5.0. IGCC ECONOMICS AND IMPACT OF 3PARTY COVENANT

Commercial investment in IGCC technology will require that cost of energy output be competitive with other generation technologies. In particular, IGCC must be cost competitive with PC generation so that developers looking to build coal capacity and state PUCs that approve cost recovery in utility rates see IGCC as a legitimate choice. The capital investment required to build the next generation of IGCC plants is generally estimated to be approximately 20 percent higher than investment required to build the next generation of PC plants, which translates into 10-15 percent higher energy cost. The 3Party Covenant more than offsets this cost differential with lower cost of capital by allowing for 80 percent federally guaranteed debt, a significantly higher percentage of debt at a lower interest rate than available under traditional utility financing. The discussion below reviews the basic cost components of IGCC power plants, summarizes IGCC cost data and estimates, and demonstrates how the 3Party Covenant reduces IGCC cost of energy to levels below PC cost of energy.

5.1. Power plant cost components

The cost of energy ($/MWh) produced by an IGCC or other power plant is a function of the Total Plant Investment, Owner's Costs, operating cost, fuel costs, and Cost of Capital. Each of these cost components is described below along with a review of how these costs are used to calculate cost of energy.

5.11. Total Plant Investment

Total Plant Investment is the total investment required to build a power plant. It includes the "Overnight Capital Cost," which is the cost of erecting the plant, plus Construction Financing Costs.

5.12. Overnight Capital Costs

Overnight Capital Costs refer to the cost of erecting the plant, including construction contingencies, but not considering Construction Financing, Owners Costs, or Cost of Capital. Typically, power plant developers hire an EPC firm to provide a cost bid for designing and building a power plant facility, which includes the firm's engineering and construction fees and procurement costs, and is the basis for estimating the Overnight Capital Cost. Most studies that compare capital costs of different types of power plants refer to the Overnight Capital Cost as the basis for comparison. The Overnight Capital Cost is sometimes referred to as the Total Plant Cost, or Engineering, Procurement, and Construction cost (EPC).

5.13. Owner's Costs

In addition to the cost of constructing a new coal power plant (IGCC or PC), there are costs associated with developing and starting up the facility. These costs, referred to as Owners Costs, include things such as the cost of land, initial engineering, legal, site improvements, and transmission interconnects, as well as start-up costs such as the initial chemicals (primarily for emissions control) and fuel, security, personnel training, and initial operational testing of the facility. These costs can very significantly from one facility to the next depending on the location, site characteristics, plant design, and other factors. Although a generalized estimate of Owner's Costs will not accurately depict all facilities, it is useful to assume some level of cost in order to achieve an estimate of Total Plant Investment.

For the purposes of calculating energy costs in this report, Owner's Costs are assumed to be 10 percent of Overnight Capital Costs for both PC and IGCC plants under traditional utility financing scenarios. In the 3Party Covenant IGCC scenarios, the capitalized Construction and Operating Reserve Fund is added to Owner's Cost, making the Owner's Costs 20 percent of the Overnight Capital Cost. Owners Costs are accounted for in the Levelized Carrying Charge, which is discussed in Section 5.17 below and calculated in Appendix B.

5.14. Construction Financing

In addition to Owners Costs, building a power plant requires financing during the construction period. Construction Financing Costs refer to the cost of equity and debt financing during the design and construction period, which is typically about 4 years (about two years of actual construction) for both IGCC and PC power plants.

Construction Financing Costs are important because, unless they are recovered during the construction period (as return on capital on Construction Work in Progress (CWIP)), they are accrued (the accrual is sometimes described as the Allowance for Funds Used During Construction (AFUDC)) and rolled-into the ultimate cost of the plant that must be paid for with long-term financing. Typically, Construction Financing Costs that are accrued for a coal power plant (IGCC or PC) are 10-15 percent of the Overnight Capital Cost.

For the purposes of calculating energy costs in this report, Construction Financing Costs are calculated assuming a four year design and construction period with level investments each year. Construction Financing Costs are added to the Overnight Capital Cost to calculate Total Plant Investment. Construction Financing Costs are calculated as part of the Levelized Carrying Charge (see Section 5.17 below and Appendix B).

5.15. Cost of Capital

Cost of Capital refers to the weighted costs of common stock, preferred stock and long-term debt used to finance a power plant project (i.e., equity returns and debt interest rate). A typical capital structure for a utility company is about 45 percent equity (common and preferred stock) and 55 percent long-term debt.[142] In regulated markets, typical after tax returns allowed for utilities are around 11.5 percent.[143] With a federal tax rate of 34 percent and average state tax rate of 4.2 percent (for a combined 38.2 percent tax rate), the pre-tax return required to achieve an 11.5 percent after-tax equity return is 18.6 percent. Mid-grade utility debt in early 2004 yielded around 6.5 percent.[144]

5.16. Operating costs

Power plant operating costs are typically broken into fuel costs and non-fuel operating and maintenance (O&M) costs. Although coal is a relatively inexpensive fuel source, fuel costs are still a significant operating cost component, typically accounting for 20 to 25 percent of the cost of energy from an IGCC or PC power plant. Fuel costs (on a $/MWh of output basis) are a function of the price of the fuel and the heat rate or efficiency[145] of the power plant. More efficient plants use less fuel per MWh of generation and, assuming the same delivered coal price, have lower fuel costs. As noted above, the efficiency of current IGCC technology is similar to the efficiencies of new PC power plants (both tend to be 35-42 percent efficient), so fuel costs will be likely be similar for IGCC and PC for the next generation of IGCC. Assuming IGCC efficiency improves as the technology is commercially deployed, IGCC fuel costs should decline relative to PC.

O&M costs include labor, maintenance material, administrative support, consumable materials (such as chemicals and water), and waste disposal. O&M costs typically account for about 20 percent of the cost of energy from an IGCC power plant and are generally similar to PC plant O&M costs. Although different gasifier designs and plant-specific characteristics can affect O&M costs, for the purposes of calculating energy costs in this report, O&M costs for both IGCC and PC plants are assumed constant at $8/MWh.

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[142] Regulatory Research Associated, Inc., Jul. 7, 2003 (providing annual data on the equity % of electric utility capital structures (49.72% YTD July 2003) and average authorized equity returns (11.38% YTD July 2003).)

[143] Id.

[144] Based on personal communications with Lehman Brothers.

[145] Power plant efficiency is a measure of the amount of electricity produced from a given amount of fuel. The ratio of fuel to electricity is call the heat rate. Heat rates and efficiency can be expressed in terms of the lower heating value (potential energy in a fuel if the water vapor from combustion of hydrogen is not condensed) of the fuel, or the higher heating value (the maximum potential energy in dry fuel) of the fuel. The percent efficiency is calculated based on dividing the heat rate (Btu/kWh) into 3,412 Btu/kWh.

5.17. Levelized Carrying Charge

Each of the costs discussed above, Total Plant Investment (made up of Overnight Capital Costs and Construction Financing), Owner's Costs, fuel, and O&M costs all contribute to the cost of producing energy (expressed as $/MWh) from a new IGCC or other power plant. Calculating the cost of energy also involves calculating (or assuming) a "Levelized Carrying Charge" for capital, which is the average annual capital cost over the life of the plant, taking into account loan amortization, financing costs (construction and long-term), taxes, and depreciation.

