An Economic Impact Analysis of Proposed Tax Incentives to Attract Integrated Gasification Combined Cycle Power Generation Facilities to Wyoming

For

The Wyoming Infrastructure Authority

Submitted by

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Executive Summary

Wyoming is currently enjoying the benefits of an international boom in energy and commodity prices. One result of this boom has been the stimulation of local and statewide revenues in a way not seen since the last major energy boom of the late 1970s. Focus on the wealth of Wyoming has led many to consider how state fortunes might be supported and enhanced in coming years. This study was undertaken at the behest of the University of Wyoming, School of Energy Resources and Office of Research for the Wyoming Infrastructure Authority (WIA). Its purpose is to provide the WIA with timely information regarding the economic benefits of locating one 500 megawatt (MW) integrated gasification combined cycle (IGCC) generating facility in either southwest Wyoming (Sweetwater County) or northeast Wyoming (Campbell County in the Powder River Basin). The State of Wyoming is currently considering two tax holidays to attract such a project to the state. First, a tax holiday on the state share of sales taxes generated from the construction of such a plant was enacted by the legislature in 2005 (HB-0272). Second, a 15-20 year holiday on the severance tax charged on the coal used by such a plant is under consideration (07LSO-0282). While Wyoming has benefited greatly from the upsurge in revenues caused by current high energy prices, there is concern that Wyoming does not benefit as much as it could from energy exports of coal, natural gas and oil because it exports mostly unprocessed energy commodities. It is thought that if the State were to facilitate the use of coal to produce electricity or other value-added commodities, and exported these products to market, Wyoming could reap additional benefits from its resources by creating jobs, tax base and other value-adding activity within the State. While such planning makes intuitive sense, this report was commissioned to determine whether such benefits could be expected to outweigh the costs of incentives the State could provide that might attract such potential.

There are other reasons to consider and promote the development of new energy technologies inside the State. Concerns regarding greenhouse gases suggest it may be prudent to consider newer technologies that allow carbon capture if new generation facilities are to be built in Wyoming. IGCC generation is one such technology. Such a plant would not only qualify for potential aid under Section 413 of the Energy Policy Act of 2005, but would also ensure that Wyoming energy will have access to jurisdictions currently considering limiting their markets to non-greenhouse gas producing sources (particularly California). Promotion and development of new energy technologies inside the State could also protect Wyoming's competitive position in national coal markets in the future.

IGCC technology could threaten demand for Wyoming coal. The emissions-regulation cost savings Wyoming coal currently offers users could be eliminated if IGCC is widely adopted elsewhere because this technology allows much lower-cost separation of sulfur from the exhaust stream. Additionally, due to the lower energy and higher moisture content of Wyoming coal, if IGCC were to become a major part of generation infrastructure elsewhere in the United States, demand for Wyoming coal could be further reduced due to the higher costs these characteristics create in energy production. Simply put, new regulations and new technologies may threaten Wyoming's current advantages in the coal market. Given these concerns, the construction of coal gasification and power generation facilities in Wyoming could partially offset these potential threats by demonstrating the commercial feasibility of the technology and creating permanent demand for Wyoming coal. Since IGCC facilities are significantly more expensive to build than traditional plants, this may be another justification to offer incentives for such plants to locate in Wyoming.

Given that IGCC technology is new, there are few operating plants or plants under construction to use as prototypes to create the modeling estimates needed to determine the costs and benefits of using tax incentives to attract such facilities. For this reason, a significant effort was necessary to define the potential construction cost of such a plant to estimate the total cost of any tax subsidies provided. The 500MW prototype plant assumed here to generate cost-benefit estimates is consistent with the specifications necessary to be eligible for Federal assistance as a commercial western IGCC demonstration project under the Energy Policy Act of 2005, and includes the ability to capture most of the carbon dioxide produced from the coal used as fuel. Such a plant would require a significant capital investment as shown in Table 5 of the report, reproduced below.

