifier	ConocoPhillips	GE Energy	Shell	Prenflo	GE Energy
Gas Turbine	GE MS 7001FA	GE MS 7001FA	Siemens V 94.2	Siemens V 94.2	MHI 701F
Efficiency (% HHV)	39.7	37.5	41.4	41.5	Unk.
Heat rate (Btu/KWh HHV)	8,600	9,100	8,240	8,230	Unk.
Fuel Feedstock	Bit. coal/ pet coke	Bit. coal/ pet coke	Bit. coal	Bit. coal/ pet coke	Asphalt
Particulate control	Candle filter	Water scrubber	Candle filter	Candle filter	Unk.
Acid gas clean-up	MDEA scrubber	MDEA scrubber	Sulfinol M	MDEA scrubber	Shell Adip
Sulfur recovery	Claus plant	H_2SO_4 plant	Claus plant	Claus plant	Lurgi Oxyclaus
Sulfur by-product	Sulfur	Sulfuric acid	Sulfur	Sulfur	Unk.
Sulfur Recovery (%)	99% design	98% design	99% design	99% design	99.8%
NOx control	Steam dil.	Nitrogen & steam dil.	Syngas sat & nitrogen dil.	Syngas sat & nitrogen dil.	Unk.

[120] Ono, Takuya, "NPRC Negishi IGCC Startup and Operation," presented at Gasification Technologies 2003, Oct. 12-15, 2003, San Francisco, CA. 2003, San Francisco, CA.