Most studies evaluating energy costs under traditional financing scenarios for coal power plants simply assume around a 15 percent Levelized Carrying Charge for capital and multiply this amount by the Total Plant Investment to attain an annual capital charge, which is divided by annual generation to calculate the capital component of energy costs. For this analysis, however, the Levelized Carrying Charge for capital has been calculated with assistance from Professor Robert Williams of Princeton University by applying the EPRI Electric Supply Technical Assessment Guide (TAG) methodology as described in the June 1993 TAG report.[146]

The calculation of Levelized Carrying Charge includes incorporation of a 10 percent Owner's Cost in the traditional utility financing scenarios and a 20 percent Owner's Cost in the 3Party Covenant IGCC scenarios (because Owner's Costs also include the 10 percent capitalized Construction and Operating Reserve Fund in the 3Party Covenant scenarios). The Levelized Carrying Charge assumes a four year construction period and equal annual investments in the traditional utility financing scenarios and assumes no construction financing cost in the 3Party Covenant scenarios due to cost recovery during construction (CWIP) under the 3Party Covenant. Calculation of a Levelized Carrying Charge is essential for evaluating the impact of the 3Party Covenant on cost of energy because the 3Party Covenant economic savings manifest in a reduction in the Levelized Carrying Charge. Appendix B illustrates the calculation of Levelized Carrying Charges under both the traditional utility financing and 3Party Covenant scenarios.

[146] This methodology accounts for the impacts of different financing assumptions on the overall cost of electricity from power plants and allows for appropriately analyzing the potential economic impacts of the 3Party Covenant program (Section 5.5 below analyzes the cost of energy impacts of the 3Party Covenant).

5.2. Published IGCC Capital Cost and Efficiency Estimates

Because there is a lack of commercial experience with IGCC (so that there are not yet well-established cost and performance characteristics or a standardized commercial design), there is considerable variability in IGCC cost estimates. Different gasifier technologies, IGCC design configurations, and fuel feedstocks have different cost and efficiency characteristics. Consequently, a generalized cost or efficiency estimate for IGCC technology may not be representative of all IGCC systems. Nonetheless, by looking at the documented performance of demonstration IGCC facilities operating today and reviewing government, academic, and industry cost assessments for the next generation of facilities, a reasonable range of expected IGCC cost and performance characteristics can be developed.

Table 5.1 lists IGCC capital cost and efficiency data from the two demonstration plants in the U.S., a number of recent studies, and two regulatory filings. The estimates and data presented are not comprehensive, but represent a survey of reported information from a variety of sources. The data demonstrate a range of IGCC costs and efficiencies across different studies and technologies. The capital cost estimates range from around $1,100/kW to over $1,700/kW and the efficiencies range from 32 to 45.5 percent. Some of the variation is the result of not all studies including the same costs,[147] some reflects different costs associated with the different gasifier technologies, and some simply reflects uncertainty regarding actual costs. Cost data from the existing IGCC plants in the U.S. and Europe, Wabash, Polk, and Buggenum, are at the high end of the spectrum, which would be expected of first-of-a-kind demonstration projects with research objectives. The estimates from the two regulatory filings shown are also significantly higher than the estimates provided by the academic, industry, and government estimates. These higher cost estimates likely result from inclusion of Owner's Costs, Construction Financing, and other plant specific costs[148] that are not typically included in comparative studies. They may also be indicative of the conservative approach taken by companies reviewing new technologies.

[147] Many of the studies are not explicit about what costs are included in their capital cost estimates. Some represent Overnight Capital Cost estimates, while others may include Owners Costs and Construction Financing Costs.

[148] In the case of the Prairie State filing, for example, the costs reflect the intended use of coal with very high ash content.

Table 5-1. Selected Published IGCC Capital Costs and Plant Efficiencies

Demonstration Plants	Gasifier Technology	Capital Cost $/kW	Efficiency % (Btu/kWh HHV)
Wabash Generating Station[1]	Concophillips	1,680	40% (8,600)
Polk Power Station[2]	GE Energy quench	1,790	37% (9,100)
NUON IGCC Plant[3]	Shell w/ Heat Recovery	1,750	41.5% (8,300)
Selected Published Estimates			
EPRI Summary of Recent Study Results (2x7FA no spare gasifier) (2003)[4]	GE Energy quench	1,100	37% (9,300)
EPRI Summary of Recent Study Results (2x7FA no spare gasifier) (2003)[4]	Concophillips	1,140	39% (8,640)
EPRI Summary of Recent Study Results (2x7FA no spare gasifier) (2003)[4]	Shell w/ Heat Recovery	1,420	41% (8,370)
IEA/Foster Wheeler (2003)[5]	GE Energy quench	1,187	36% (9,400)
IEA/Foster Wheeler (2003)[5]	Shell w/ Heat Recovery	1,371	41% (8,370)
Jacobs consultancy (No shift, no capture) (2003)[6]	GE Energy quench	1,164	41% (8,384)
Jacobs consultancy (Shift, no capture) (2003)[6]	GE Energy quench	1,169	39% (8,777)
EIA Annual Energy Outlook (2004 Assumptions)[7]	unspecified	1,383	43% (8,000)
NETL/EPRI Parsons Case 9A (E-Gas w/ F turbine) (2002)[8]	ConcoPhillips	1,070	40% (8,609)
NETL/EPRI Parsons Case 3B (E-Gas w/ H turbine) (2002)[8]	ConcoPhillips	1,262	43% (7,915)
NETL PED-IGCC-98-001(revised June 2000)[9]	Concophillips	1,365	45% (7,583)
NETL PED-IGCC-98-002(revised June 2000)[9]	Shell w/ Heat Recovery	1,371	45.7% (7,466)
NETL PED-IGCC-98-003(revised June 2000)[9]	GE Energy quench	1,307	39.7% (8,595
NETL PED-IGCC-98-003(revised June 2000)[9]	GE Energy w/ Heat Recovery	1,439	43.5% (7,844)
David & Herzog Year 2000 Plant (2000)[10]	unspecified	1,401	40% (8,506)
David & Herzog Year 2012 Plant (2000)[10]	unspecified	1,145	45% (7,513)
EPRI Shell-HR output maximized, Illinois # 6 coal (1998)[11]	Shell w/ Heat Recovery	1,340	41% (8,225)
EPRI Shell-HR, output maximized Pittsburgh # 8 coal (1998)[11]	Shell w/ Heat Recovery	1,274	43% (7,881)
EPRI GE Energy-HR, output maximized, Illinois # 6 coal (1998)[11]	GE Energy w/ Heat Recovery	1,314	42% (8,214)
EPRI GE Energy-HR, output maximized, Pittsburgh # 8 coal (1998)[11]	GE Energy w/ Heat Recovery	1,247	42% (8,113)
EPRI GE Energy-Q, output maximized, Illinois # 6 coal (1998)[11]	GE Energy quench	1,201	35% (9,622)
EPRI GE Energy-Q, output maximized, Pittsburgh # 8 coal (1998)[11]	GE Energy quench	1,148	37% (9,316)
EPRI ConocoPhillips-HR, output maximized, Illinois # 6 coal (1998)[11]	ConcoPhillips	1,225	41% (8,248)
EPRI ConocoPhillips-HR, output maximized, Pittsburgh # 8 coal (1998)[11]	ConcoPhillips	1,171	42% (8,066)
Regulatory Filings			
SFA Pacific BACT Analysis of Prairie State (4 gasifiers)[12]	GE Energy quench	1,795	32% (10,622)
SFA Pacific BACT Analysis of Prairie State (10 gasifiers)[12]	GE Energy quench	1,516	32% (10,576)
SFA Pacific BACT Analysis of Prairie State (4 gasifiers)[12]	ConcoPhillips	1,876	36% (9,492)
SFA Pacific BACT Analysis of Prairie State (10 gasifiers)[12]	ConcoPhillips	1,584	36% (9,451)
WEPCO Elm Road Proposal[13]	GE Energy quench	1,739	Unspecified