Table 5: Capital Costs for a 500MW Plant

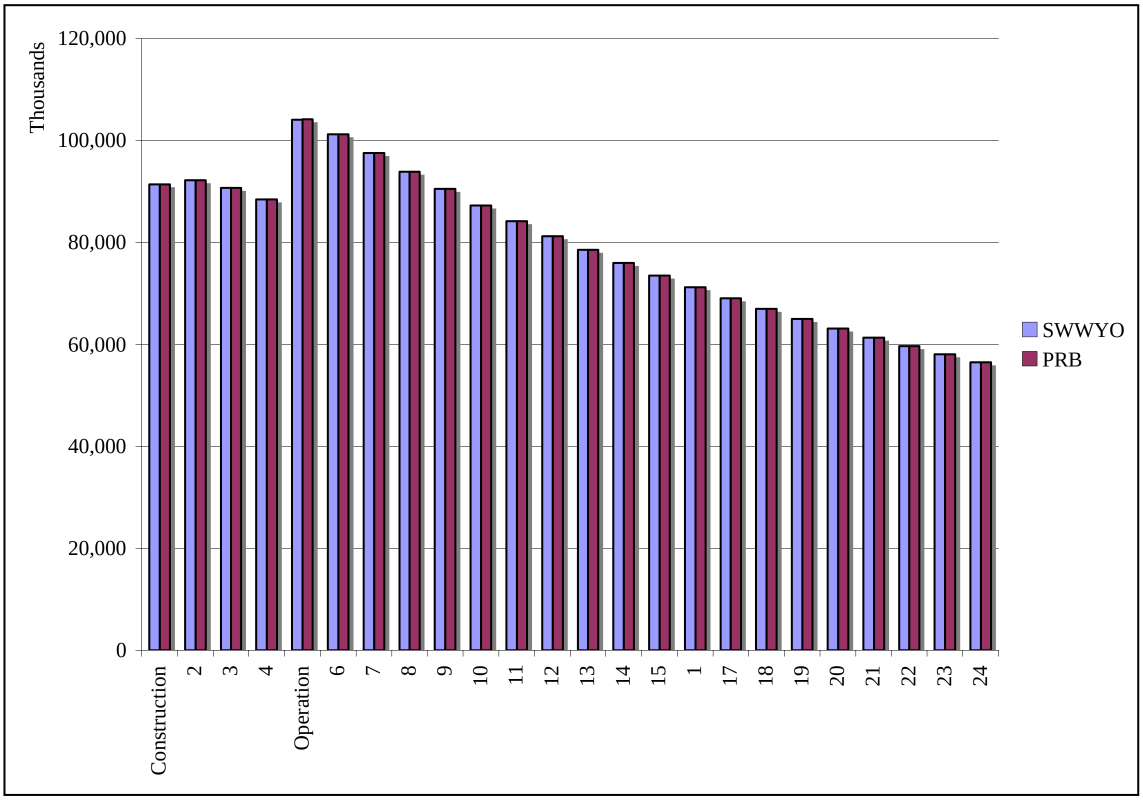
Plant costs		Comment/source
$1,127,751,714	EPC cost	scaled up from Nexant (2005)
$342,836,521	CO2 capture equip.	Buchanan et al (2003)
$1,470,588,235	**Total EPC cost w/ CO2 capture**	
$14,705,882	Initial working capital	1% of EPC-Nexant (2005)
$161,764,706	Owner's contingency	11% of EPC-Nexant (2005)
$44,117,647	Development fee	3% of EPC-Nexant (2005)
$14,705,882	Start-up	1% of EPC-Nexant (2005)
$44,117,647	Owners cost	3% of EPC-Nexant (2005)
$1,750,000,000	Total capital costs	

**Estimated 2008 dollars and material costs.*

Our estimates indicate that construction of such a plant would require a capital investment of $1.75 billion dollars; or approximately 35% more than the cost of an equivalent generating facility using traditional pulverized coal technology and lacking carbon capture capability. Under current incentive proposals, such an IGCC facility would require an annual subsidy in lost severance taxes (assuming the coal used to fuel the plant was instead exported) of between approximately $560,000/year and $1.25 million/year depending on the location (the southwest location is more expensive due to the higher value of coal in that region). The sales-tax holiday on plant construction would cost the state between $22.2 to $22.6 million.

