Appendix 12

TOP-DOWN COMMERCIAL EVALUATION OF IGCC

APPENDIX 12 – INTEGRATED GASIFICATION COMBINED CYCLE

Introduction

A top-down analysis of Integrated Gasification Combined Cycle (IGCC) was conducted to evaluate the technology against that of the WPES (a pulverized coal boiler equipped with an SCR, dry scrubber, and baghouse). The analysis takes a five step approach: (1) describe the technology, (2) eliminate the technology from further analysis if it is determined to be infeasible, (3) rank the technologies according to control effectiveness, (4) analyze the economic, energy, and additional environmental impacts of the technologies, and (5) select the most appropriate technology based on the determinations of steps 3 and 4.

Step 1 - Control Technology Description

IGCC is a power generation method by which coal (or other solid or liquid feedstock such as pet coke or heavy oil) is gasified and used as the feedstock for a combustion turbine combined cycle power block. Coal-fired power generated in this manner has the potential to be more efficient and have fewer emissions than if generated from a PC fired boiler.

IGCC technology is still developing with regard to providing syngas to combustion turbines on a high availability basis. This technology is a combination of process equipment from the petroleum industry (gasification to generate syngas) and the power industry (gas turbines to efficiently burn the syngas to achieve high efficiency). Gasification is used worldwide to produce a variety of other products. IGCC, however, has limited experience operating on "F" combustion turbine technology (two units operating in the US and two or three others in the world.) In addition to the poorer reliability, the anticipated cost to construct an IGCC plant is significantly greater than for a PC plant. Absent federal or state funding to offset the reliability risks and additional cost requirements, the combination of these factors makes it extremely difficult to develop and finance an IGCC project in a competitive marketplace. This conclusion is supported by a February 2004 Symposium hosted by the Belfer Center for Science and International Affairs at the Kennedy School of Government, Harvard University.[1]

Technology

There are four primary processes in an IGCC power plant: gasification, synthetic gas (syngas) cleanup, cryogenic air separation, and gas turbine combined cycle. Gasification is the process of converting a liquid or solid feedstock (in a gasifier) to a gas mixture primarily composed of hydrogen and carbon monoxide referred to as synthetic gas (syngas). The cryogenic air separation unit provides the oxygen necessary for the gasification process and can be integrated with the combined cycle power block to provide nitrogen gas to the gas turbines to reduce NO_x emissions. Impurities such as sulfur compounds, metals, alkalytes, ash, and ammonia must be removed from the syngas in the gas cleanup process to prevent corrosion of the gas turbine. After it is cleaned, the syngas is combusted in the gas turbine which is part of the combined cycle power block.

[1] The working paper can be found at
http://bcsia.ksg.harvard.edu/BCSIA_content/documents/FinancingIGCC.pdf

Gasifiers

There are three generic configurations for a gasifier: moving-bed (fixed-bed) reactor, fluidized-bed reactor, and entrained-flow reactor. In a moving-bed reactor, large particles of coal move slowly down through the gasifier while reacting with gases moving up through it. The counterflow pattern creates several different reaction zones that accomplish the gasification process at temperatures averaging 1,470°F to 1,830°F. Fluidized-bed reactors continuously feed coal into a 1,470°F to 1,650°F reactor so that coal at all stages of the reaction process is in the same reaction zone. Steam and oxygen/air are fed from the bottom and rise up through the bed of coal. Entrained-flow reactors mix a stream of fine coal particles with steam and oxygen/air at high temperatures of 2,730°F to 3,450°F to create a stream of tar and oil free crude gas. Each gasifier configuration can be designed to utilize air or oxygen to react with the coal for syngas creation. Each different configuration of gasifier is available from numerous vendors, although only oxygen-blown systems have currently been proven at commercial scale. Air blown systems have been attempted but not successfully scaled up to commercial size as evidenced by experience at the air-blown fluidized bed KRW gasifier at the Piñon Pine IGCC facility near Reno, Nevada in the mid-1990's.