[1] DOE, Clean Coal Technology Topical Report Number 20, "The Wabash River Repowering Project—an Update," September 2000.
[2] NETL, "Tampa Electric Polk Power Station Integrated Gasification Combined Cycle Project Final Technical Report," August 2002, p. ES-6. Cost estimate based on direct cost escalated to 2001 dollars.
[3] Plant Data provided by Shell Global Solutions.
[4] Neville Holt, George Booras (EPRI) and Douglas Todd (Process Power Plants), "Summary of Recent IGCC Studies of CO2 Capture for Sequestraiton," Presented at Gasification Technologies Conference, San Francisco, CA, October 14, 2003.
[5] Foster Wheeler Energy Ltd, 2003; "Potential for Improvement in Gasification Combined Cycel Power Generation with CO_2 Capture," IEA Greenhouse Gas R&D Programme, Report Number PH4/19, May 2003.
[6] John Griffiths and Stephen Scott of the Jacobs Consultancy, "Evaluation of Options for Adding CO2 Capture to ChevronTexaco IGCC," Gasification Technologies Conference, San Francisco, CA, October 12-15, 2003.
[7] EIA, Assumptions to the Annual Energy Outlook 2004, p. 71.
[8] NETL/EPRI, "Updated Cost and Performance Estimates for Fossil Fuel Power Plants with CO_2 Removal," December 2002; "Evaluation of Innovative Fossil Fuel Power Plants with CO2 Removal," Interim Report, December 2000.
[9] NETL, Process Engineering Division, PED-IGCC-1988, Revised June 2000.
[10] Jeremy David and Howard Herzog, "The Cost of Carbon Capture," 2000.
[11] Neville Holt (EPRI), "IGCC Power Plants--EPRI Design & Cost Studies," Presented at EPRI/GTC Gasification Technologies Conference, San Francisco, CA, October 6, 1998; results shown are for study cases where maximum attainable gas turbine outputs within pressure ratio and temperature constraints were analyzed.
[12] SFA Pacific, Inc., "Evaluation of IGCC to Supplement BACT Analysis of Planned Prairie State Generating Station," May 11, 2003, p. 35.
[13] Public Service Commission of Wisconsin and Department of Natural Resource, "Final Environmental Impact Statement, Elm Road Generating Station--Volume 1," July 2003, Chapter 2, p. 12.

5.21. Impact of Coal Rank on Capital Cost and Efficiency

One variable that affects IGCC costs and efficiency is the rank and quality of the coal feedstock. Generally, bituminous coal and petroleum coke fuel feedstocks provide the lowest-cost IGCC operation. These higher rank coals can be gasified most efficiently, which reduces the required size (cost) of fuel handling and gasifier equipment. Table 5-2 illustrates Overnight Capital Cost and efficiency estimates for the ConocoPhillips IGCC system presented at the 2002 Gasification Technologies Conference as Summarized by EPRI. As is illustrated, the lower rank coals (sub-bituminous and lignite) increase the cost and reduce the efficiency of the IGCC plant.

The various gasification technologies accommodate different coal ranks with different levels of impact. For example, dry feed systems (Shell technology), unlike slurry feed systems, have less stringent requirements on ash and water content of coal and therefore a wider feed quality window with the ability to take low rank coal with little downgrade in efficiency and relatively small increase in cost. In China, a gasification project using a dry feed system will be using coal with over 30 percent ash.[149]

Table 5-2. Cost and Efficiency Estimates for ConocoPhillips Gasifier using Different Coals

Fuel Feedstock	Overnight Capital ($/KW)	Heat Rate (Btu/kWh)
Petroleum Coke	1,160	8,380
Bituminous Coal (Pitts # 8)	1,140	8,380
Bituminous Coal (Ill # 6)	1,240	8,883
Sub-Bituminous Coal (Powder River Basin)	1,410	9,553
Lignite Coal	1,580	10,224

Source: Neville Holt, George Booras (EPRI) and Douglas Todd (Process Power Plants), "Summary of Recent IGCC Studies of CO_2 Capture for Sequestraiton," Presented at Gasification Technologies Conference, San Francisco, CA, October 14, 2003, (referencing E-Gas IGCC Estimates for Domestic US Coals from Gasification Technologies 2002).

[149] Personal communication with Shell Global Solutions.

5.22. Gasifier Redundancy

Another important issue in designing IGCC power plants for commercial operation is assuring that they operate with high availability.[150] To be viewed as a viable technology for commercial electricity generation, power plant technologies generally need to achieve availabilities around 90 percent.[151] Achieving this level of availability with current gasification technologies is generally believed to require redundant gasifier capacity, which increases the cost of IGCC facilities, or a back-up fuel supply such as natural gas. Table 5-3 provides cost estimates based on a presentation by EPRI at the 2003 Gasification Technologies Conference summarizing capital cost estimates for different gasification technologies utilizing bituminous coal and assuming a redundant gasifier--e.g., a dual-train system with two gasifiers that each feed a combustion turbine and the addition of a spare gasifier available to feed either CT when needed. This configuration is expected to enable IGCC facilities to operate above 90 percent availability and has been proven successful for very high availability at the Eastman Chemicals gasification facility in Kingsport, Tennessee.

Table 5-3. Capital Cost Estimates Assuming Redundant Gasifier (Dual-Train IGCC with 1 Spare Gasifier)

Gasification Technology	Overnight Capital Cost Range ($/KW)	Approximate Avg. Captial Cost ($/kW)
GE Energy Quench	1,160--1,340	1,270
GE Energy Heat recovery	1,400--1,500	1,450
ConocoPhillips	1,230--1,390	1,300
Shell*	1,570--1,670	1,620

* Shell questions the need for a spare gasifier in its configuration. Shell has indicated that because of its different design, its system can achieve over 90 percent availability without a redundant gasifier.

Source: Neville Holt, George Booras (EPRI) and Douglas Todd (Process Power Plants), "Summary of Recent IGCC Studies of CO_2 Capture for Sequestraiton," Presented at Gasification Technologies Conference, San Francisco, CA, October 14, 2003.

[150] Availability is a measure of the percentage of time in a period during which a plant was actually running at full capacity or, if not running, fully available to run. The term is used to describe the reliability of a power plant and its component systems.
[151] See SFA Pacific, p. 20, which states: "SFA pacific anticipates that a 2-year record (at least) of 92+% availabilities (plus demonstrated economics comparable to PC power plants) will be required to convince financial institutions that the risk in financing IGCC projects is comparable to that of PC projects."

The EPRI summary indicates that the cost of IGCC systems with a redundant gasifier is estimated between $1,160/kW and $1,670/kW, with the costs lowest for the GE Energy technology and highest for the Shell technology. This assessment assumes a redundant gasifier available for 50 percent of the plant turbine capacity. Studies have indicated that under different configurations (such as 3 or 4 operating and one spare gasifier) with less redundancy, high availabilities may be achievable at reduced cost.[152] Shell claims that its technology does not require extended, planned outages for refractory replacement, and therefore may be able to achieve over 90 percent availability without spare gasifier capacity, which will reduce its cost.[153]All companies are refining their cost estimates based upon the most current engineering and experience.