While these are large costs to State revenues, the estimated benefits of the new economic activity created by the construction and operation of such a plant are significant. As a baseline of comparison, results reported are in excess of the jobs that would be created if the amount of coal assumed to fuel the plant were instead exported out of the State. These results are summarized in Figures 4 and 5 of the report, reproduced below. Specifically, while the results are dependent on where the plant is located, the construction of such a plant is estimated to create in excess of 2300 jobs in either region in the four years it would take to construct it (this includes both jobs directly and indirectly related to construction), and at least 295 new jobs in the years afterward when the plant was in operation, including 160 high-paying technical jobs at the plant itself. These new jobs would create between $90 and over $100 million annually in additional labor income during the first four years of construction, and an additional $13 million to $18 million annually in State labor income over the following 20 years after the plant began operation. Total statewide job impact would be even larger due to the multiplier effect, creating in excess of 2,500 jobs during the construction phase (an minimum of at least 200 more jobs outside the region the plant was located in) and then over 800 new jobs (over 500 more jobs outside the region) in the first year after the plant began operation declining to just over 400 new jobs persisting as much as 20 years later.

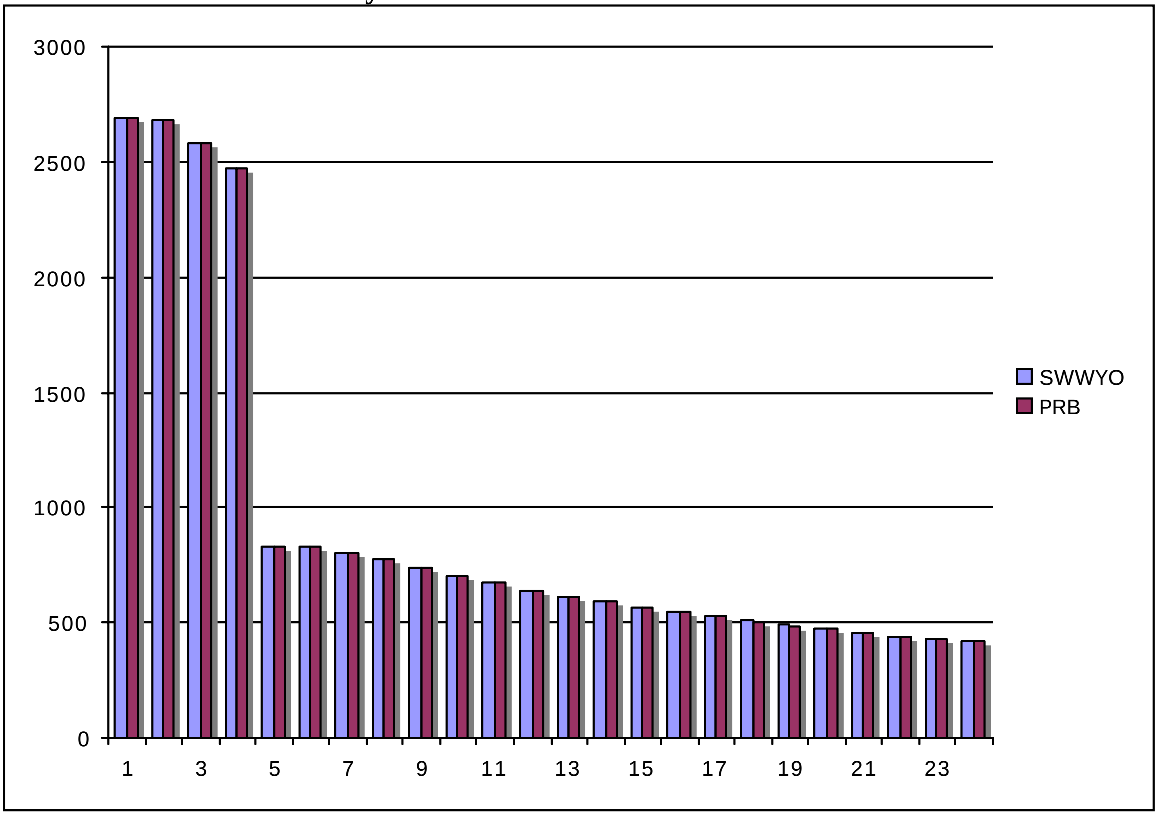
Figure 4: Wyoming Gross State Product changes from construction and operation of a 500MW IGCC facility



Source: State of Wyoming REMI computations prepared for this report

If such a plant were constructed, we estimate that gross state product (GSP) would observe a maximum annual increase of $104 million, falling to $56 million by the end of the 20-year planning cycle considered. Far from costing the state, if it is assumed the tax incentives offered cause such a plant to locate in Wyoming, the additional economic activity such a plant creates results in additional tax revenues to State and local government net of subsidies of between $10.9 million and $11.7 million annually. The majority of these additional revenues accrue to local governments, with the State seeing an increase in revenue of between over $1.3 million to over $2 million annually for the subsidy investment, depending on the plant location. Given these results, it is the conclusion of this report that if current and proposed tax incentives offered result in a 500MW plant locating in Wyoming, the additional economic activity generated will more than cover the subsidy cost and result in significant job creation within the State.