Each of the technologies converts carbon based feedstock in the presence of oxygen and steam while at high pressure and temperature into syngas which is primarily composed of hydrogen gas and carbon monoxide. In addition, the raw syngas contains carbon dioxide, moisture, hydrogen sulfide, carbonyl sulfide, methane, ammonia, hydrogen chloride, and trace amounts of other components present in the feedstock.

Syngas Cleanup

The syngas typically exits the gasifier at 2,200°F to 3,000°F. The gas must be cooled to 1,000°F to 1,250°F to condense alkalis in the flue gas stream prior to entering the gas turbine where they would cause corrosion and/or erosion. Cleanup at temperatures of 1,000°F to 1,250°F is still being researched as the previous attempts at commercial sized hot gas cleanup units (HGCU's) have failed. Cold gas cleanup at a temperature of approximately 400°F is a proven technology where the majority of the hydrogen sulfide, carbonyl sulfide and nitrogen is removed from the syngas. As an additional cleanup process, mercury removal from the syngas has been proven through the use of adsorbent beds. Separation of carbon dioxide is also possible for sequestration or other disposal.

Cryogenic Air Separation

Current gasification processes require a compressed oxygen feed to the gasifier generated with an Air Separation Unit. Compressed oxygen generation is well proven commercially and used extensively worldwide. The process is very expensive and consumes a large amount of energy.

Gas Turbine Combined Cycle

The purified syngas is fed into a gas turbine combined cycle power block. Due to the lower heat content of syngas relative to natural gas, the mass flow through the turbines is much higher with syngas thereby affecting the ease at which some gas turbines can be converted to syngas use. In addition to the syngas, nitrogen or steam can be injected into the gas turbines to reduce the flame temperature and thus reduce the NO_x emissions.

History

While gasification technology has existed since the 1870's and was used extensively by Germany, France, and Britain during World War II to create fuel, the integration of gasification equipment with a combined cycle power block for electricity production is not yet a mature technology. In general, there have been two generations of IGCC power plants built. Both generations have relied heavily upon government funding and financing. Table 12.1 below summarizes the demonstration and commercial IGCC coal-fired power plants built to date which utilize oxygen-blown, pressurized entrained flow gasification.

Table 12.1 – IGCC Coal-Fired Power Plant Summary

Plant	Location	Operation	Power MW (net)	Design Feedstock	Gasification Process	ASU-CT Integration	Financial Support
SCE Cool Water	Barstow, California	1984-1988	120	Bit. Coal	Texaco	None	EPRI and Utility Consortium
LGTI (Destec/Dow)	Plaquemine, Louisiana	1987-1995	160	Subbit. Coal natural gas blend (80/20)	E-Gas	None	Partial DOE
NUON (Demkolec B.V.)	Buggenum, The Netherlands	1994 – present	254	Bit. coal	Shell	100%	Netherlands gov't support
Global Energy – PSI Wabash River (Destec)	Terre Haute, Indiana	1996 – present	262	Bit. Coal (now 100% petcoke)	E-Gas	None	Partial DOE
TECO Polk Power Station	Polk, Florida	1996 – present	250	Bit. Coal and Petcoke	Texaco	None	Partial DOE
Frontier Oil & Refining Co.	El Dorado, Kansas	1996 – present	40 (cogen)	Petcoke	Texaco	<25%	State tax-exempt bonds for use of petcoke
Elcogas S.A.	Puetollano, Spain	1997 – present	321	Coal & Petcoke	PRENFLO	100%	Spanish gov't support
Motiva Enterprises Refinery	Delaware City, Delaware	2000 – present	180	Petcoke	Texaco	N.A.	State tax-exempt bonds for use of petcoke

While several of the plants were originally designed to operate on coal, of the six IGCC plants operating, only one fires exclusively coal while the rest fire either a combination of petcoke and coal or 100% petcoke. In a report for Illinois on the possibility of using IGCC at the Prairie State Generating Station, SFA Pacific noted that switching to petcoke improved the availability of the Wabash River facility.[2] Thus, gasification of petcoke is not directly comparable to gasification of coal and the global experience of coal gasification is far more limited than is generally suggested.