5.23. Repowering and Refueling

Critical in the cost of developing IGCC is whether a project is being developed on a greenfield site or is a repowering of an existing coal facility or refueling of an existing natural gas combined cycle facility. Repowering of existing coal facilitates may allow developers to take advantage of existing coal handling, electricity interconnect, and steam turbine facilities to reduce the cost of the project, while refueling allows utilization of the entire existing natural gas combined cycle power block. As discussed in Section 3.4 above, refueling of an existing natural gas combined cycle power block, which accounts for 30 to 35 percent of IGCC capital costs but requires modification to refuel to syngas, can reduce the cost of IGCC development when the NGCC plant or turbine are available at discount prices.

5.24. Planning for CO_2 Capture

Another important consideration in designing IGCC systems is the extent to which the design accommodates reductions in the cost of future CO2 emissions control. Doing so could involve, for example, ensuring the plant footprint could handle the additional equipment required for CO2 capture, incorporating shift reactors into the long term engineering plan of the gas clean-up processes, and evaluating the appropriate sizing of the ASU, coal handling, and turbine equipment to optimize for operational changes associated with beginning to capture CO2 at the facility.[154]

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[152] Neville Holt, George Booras (EPRI) and Douglas Todd (Process Power Plants), "Summary of Recent IGCC Studies of CO_2 Capture for Sequestration," presented at Gasification Technologies Conference, San Francisco, CA, Oct. 14, 2003.

[153] Since 2001, Shell has licensed its coal gasification technology to more than 10 end-users in the chemical industry and all of them have single gasifer designs and are planning to run at over 90 percent availability. (Comments received from Shell on February Draft report).

[154] A study by Parsons indicates that design modifications (including adding a parallel air compressor to the ASU, removing the COS hydrolysis reactor, inserting two shift reactors, and expanding the Selexol process) to minimize future CO_2 capture costs could be incorporated into IGCC facilities for an additional capital cost of about 5% and would have very little impact on plant operation prior to actual CO_2 capture. Pre-investing for CO_2 capture is estimated to save about 25% in terms of future cost of energy with capture. See, Parsons/EPRI, “Pre-Investment of IGCC for CO2 Capture with the Potential for Hydrogen Co-Production,” presented at Gasification Technologies 2003, San Francisco, CA, Oct. 2003.

5.3. Cost Estimates from Technology Suppliers

To assist in the development of IGCC cost and performance information, data requests were sent to each of the major suppliers of entrained flow gasification technologies, including GE Energy, ConocoPhillips, and Shell. The requests asked for capital and operating costs, efficiency, and availability information for both a new IGCC plant and an IGCC plant developed under an NGCC refueling scenario. GE Energy responded to the request and provided the data summarized below and Shell responded to the request by providing comments on the February Draft Report relating to its technology.

5.31. GE Energy

GE Energy provided cost and performance data for a new plant assuming three coal gasification trains (2 operating and 1 spare) and configured with Radiant Syngas Cooling (as opposed to a quench cooling system). The analysis assumed a power block consisting of two GE frame 7FA combustion turbines and a single steam turbine. The results provided by GE Energy for this configuration are illustrated in Table 5-4.

Table 5-4. GE Energy Data for New IGCC Plant

Net power output	564.9 MW
Investment Cost*	$772,000,000
Overnight Capital Cost*	$1,367/kW
Fixed Operating Cost	$22.9/kW-yr ($3.08/MWh at 85% capacity factor)
Variable Operating Cost	$3.90/MWh
Heat Rate	8717 Btu/kWh HHV
Efficiency	39.1% HHV
IGCC Availability	93.8% without backup fuel firing
IGCC Availability	95.0% with backup fuel firing

* This does not include contingency, EPC fee, sales tax or owner's cost.

GE Energy also provided information on the cost and performance of an IGCC developed in a natural gas combined cycle refueling scenario, which is illustrated in Table 5-5.

Table 5-5. GE Energy Data for NGCC Refueling Scenario

Net power output	541 MW
Investment Cost*	$537,000,000
Overnight Capital Cost*	$993/kW
Fixed Operating Cost	$22.9/kW-yr ($3.08/MWh at 85% capacity factor)
Variable Operating Cost	$3.90/MWh
Heat Rate	9102 Btu/kWh HHV
Efficiency	37.5% HHV
IGCC Availability	93.8% without backup fuel firing
IGCC Availability	95.0% with backup fuel firing

* Cost of gasifier construction and integration. This does not include contingency, EPC fee, sales tax or owner's cost. This cost includes an allowance for converting the CT combustors and controls to allow firing on either natural gas or syngas.

5.4. Reference Cases

The discussion above illustrates the disparity in Overnight Capital Cost and efficiency estimates for IGCC, how different gasification technologies and different feedstocks impact costs, and several design considerations (gasifier redundancy, readiness for CO_2 capture, and greenfield site vs. repowering) that can influence IGCC plant costs. The bottom line is that no single IGCC cost estimate or performance characteristic can accurately depict the spectrum of possible future IGCC facilities. At the same time, however, the data and estimates provide reasonable cost and performance ranges for evaluating the impact of the 3Party Covenant on IGCC cost competitiveness.

Based on the studies above and discussions with industry experts, reference IGCC, PC and NGCC power plants were developed to illustrate the 3Party Covenant impact on the cost of energy. Table 5-6 illustrates capital and operating parameters and a calculated cost of energy for a number of representative IGCC power plants, all assuming the availability of redundant gasifier capacity to provide high plant availability. Included in Table 5-6 is the Reference IGCC case, which is intended to represent a reasonable middle ground estimate of the cost and performance characteristics of the next set of IGCC facilities that will be built and is in line with other published estimates and the recent data received from technology suppliers.

The Reference IGCC plant is assumed to have a $1,400/kW Overnight Capital Cost and a 10 percent Construction and Operating Reserve Fund and to be designed and constructed over four years. The reference IGCC plant is assumed to operate at 39% efficiency and have O&M costs of 8 $/MWh. Table 5-6 also provides three generic alternative scenarios at different capital costs, and three specific examples with different gasifier technologies based on information on IGCC's with redundant gasifier technology presented by EPRI at the 2003 Gasification Technology Conference and provided by technology vendors.[155]

Table 5-7 illustrates capital and operating parameters and a calculated cost of energy for a series of NGCC and supercritical PC power plant scenarios. Reference case NGCC and PC cases are highlighted along with three alternative scenarios. For the NGCC case, the representative plant is based on a facility operating at a 50 percent capacity factor, which is a reasonable level of operation for a load-following natural gas plant with delivered natural gas prices averaging $4.50/mmBtu.[156]

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[155] The EPRI examples use capital cost and heat rate information taken from: Neville Holt, George Booras (EPRI) and Douglas Todd (Process Power Plants), "Summary of Recent IGCC Studies of CO_2 Capture for Sequestraiton," presented at Gasification Technologies Conference, San Francisco, CA, Oct. 14, 2003.

[156] Changing natural gas prices dramatically affect the economics of NGCC by changing variable costs and changing how much a plant operates during the year. The amount of time a plant operates is determined by how its variable costs compare with the variable costs of other available power plants, which affects where the plant is in the dispatch order. Therefore, changes in natural gas prices can significantly change the capacity factor of a NGCC plants, because the fuel costs are a variable cost.