There are currently six IGCC technology owners, none of whom directly sell an IGCC or gasification plant. These owners license the technology to a third party who will be responsible for the detailed design and erection. While two of the owners have partnered with construction firms, neither consortium has yet provided a firm cost and guarantees.

Performance

According to a 2002 paper published by GE Power Systems, the efficiency of IGCC units can theoretically reach 52%. However, the efficiencies of the four commercially operating facilities in Table 12.1 (Global Energy – PSI Wabash River, TECO Polk Power Station, NUON and Elcogas) range from 37.5% to 41.5%. These efficiencies are comparable to the performance of recent PC facilities.[3]

PC-fired generation is expected to have a minimum reliability of 90%, a target generally achievable within the first year of commercial operation. In comparison, recent plant availabilities for the Elcogas, Polk, Wabash River, and NUON facilities were only 60%, 73%, 77%, and 86%, respectively.[4] In addition, an article in the March 2004 *Power Engineering* magazine reported that three to four years was necessary at U.S. IGCC plants to achieve these 60% to 86% levels of mature reliability.

Although not an IGCC plant, the Eastman Kodak Facility in Tennessee has been cited as a successful implementation of gasification technology due to its 2000 to 2003 reliability of 98.1%. It is important to note that this facility is equipped with a spare gasifier which adds significantly to the capital cost. Eastman Kodak estimates the reliability would only be 88% to 90% if it were not equipped with a spare gasifier. It should be noted that Eastman Kodak has achieved this level of reliability in part due to having 20 years of operating experience with this facility.[5]

The operational flexibility of IGCC units is significantly less than that of PC-fired generation. PC-fired generation has proven operating flexibility to operate as baseload, load-following, and on-off cycling units. Minimum load is 25% to 30% range, without supplemental fuel. IGCC is best operated only as baseload. For a 2x2x1 configuration, with two combustion turbines (CTs) and gasifiers, some load following can be accomplished, either by load reducing on individual CTs (range is 60% to 100%) or shutting down a gasifier/CT train. The gasifiers are best operated at a constant rate rather than cycled. The operating range of the gas turbine is typically 60% to 100%, with the heat rate deteriorating at lower loads.[6]

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[2] SFA Pacific, Inc, "Evaluation of IGCC to Supplement BACT Analysis of Planned Prairie State Generating Station," May 11, 2003.
[3] Rosenberg, William G. et al., "Financing IGCC – 3Party Covenant," BSCIA Working Paper 2004-01, Energy Technology Innovation Project, Belfer Center for Science and International Affairs, page 33.
[4] SFA Pacific, Inc, "Evaluation of IGCC to Supplement BACT Analysis of Planned Prairie State Generating Station," May 11, 2003.
[5] Trapp, Bill et al., "Coal gasification: Ready for prime time," *Power Engineering* March 2004.
[6] Sargent & Lundy, LLC, "New Coal Generation Technology Assessment Study." November 2005

Step 2 - Eliminate Technically Infeasible Options

IGCC technology has limited commercial experience and WPEA does not yet consider the technology to be a reliable source of coal electrical generation. The Department of Energy has the commercialization of IGCC by 2015 as one of its objectives, supporting the position that it is not a true commercial option today.

There are no IGCC units which either currently or historically operated on 100% PRB coal. The lack of experience is shown by the recent funding provided to build a PRB-fired IGCC demonstration unit in Orange County, Florida. While vendors claim that PRB can be gasified, they also indicate that the fuel feed system and overall heat rate will be affected. GE, one of the IGCC technology owners, presented that PRB coal is only ready for gasification in the short term if blended with petcoke.[7]

However, based on the criteria of broader (coal, not specifically PRB) commercial sales and permit history, for the purposes of this analysis, IGCC is considered technically feasible.

Step 3 - Rank Control Technologies

One often stated benefit of IGCC technology is the potential for lower emissions than what is achievable by PC units. However, the demonstrated emission rates of the TECO, Global Energy and LGTI plants have not shown the emissions from IGCC units to be significantly better than those of a PC plant. In fact, emissions of NO_x and SO_2 are higher than for a PC plant equipped with SCR and scrubber. While it is possible to further reduce the pollutant emissions through modifications to the control process or addition of specialized pollution control units, this would further add to the cost and complexity of an IGCC plant.

SO_2

The lowest SO_2 emissions demonstrated by an operating IGCC facility on an annual average basis was 0.132 lb/MMBtu, however, this same plant has shown annual average SO_2 emission rates as high as 0.266 lb/MMBtu. The demonstrated SO_2 emissions of this facility and others are shown in Table 12.2 below.

In addition to the emission levels shown below, the Polk and Wabash River facilities generate additional SO_2 emissions as a result of tail gas incinerators converting trace acid gas components leaving tank vents to their oxide forms (SO_2, NOx, H_2O and CO_2) and SO_2 being liberated from the combustion of syngas that must be flared during startup and shutdown periods or turbine malfunctions and trips.

Two permitted IGCC projects, Lima Energy and Kentucky Pioneer Energy, have proposed SO_2 emission limits that are lower than what has been demonstrated by existing projects. These limits are summarized in Table 12.2. Neither the Lima Energy nor Kentucky Pioneer facility have been constructed, therefore, these SO_2 emission limits have not been demonstrated and should not be considered a reliable point of comparison for such an immature technology.

The Taylorville Energy Center and Southern Illinois Clean Energy Center (SICEC) are two recently proposed projects which have not yet been permitted. These proposed projects are

[7] GE, "The IGCC Option," California Energy Commission Workshop, August 17, 2005.

included to demonstrate the wide variability in proposed emission rates from IGCC plants.

A comparison of the proposed WPEA limit to proposed and demonstrated IGCC SO_2 emission rates is presented in Table 12.2.

Table 12.2 – Ranking of SO_2 Emission Rates

Facility	SO_2 (lb/MMBtu)	Averaging Period	Plant Type	Notes
Lima Energy	0.021[8]	12-month avg	IGCC	Permitted not constructed
Kentucky Pioneer	0.032[9]	3-hour avg	IGCC	Permitted not constructed
SICEC	0.033	30-day rolling avg	IGCC	Proposed
Taylorville Energy Center	0.045	3-hour avg	IGCC	Proposed
WPEA	0.09	24-hour rolling avg	PC with dry scrubber	Proposed
TECO Polk	0.135 – 0.224	Annual avg	IGCC	Demonstrated
Global Energy Wabash River	0.132 – 0.266	Annual avg	IGCC	Demonstrated
LGTI	<0.15	Annual avg	IGCC	Demonstrated

NO_x

The lowest NO_x emissions demonstrated by an operating IGCC facility on an annual average basis was 0.09 lb/MMBtu, however, this same plant has shown annual average NO_x emission rates as high as 0.15 lb/MMBtu. The demonstrated NO_x emissions of this facility and others are shown in Table 12.3 below.

Two permitted IGCC projects, Lima Energy and Kentucky Pioneer Energy, have proposed NO_x emission limits that are lower than what has been demonstrated by existing projects. These limits are summarized in Table 12.3. Neither the Lima Energy nor Kentucky Pioneer facility have been constructed, therefore, these NO_x emission limits have not been demonstrated and should not be considered a reliable point of comparison for such an immature technology.

The Taylorville Energy Center and SICEC are two recently proposed projects which have not yet been permitted. These proposed projects are included to demonstrate the wide variability in proposed emission rates from IGCC plants.

A comparison of the proposed WPEA limit to proposed and demonstrated IGCC NO_x emission rates is presented in Table 12.3.