Table 5-6. Cost of Energy Estimates for IGCC Power Plants under Traditional Financing

	IGCC Reference[1] (2+1 gasifiers, ($1,400/kW; 85% CF 39% Eff.)	IGCC 1[2] (2+1 gasifiers, $1,200/kW; 85% CF 42% Eff.)	IGCC 2[2] (2+1 gasifiers, $1,400/kW; 75% CF; 39% Eff.)	IGCC 3[2] (2+1 gasifiers, $1,600/kW; 85% CF; 39% Eff.)	IGCC 4[3] ConocoPhil (2+1 gasifiers)	IGCC 5[3] GE Energy Q (2+1 gasifiers)	IGCC 6[4] Data from GE Energy (2+1 gasifiers)	IGCC 7[5] Shell (2+1 gasifiers)
Design and Construction								
Plant Size (MW)	**550**	550	550	550	550	550	564.9	550
Overnight Capital Cost ($/kW)	**$1,400**	$1,200	$1,400	$1,600	$1,300	$1,270	$1,367	$1,620
Total Plant Investment ($/KW)[6]	**$1,596**	$1,368	$1,596	$1,824	$1,482	$1,448	$1,558	$1,847
Operation								
Fuel cost ($/mmBtu)	**$1.25**	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25
Plant Efficiency (%)	**39%**	42%	39%	39%	40%	36%	39%	41%
Heat Rate (Btu/kWh HHV)	**8,700.00**	8,200.00	8,700.00	8,700.00	8,550.00	9,450.00	8,717.00	8,370.00
Plant Capacity Factor (%)	**85%**	85%	75%	85%	85%	85%	85%	85%
Annual Generation (MWh)	**4,095,300**	4,095,300	3,613,500	4,095,300	4,095,300	4,095,300	4,206,245	4,095,300
Financing								
Percentage Debt	**55%**	55%	55%	55%	55%	55%	55%	55%
Debt Interest Rate	**6.5%**	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%
Percent Equity	**45.0%**	45.0%	45.0%	45.0%	45.0%	45.0%	45.0%	45.0%
After tax Equity Return	**11.5%**	11.5%	11.5%	11.5%	11.5%	11.5%	11.5%	11.5%
Tax rate (Federal & State)	**38.2%**	38.2%	38.2%	38.2%	38.2%	38.2%	38.2%	38.2%
Pre-tax Equity Return	**18.6%**	18.6%	18.6%	18.6%	18.6%	18.6%	18.6%	18.6%
Pre-tax WACC	**11.9%**	11.9%	11.9%	11.9%	11.9%	11.9%	11.9%	11.9%
Levelized Carrying Charge[7]	**17.0%**	17.0%	17.0%	17.0%	17.0%	17.0%	17.0%	17.0%
Estimated Cost of Energy								
O&M (cent/kWh)	**0.80**	0.80	0.80	0.80	0.80	0.80	0.69	0.80
Fuel (cent/kWh)	**1.09**	1.03	1.09	1.09	1.07	1.18	1.09	1.05
Capital (cent/kWh)	**3.65**	3.13	4.14	4.18	**3.39**	3.32	3.57	4.23
Cost of Energy (cent/kWh)	**5.54**	**4.96**	**6.03**	**6.06**	**5.26**	**5.30**	**5.35**	**6.07**

[1]Reference case developed by authors to be representative generic IGCC plant.

[2]Generic alternative IGCC cases assuming a spare gasifier.

[3]IGCC cost and performance information taken from: EPRI, "Summary of Recent IGCC Studies of CO2 Capture for Sequestration, Presented at Gasification Technology Conference, San Francisco, CA (October 14, 2003).

[4] GE Energy IGCC case based on data provided by GE Energy Gasification Technologies.

[5]IGCC cost and performance information taken from: EPRI, "Summary of Recent IGCC Studies of CO2 Capture for Sequestration, Presented at Gasification Technology Conference, San Francisco, CA (October 14, 2003). Shell questions the need for a spare gasifier with their technology. It remains to be seen whether initial commercial IGCC developers in the U.S. will require configurations with spare gasifiers or not. Without the spare gasifier the cost would be considerably lower. Shell also believes the Oth their te their dry feed system is 50-70 percent of one of the slurry feed systems.

[6]Equals Overnight Capital Cost plus interest during construction. Interest during construction equals 14% of Overnight Capital Cost for PC and IGCC (4 year construction).

[7]Calculated using EPRI TAG methodology (See Appendix A). Includes 10% Owner's Cost, 10% Capitalized Operating Reserve and assumes 4 year construction with equal annual investments.

Table 5-7. Cost of Energy Estimates for NGCC and PC Power Plants under Traditional Financing

	NGCC Reference ($4.50 gas; 50% CF; 50% Eff.)	NGCC 1 ($4.00 gas; 85% CF; 50% Eff.)	NGCC 2 ($4.50 gas; 85% CF; 50% Eff.)	NGCC 3 ($5.00 gas; 35% CF; 50% Eff.)	PC Reference ($1,200/kW; 85% CF; 39% Eff.)	PC 1 ($1,100/kW 85% CF; 38% Eff.)	PC 2 ($1,300/kW; 85% CF 39% Eff.)	PC 3 ($1,400/kW; 85% CF 40% Eff.)
Capital Costs								
Plant Size (MW)	**500**	500	500	500	**550**	550	550	550
Overnight Capital Cost ($/kW)	**$510**	$510	$510	$510	**$1,200**	$1,100	$1,300	$1,400
Total Plant Investment ($/kW)[1]	**$532**	$532	$532	$532	**$1,368**	$1,254	$1,482	$1,596
Operation								
Fuel cost ($/mmBtu)	**$4.50**	$4.00	$4.50	$5.50	**$1.25**	$1.25	$1.25	$1.25
Plant Efficiency (%)	**50%**	50%	50%	50%	**39%**	38%	39%	40%
Heat Rate (Btu/kWh HHV)	**6,800.00**	6,800	6,800	6,800	**8,700**	9,000	8,700	8,500
Plant Capacity Factor (%)	**50%**	85%	85%	35%	**85%**	85%	85%	85%
Annual Generation (MWh)	**2,190,000**	3,723,000	3,723,000	1,533,000	**4,095,300**	4,095,300	4,095,300	4,095,300
Long-term Financing								
Percentage Debt	**55%**	55%	55%	55%	**55%**	55%	55%	55%
Debt Interest Rate	**6.5%**	6.5%	6.5%	6.5%	**6.5%**	6.5%	6.5%	6.5%
Percent Equity	**45.0%**	45.0%	45.0%	45.0%	**45.0%**	45.0%	45.0%	45.0%
After tax Equity Return	**11.5%**	11.5%	11.5%	11.5%	**11.5%**	11.5%	11.5%	11.5%
Tax rate (Federal & State)	**38.2%**	38.2%	38.2%	38.2%	**38.2%**	38.2%	38.2%	38.2%
Pre-tax Equity Return	**18.6%**	18.6%	18.6%	18.6%	**18.6%**	18.6%	18.6%	18.6%
Pre-tax WACC	**11.9%**	11.9%	11.9%	11.9%	**11.9%**	11.9%	11.9%	11.9%
Levelized Carrying Charge[2]	**16.9%**	16.9%	16.9%	16.9%	**17.0%**	17.0%	17.0%	17.0%
Estimated Cost of Energy								
O&M (cent/kWh)	**0.25**	0.25	0.25	0.25	**0.80**	0.80	0.80	0.80
Fuel (cent/kWh)	**3.06**	2.72	3.06	3.74	**1.09**	1.13	1.09	1.06
Capital (cent/kWh)	**2.06**	1.21	1.21	2.94	**3.13**	2.87	3.39	3.65
Cost of Energy (cent/kWh)	**5.37**	**4.18**	**4.52**	**6.93**	**5.02**	**4.80**	**5.28**	**5.52**

[1]Equals Overnight Capital Cost plus interest during construction. Interest during construction equals 4.4% of overnight capital cost for NGCC (2 yr construction) and 14% of Overnight Capital Cost for PC and IGCC (4 year construction).