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[8] The proposed IGCC emission limits were converted to a lb/MMBtu basis by dividing the stated lb/hr value by the maximum heat input to the plant. If operating at a reduced load, the emissions (on a lb/MMBtu basis) would be higher than the value stated in Table 12.2.
[9] Ibid

Table 12.3 – Ranking of NO_x Emission Rates

Facility	NO_x (lb/MMBtu)	Averaging Period	Plant Type	Notes
Taylorville Energy Center	0.058	24-hour rolling avg	IGCC	Proposed
SICEC	0.059	30-day rolling avg	IGCC	Proposed
WPEA	0.07	24-hour rolling avg	PC with SCR	Proposed
Kentucky Pioneer	0.0735	3-hour avg	IGCC	Permitted not constructed
Lima Energy	0.097	12-month avg	IGCC	Permitted not constructed
TECO Polk	0.09 to 0.15	Annual avg	IGCC	Demonstrated
Global Energy Wabash River	0.14 – 0.17	Annual avg	IGCC	Demonstrated
LGTI	0.26	Annual avg	IGCC	Demonstrated

PM_{10}

Table 12.4 below indicates that demonstrated and proposed filterable PM_{10} emission rates are 0.011 lb/MMBtu and below for operating IGCC facilities. These low PM_{10} emission rates are achievable because most of the coal ash is recovered as slag or bottom ash from the gasifier. Ash entrained in the syngas is removed in the gas cleanup process prior to combustion in the gas turbine.

A comparison of the proposed WPEA limit to proposed and demonstrated IGCC PM_{10} emission rates is presented in Table 12.4.

Table 12.4 – Ranking of PM_{10} Emission Rates

Facility	PM_{10} (lb/MMBtu)	Averaging Period	Plant Type	Notes
Taylorville Energy Center	0.007	30-day rolling avg	IGCC	Proposed
SCIEC	0.00924	30-day rolling avg	IGCC	Proposed
LGTI	<0.01	Annual avg	IGCC	Demonstrated
Lima Energy	0.010	12-month avg	IGCC	Permitted not constructed
Kentucky Pioneer	0.011	3-hour avg	IGCC	Permitted not constructed
TECO Polk	0.011	Annual avg	IGCC	Demonstrated
Global Energy Wabash River	0.011	Annual avg	IGCC	Demonstrated
WPEA	0.015	3-hour avg	PC with fabric filter	Proposed

Step 4 - Evaluate Economic, Energy and Additional Environmental Impacts

The economic, energy and environmental impacts of the technologies are discussed below.

Economic Impacts

Published estimates of the costs to construct an IGCC plant are substantially higher than the estimated cost to construct a PC plant. An article in the November 2003 issue of *Power Engineering* stated that if all the costs for the Polk IGCC plant had been included in the price, the cost would have changed from $1,650 per kW to $2,430 per kW. At the 2003 Coal-Fired Generation Symposium, Burns & McDonnell, a consulting firm specializing in power plant EPC projects, presented that the true cost for an IGCC unit would be approximately $2,500 per kW for all the necessary redundancies to be included. Including all the modifications prior to mothballing, the Piñon Pine IGCC unit in Nevada had a cost of $3,393 per kW.[10] For comparison, an often cited approximate cost for a PC facility is $1,200 per kW.

IGCC cost estimates are significantly affected by the type of fuel burned. PRB coal, due to the high moisture and low heat rate require larger or more gasifiers to process sufficient fuel for the CTs and depending on the type of IGCC technology used (air blown versus slurry), the coal may have to be dried prior to gasification further increasing the costs. PRB coal also has a low fixed carbon ratio increasing the difficulty of gasification. The low fixed carbon is the reason GE presently will only sell a PRB/petcoke blend gasification system; a 100% PRB system is not available.

A report prepared by Sargent & Lundy estimates both construction and comparative busbar generating cost estimates for IGCC and PC technology for a generic, green-field 800 MW project to be located in Texas. IGCC construction costs were estimated at more than 30% higher and IGCC busbar generating costs were estimated at more than 24% higher than a PC plant. as shown in Tables 12.5 and 12.6 below.[11]

Table 12.5 – Comparison of PC and IGCC Construction Costs for PRB Coal

	PC	Present IGCC	Future IGCC*
Total project cost, $MM	$1,341	$1,761	$1,812
$/kW overall project costs	$1,673	$2,185	$2,248
Differences, $/kW	Base	30.6%	34.4%

* Assumes a lower heat rate than is currently achievable.