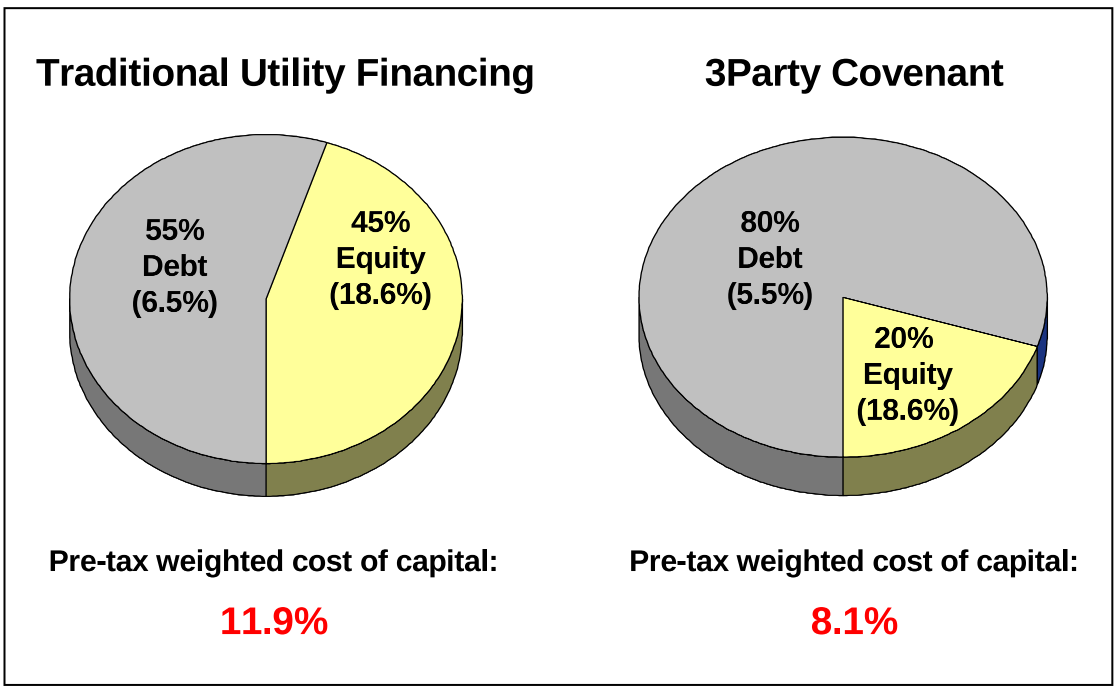
[2]Calculated using EPRI TAG methodology (See Appendix A). Includes 10% Owner's Cost and assumes 4 yr PC construction and 2 yr NGCC construction with equal annual investments.

5.5. 3Party Covenant Cost of Energy Impact

A primary benefit of the 3Party Covenant is that it significantly reduces Cost of Capital. The lower financing costs, in turn, reduce the cost of energy from an IGCC power plant about 25 percent. The cost of energy reductions result from:

1. Providing for a significantly higher ratio of debt to equity than a traditional utility financing ratio (from 55/45 to 80/20 under the 3Party Covenant). The higher ratio results in the replacement of 18.6 percent pre-tax equity (assuming an allowed after-tax return of 11.5 percent and 38.2 percent federal and state combined tax rate) with 5.5 percent federal debt for 25 percent of Total Plant Investment.[157]
2. Lowering the cost of debt through the federal loan guarantee, which reduces the interest charge from a typical 6.5 percent for a mid-grade utility bond in January 2004 to the 5.5 percent rate associated with a federal agency bond (essentially a ¾ to1 percent reduction in the cost of long-term debt).
3. Funding construction financing costs during the construction (adding Construction Work in Progress (CWIP) to the rate base), rather than accruing

Figure 5-1. Cost of Capital Reduction under 3Party Covenant



[157] In November 2003, the Wisconsin Public Utility Commission approved construction of two PC plants with a 45/55 debt to equity ratio and a 12.7 percent after-tax equity return.

these costs, which typically account for 10-15 percent of Overnight Capital Costs, by allowing them to be added to the rate base as incurred.

As illustrated in Figure 5-1, these changes reduce the pre-tax, nominal weighted average cost of capital of an IGCC plant from about 12 percent under traditional utility financing to 8 percent under the 3Party Covenant. Since the cost of capital accounts for over 60% of the total cost of energy in a capital intensive coal based PC or IGCC, this change in cost of capital (along with the reduction in construction financing costs) reduces the total energy cost about 25 percent. These results are demonstrated in Table 5-8 which illustrates the cost of energy impact of the 3Party Covenant for each of the IGCC plants shown in Table 5-6 above. As illustrated in Table 5-8, the 3Party Covenant reduces the cost of energy of the reference IGCC plant from 5.54 cents/kWh (55.4 $/MWh) to 4.15 cents/kWh (41.5 $/MWh), which is a 25 percent reduction.

The analysis presented in Table 5-8 assumes the Line of Credit (see Section 4.33 above) is not drawn by the project. If the 15 percent Line of Credit were fully drawn, the cost of energy of the Reference IGCC plant financing under the 3Party Covenant would be 4.5 cents/kWh.