[10] February 12, 2003 letter from Indeck Elwood to IL EPA on Supplemental IGCC information for Indeck PSD permit application.
[11] Sargent & Lundy, LLC, "New Coal Generation Technology Assessment Study." November 2005

Table 12.6 – Comparison of PC and IGCC Busbar Generating Costs for PRB Coal

	Levelized $/MWh Over Thirty Years, From 2009		
	PC	**Present IGCC**	**Future IGCC***
Total $/MWh	$51.09	$63.68	$63.09
Differences, Percent	Base	24.6%	23.5%
Differences, $/MWh	Base	$12.59	$12.00

* Assumes a lower heat rate than is currently achievable.

In a February 2004 symposium held at the John F. Kennedy School of Government at Harvard University a method was presented by which an IGCC plant could potentially be commercially financed. The corresponding working paper summarized various reported capital costs for PC plants at $1,022 to $1,154 per kW with an outlier cost for the WE Power Elm Road Generating Station at $1,415 per kW. The costs reported for IGCC units ranged from $1,070 to $1,876 per kW for single gasifier systems. Not all of the reported costs included the option of a spare gasifier. The published costs that included a redundant gasifier ranged from $1,160 to $1,670 per kW. Additionally, costs for gasification of subbituminous coal increased the price by $170 to $270 per kW over that of bituminous coals due to inefficient gasification requiring larger equipment. The conclusion of the paper was that the only way for an IGCC plant to be economically feasible was to have a three party arrangement in which power sales were guaranteed through a state Public Utility Commission, low interest loans were backed by the federal government, and a third party provided 20% equity. The paper concluded that only in this manner would the costs for an IGCC plant be competitive with those from a PC plant.[12]

Not included or discussed in the above cost estimates, construction of an IGCC plant today would first require a Front End Engineering and Design (FEED) study, estimated at $5 to $8 million dollars and one year of time. The result of the FEED study is not the final design and is insufficient for start of construction. Conversely, an EPC contractor for a PC plant will provide a fixed price proposal with guarantees for no cost. Thus, IGCC is still at such a level of infancy that significant development costs are required upfront to evaluate the process.

Perhaps even more compelling are the recent decisions by regulatory agencies that IGCC technology is not cost effective. In the 2003 Wisconsin Public Utilities Commission decision on the Elm Road Power Station, the Commission determined that "IGCC technology, while promising, is still expensive and requires more maturation. For these reasons, the application to construct the IGCC unit is denied."[13] In addition, in the March 17, 2004 Draft EIS for the WPS Weston Unit 4 Power Plant, the Public Service Commission and Wisconsin Department of Natural Resources stated that the "PSC analyses of an IGCC plant for WEPCO's [We Power] CPCN application for the Elm Road Generating Station concluded that the IGCC plant was not cost-effective in any circumstance. Since that case, no significant improvements to the technology have been made and an update of that analysis has not been necessary."

In yet another case, SFA Pacific, Inc. in its May 11, 2003 filing to the Illinois EPA, found that for the Prairie State Energy Campus, the costs of producing electricity using an IGCC plant would be 33% to 36% higher than for the proposed PC plant. The Illinois EPA supported that finding in its issuance of an air permit for construction of PC boilers at the Prairie State Energy Campus. Finally, the Arizona Corporation Commission stated that "IGCC is not yet a mature, reliable or

[12] http://bcsia.ksg.harvard.edu/BCSIA_content/documents/FinancingIGCC.pdf
[13] Wisconsin Electric Power Co. 228 PRU4th 444, 2003 WL 22663829 at 26 (Wisc. P.S.C. Nov. 10, 2003)

economic technology alternative for the SGS [Springerville Generating Station]."[14]

The decision of American Electric Power (AEP) to build an IGCC plant has been cited as an example of the competitive nature of IGCC to PC, however, on its website, AEP states that "AEP will build one or more IGCC units, providing that costs can be recovered through the regulatory process."[15]

Assuming an IGCC facility to be $512 per kW more expensive to install than a similarly sized PC facility, and assuming that the lowest proposed emission limits of IGCC facilities were achievable, the incremental removal cost for SO_2, PM_{10}, and NO_x emissions was estimated to be $187,000, $1,614,000, and $1,076,000 per ton, respectively.