Table 5-8. Cost of Energy Estimates for IGCC Power Plants under 3Party Covenant

	IGCC Reference[1] (2+1 gasifiers, ($1,400/kW; 85% CF 39% Eff.)	IGCC 1[2] (2+1 gasifiers, $1,200/kW; 85% CF 42% Eff.)	IGCC 2[2] (2+1 gasifiers, $1,400/kW; 75% CF; 39% Eff.)	IGCC 3[2] (2+1 gasifiers, $1,600/kW; 85% CF; 39% Eff.)	IGCC 4[3] ConocoPhil (2+1 gasifiers)	IGCC 5[3] GE Energy Q (2+1 gasifiers)	IGCC 6[4] Data from GE Energy (2+1 gasifiers)	IGCC 7[5] Shell (2+1 gasifiers)
Design and Construction								
Plant Size (MW)	**550**	550	550	550	550	550	564.9	550
Overnight Capital Cost ($/kW)	**$1,400**	$1,200	$1,400	$1,600	$1,300	$1,270	$1,367	$1,620
Total Plant Investment ($/KW)[6]	**$1,400**	$1,200	$1,400	$1,600	$1,300	$1,270	$1,367	$1,620
Operation								
Fuel cost ($/mmBtu)	**$1.25**	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25
Plant Efficiency (%)	**39%**	42%	39%	39%	40%	36%	39.1%	41%
Heat Rate (Btu/kWh HHV)	**8,700.00**	8,200.00	8,700.00	8,700.00	8,550.00	9,450.00	8,717	8,370.00
Plant Capacity Factor (%)	**85%**	85%	75%	85%	85%	85%	85%	85%
Annual Generation (MWh)	**4,095,300**	4,095,300	3,613,500	4,095,300	4,095,300	4,095,300	4,206,245	4,095,300
Financing								
Percentage Debt	**80%**	80%	80%	80%	80%	80%	80%	80%
Debt Interest Rate	**5.5%**	5.5%	5.5%	5.5%	5.5%	5.5%	5.5%	5.5%
Percent Equity	**20.0%**	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%
After tax Equity Return	**11.5%**	11.5%	11.5%	11.5%	11.5%	11.5%	11.5%	11.5%
Tax rate (Federal & State)	**38.2%**	38.2%	38.2%	38.2%	38.2%	38.2%	38.2%	38.2%
Pre-tax Equity Return	**18.6%**	18.6%	18.6%	18.6%	18.6%	18.6%	18.6%	18.6%
Pre-tax nominal WACC	**8.1%**	8.1%	8.1%	8.1%	8.1%	8.1%	8.1%	8.1%
Levelized Carrying Charge[7]	**12.0%**	**12.0%**	**12.0%**	**12.0%**	**12.0%**	**12.0%**	**12.0%**	**12.0%**
Estimated Cost of Energy								
O&M (cent/kWh)	**0.80**	0.80	0.80	0.80	0.80	0.80	0.69	0.80
Fuel (cent/kWh)	**1.09**	1.025	1.09	1.09	1.07	1.18	1.09	1.05
Capital (cent/kWh)	**2.26**	1.94	2.56	2.58	2.10	2.05	2.20	2.61
Cost of Energy (cent/kWh)	**4.15**	**3.76**	**4.45**	**4.47**	**3.97**	**4.03**	**3.98**	**4.46**
Comparison to Cost of Energy under Traditional Financing								
Cost of Energy (cent/kWh) under Traditional Financing	**5.54**	**4.96**	**6.03**	**6.06**	**5.26**	**5.30**	**5.35**	**6.07**
Percent Reduction under 3Party Covenant	**25%**	**24%**	**26%**	**26%**	**25%**	**24%**	**25%**	**27%**

[1]Reference case developed by authors to illustrate representative generic IGCC plant.

[2A]lternative generic IGCC cases developed by authors assuming a spare gasifier.

[3]IGCC cost and performance information taken from: EPRI, "Summary of Recent IGCC Studies of CO2 Capture for Sequestration, Presented at Gasification Technology Conference, San Francisco, CA (October 14, 2003).

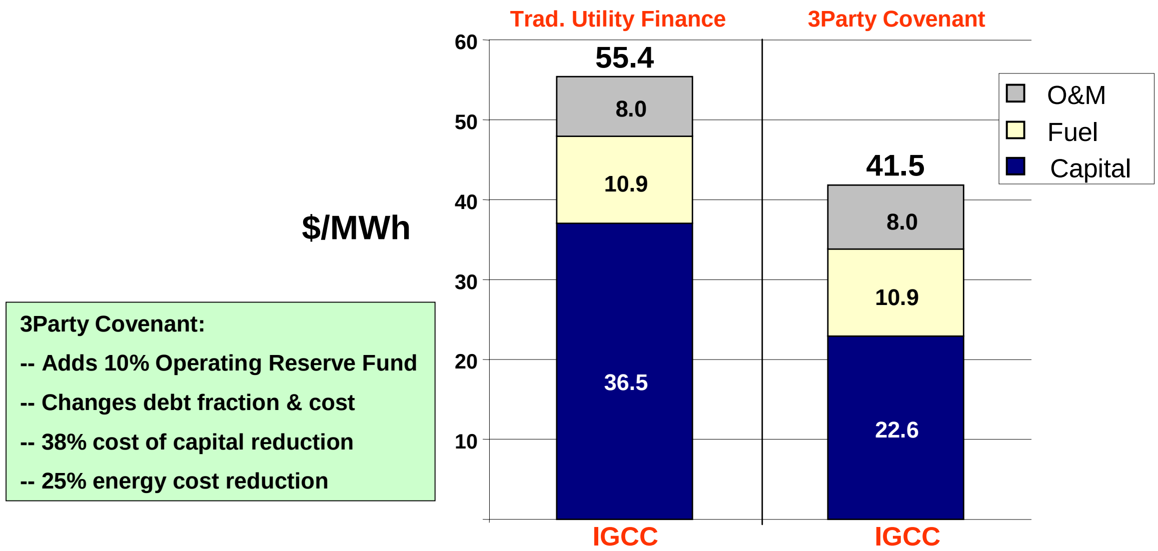
[4] GE Energy IGCC case based on data provided by GE Energy Gasification Technologies.

[5]IGCC cost and performance information taken from: EPRI, "Summary of Recent IGCC Studies of CO2 Capture for Sequestration, Presented at Gasification Technology Conference, San Francisco, CA (October 14, 2003). Shell questions the need for a spare gasifier with their technology. It remains to be seen whether initial commercial IGCC developers in the U.S. will require configurations with spare gasifiers or not. Without the spare gasifier, the cost would be considerably lower. Shell also believes the h their tech their dry feed system is 50-70 percent of one of the slurry feed systems.

[6]Equals Overnight Capital Cost plus interest during construction. No interest during construction accrues in the 3Party Covenant case due to CWIP.

[6]Calculated using EPRI TAG methodology (See Appendix A). Includes 10% Owner's Cost and Construction Financing Costs, assuming 4 year construction with equal annual investments.

Figure 5-2. 3Party Covenant Impact on IGCC Cost of Energy

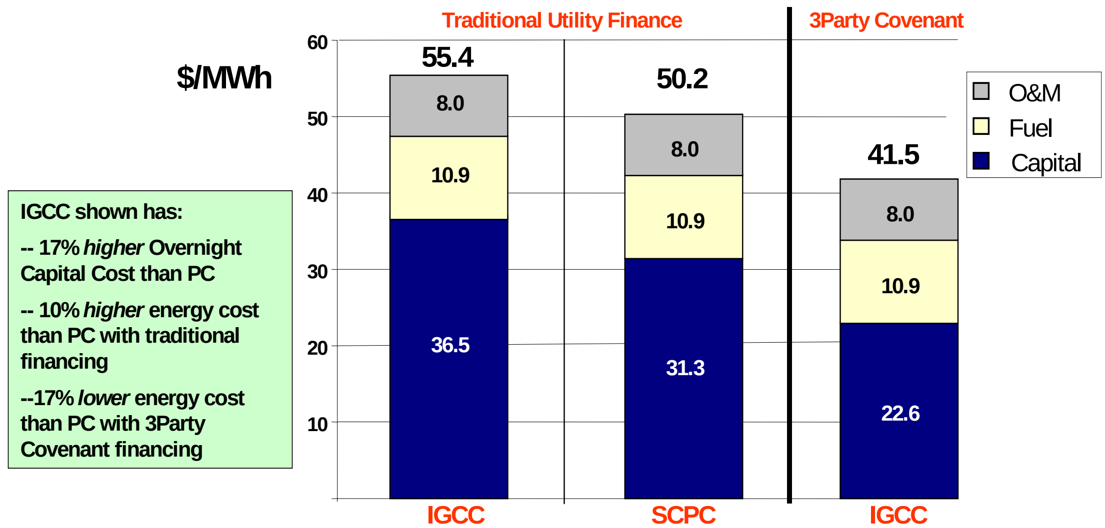


Overnight Capital Cost ($/kW)	$1,400	$1,400
Fuel Cost ($/mmBtu)	$1.25	$1.25
Capacity Factor	85%	85%
Heat Rate (btu/KWh HHV)	8,700	8,700
Debt Fraction	55%	**80%**
Debt Cost	6.5%	**5.5%**
Pre-Tax Equity Return	18.6%	18.6%