Energy and Additional Environmental Impacts

The net heat rate for a new PC technology ranges from 9,000 – 12,000 Btu/kWh and has been assumed to be 9,842 Btu/kWh for the WPES in this application. The goal of IGCC technology is to achieve a heat rate less than 8,800 Btu/kWh. Table 12.7 below shows the actual historical heat rates and capacity factors for the Polk and Wabash River IGCC facilities. As shown by the Table, the demonstrated capability of IGCC is not more efficient than the PC plant proposed for the WPES.[16]

Table 12.7 – Polk and Wabash River Historical Heat Rate and Capacity Factors

	Polk		**Wabash River**	
	Heat Rate Btu/kWh	**Capacity Factor**	**Heat Rate Btu/kWh**	**Capacity Factor**
1996	N/A	11.54	22,152	9.18
1997	N/A	45.38	11,716	34.95
1998	N/A	62.37	11,341	52.44
1999	9,877	70.2	10,225	32.88
2000	10,378	77.01	8,746	44.54
2001	10,725	63.46	9,244	36.08

The high elevation of the WPES site will also cause further degradation of the CT, increasing the heat rate of an IGCC plant at this locale.

While the potential efficiency of an IGCC plant is theoretically higher than what is achievable with a pulverized coal facility, the lower reliability of IGCC plants and the resulting increase in the number of annual starts, shutdowns, and malfunctions has the potential to consume additional energy from the grid and/or increase the total annual emissions emitted from the facility. An IGCC facility firing syngas will also take longer to startup than does a PC plant. Comparative startup times are shown in Table 12.8 below.[17]

[14] Arizona Corporation Commission Decision No. 65347
[15] http://www.aep.com/about/igcc/default.htm
[16] Sargent & Lundy, LLC, "New Coal Generation Technology Assessment Study." November 2005
[17] Ibid.

Table 12.8 – Startup Times

Start Type	PC	IGCC Backup	IGCC Syngas
Hot Start (shutdown less than 8 hours)	2-1/2 hours	0.75 to 1 hour	<6 hours
Warm Start (shutdown 8 to 36 hours)	3-1/2 hours	1.15 to 2 hours	<36 hours
Cold Start (shutdown greater than 36 hours)	5 hours	2 to 3 hours	<48 hours

The potential for an increase to the total annual emissions from the facility is due to the fact that emission rates are generally much higher from a combustion turbine during startups and shutdowns than with baseload operation.

For the power block alone, IGCC requires approximately 40% to 65% more space than a PC unit. However, the solid waste disposal area for an IGCC will be less and can be significantly reduced if the sulfur and slag byproducts can be sold. Due to the remote nature of the WPES, it is not expected that there will be a profitable market for either product.

<u>Step 5 - Select Technology</u>

The coal-fired IGCC power plant is not yet a mature technology and as such it is still receiving government and other demonstration funding. General Electric, one of the major IGCC technology owners, has indicated it cannot presently design based on 100% PRB coal plant due to problems gasifying PRB coal. Plant availability is expected to be approximately 15 percentage points lower than that of a PC plant and IGCC technology does not allow for the operating flexibility of a PC plant (i.e. longer startup times, less load following capability). The capital cost of an IGCC plant is estimated to be 15% to 145% higher than a PC plant with a great deal of uncertainty surrounding pricing and performance guarantees. The potential efficiency improvements for an IGCC plant have not been reliably and commercially demonstrated and any efficiency improvements would be penalized due to combustion turbine derating at the high elevation of the proposed WPES site. The demonstrated SO_2 and NO_x emission rates from coal-fired IGCC facilities are higher than the emission rates expected from the proposed PC facility. While the PM_{10} emission rates and proposed (but unproven) SO_2 and NO_x emission rates are lower with an IGCC facility, the lack of commercial experience, lower availability and reliability, higher capital cost, and unproven environmental benefits for a similarly sized IGCC facility does not justify the selection of IGCC technology. The purpose of the proposed White Pine Energy Station is to be a reliable, low cost, baseload electric generation facility which can only be accomplished with a PC plant.