Figure 5-2 illustrates the impact of the 3Party Covenant graphically by comparing the cost of energy associated with the Reference IGCC plant financed under a traditional utility financing scenario compared with the same plant financed under the 3Party Covenant. As is illustrated, the 3Party Covenant reduces the cost of capital component of energy costs from 36.5 $/MWh to 22.6 $/MWh, which is a 38 percent reduction. As a result, the reference IGCC plant financed under traditional utility financing has a calculated cost of energy of 55.4 $/MWh, while the same plant financed under the 3Party Covenant has a cost of energy of 41.5 $/MWh. The 3Party Covenant reduces the cost of capital component of energy cost approximately 38 percent and energy cost 25 percent. This energy cost reduction occurs despite the addition of a 10 percent capitalized Construction and Operating Reserve Fund ($70 million) in the 3Party Covenant scenario. If the 15 percent Line of Credit is also assumed to be drawn down by the project (with a 20 percent equity match), the cost of energy will be 45.0 $/MWh, which is a 19 percent reduction from the traditionally financed case (where the assumption is that no additional capital is needed).

Figure 5-3 illustrates how the 3Party Covenant affects the relative cost of energy of IGCC compared to PC. The figure illustrates the Reference IGCC plant assuming traditional utility financing and under the 3Party Covenant compared to a PC plant built with traditional utility financing. Figure 5-3 illustrates that the Reference IGCC plant has a 17 percent higher Overnight Capital (or EPC) cost than the PC plant, which results in a 10

Figure 5-3. IGCC Cost of Energy versus Super-Critical PC



Overnight Capital Cost ($/kW)	$1,400	$1,200	$1,400
Fuel Cost ($/mmBtu)	$1.25	$1.25	$1.25
Capacity Factor	85%	85%	85%
Heat Rate (btu/KWh HHV)	8,700	8,700	8,700
Debt Fraction	55%	55%	80%
Debt Cost	6.5%	6.5%	5.5%
Pre-Tax Equity Return	18.6%	18.6%	18.6%

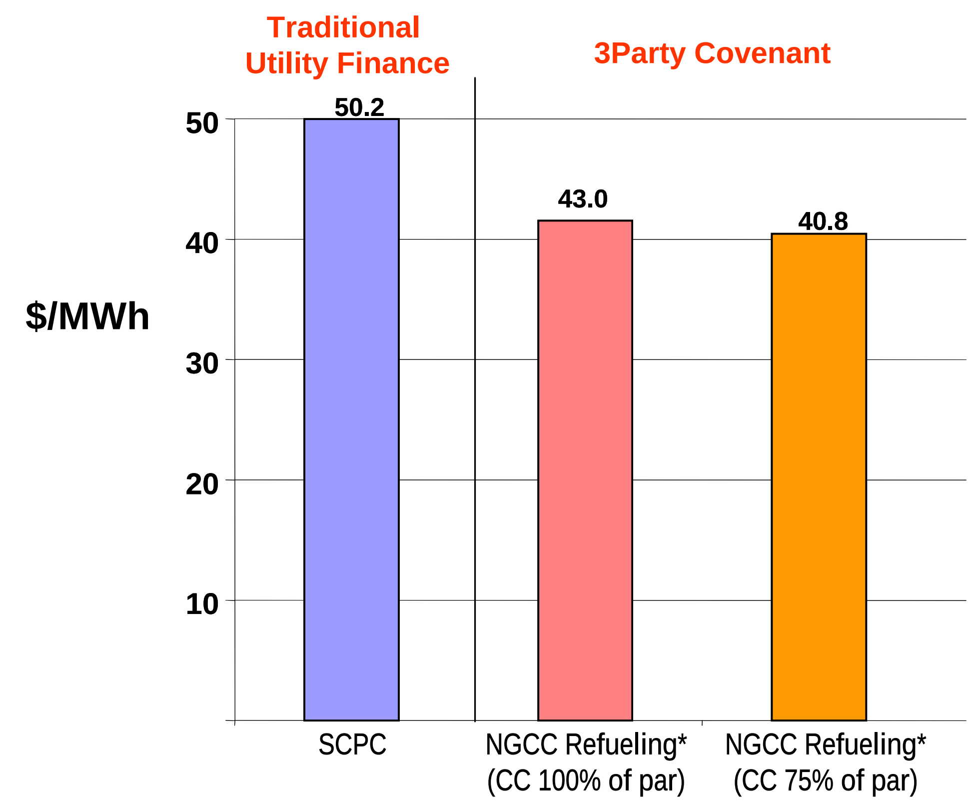
percent higher cost of energy when both are financed traditionally. However, when 3Party Covenant financing is applied to the IGCC plant, its cost of energy is reduced to a level 17 percent below the PC plant. If the 15 percent Line of Credit is drawn, the cost of energy remains 10 percent below the PC plant.

5.6. 3Party Covenant Cost of Energy for NGCC Refueling Scenarios

As discussed in Section 3.4 above, there may be opportunities to create favorable IGCC economics by refueling distressed NGCC assets with coal gasification systems. Under the Reference case IGCC, it is assumed that the gasifier island accounts for about 65 percent of the $1,400/kW Overnight Capital Cost, or roughly $900/kW and that the combined cycle power block accounts for 35 percent of the Overnight Capital Cost, or about $500/kW. If available for refueling at 75 percent of par, the cost is reduced to about $375/kW, and at 50 percent of par, it is reduced to $250/kW. If these costs are applied as the combined cycle power block component of the IGCC EPC cost, the Overnight Capital Cost is reduced to $1,275/kW and $1,150/kW, respectively (well below the $1,400/kW reference case assumption).

In refueling scenarios, there is likely to be some inefficiency in design and construction of the gasification system and its integration due to retrofit requirements. For example, a

Figure 5-4. Cost of Energy of NGCC Refueling under 3Party Covenant



*Assumes 1% efficiency penalty & 5% Overnight Capital Cost penalty in NGCC refueling scenarios vs. Reference IGCC.

$15/kW cost has been suggested for refitting the combustion turbine. Other costs might include the need for supplemental steam generation or site improvements. In addition, plant integration may be less than is achieved at a facility designed originally to be an IGCC, which may result in reduced efficiency. For this analysis, a 5 percent capital cost and 1 percent efficiency penalty is incorporated into the NGCC refueling scenarios to address these issues.

Figure 5-4 illustrates the cost of energy achieved in NGCC refueling scenarios assuming the combined cycle power block was contributed to the project at 75 percent of its original par value (assumed to be $500/kW). Figure 5-4 illustrates that combining 3Party Covenant financing and the potential cost savings associated with using existing distressed NGCC assets produces energy at levels below an all-new IGCC and at levels 19 percent below the reference PC plant built with tradition utility financing. Actual project savings will depend on the cost of the distressed asset to the project and the level of additional cost associated with retrofitting the combined cycle power block to work with a coal gasification system.