Figure 5: Wyoming Statewide job effects from construction and operation of an IGCC facility.



Source: State of Wyoming REMI computations prepared for this report

I. Introduction:

Wyoming is currently enjoying the benefits of an international boom in energy and commodity prices. The result of this boom has greatly stimulated local and statewide revenues in a way not seen since the last major energy boom of the late 1970s, and has resulted in significant improvements in State tax revenues. Resulting budget surpluses have been put to many beneficial uses, including investment in the Wyoming Permanent Mineral Trust Fund and reinvestment in statewide infrastructure, education and social program improvements. Efforts have also been made to diversify Wyoming's economy and to increase value-added in State energy production, including the consideration of additional power generation and energy refining facilities, transmission capacity and the development of additional transport infrastructure. In 2004, the State Legislature created the Wyoming Infrastructure Authority to enhance these efforts, with the intent to "…diversify and expand the state's economy through improvements in Wyoming's electric transmission infrastructure and to facilitate the consumption of Wyoming energy." The Legislature expressly directed this authority to participate in "…planning, financing, constructing, developing, acquiring, maintaining and operating transmission facilities and their supporting infrastructure." (Wyoming, 2004). In 2006, the Legislature expanded the Wyoming Infrastructure Authority's role to also promote "advanced coal technology facilities." (Wyoming, 2006)

For Wyoming, the current national energy outlook is very optimistic. Demand for electric power is projected to increase in the United States by 43 percent over the next 25 years (EIA, 2006). Wyoming currently mines over 400 million tons of coal per year, supplying about 36 percent of the coal used by the nation's coal-fired power plants. Coal accounts for over 50 percent of U.S. baseload generating capacity, implying that Wyoming coal "keeps the lights on" for about 18 percent of the country. With growing demand for electricity comes growing demand for Wyoming coal. Demand for Wyoming coal, particularly coal mined in the Powder River Basin (PRB), is driven in large part by national sulfur-dioxide regulations and by the fact that PRB coal is uniquely low in sulfur content thus the use of this coal results in significant emission-reduction cost savings when used in traditional power-generation facilities. Currently, Wyoming is limited by the rail transportation capacity serving the PRB, and future plans include the potential increase of rail services serving this area.

National demand for domestically produced energy has also resulted in a dramatic increase in Wyoming energy exports from other traditional and renewable sources. Production of natural gas in Wyoming has also increased dramatically to serve national demand for heating and power generation. Wyoming oil production has increased significantly, and this has been made possible through the application of new technologies to old fields. In particular, enhanced oil recovery techniques including CO_2 injection have increased oilfield productivity and allowed producers to scavenge previously unrecoverable oil reserves. Wind resources have also been profitably harnessed in southeast Wyoming to generate electricity to meet rising demand in the front range of Colorado.

Significant consideration is now being given to increasing Wyoming electrical production capacity using traditional and renewable sources. Increasing Wyoming production of energy exports and electricity is seen as an important component in the diversification and enhancement of the State's economy. Expansion of Wyoming generation capacity would increase the value-added component of Wyoming energy exports while supplying increasing demand in the Rocky Mountain region and in the western United States, particularly California. Currently a major impediment to such an energy production expansion is the lack of transmission capacity to allow new Wyoming electrical generation to be delivered to these markets. Under the leadership of the Wyoming Infrastructure Authority, several transmission expansion initiatives are currently underway, to access the Utah, Colorado and Arizona markets. (see www.wyia.org for details.) To further reduce this constraint, a recent multi-state initiative proposes building a new electrical transmission corridor to access the California market.[1] Reduction of transport bottlenecks elsewhere in national energy system, particularly in national pipeline and rail systems would also allow additional energy exports and increased energy revenues to accrue to the State.

Investment in Wyoming energy infrastructure; however, must be made carefully, considering changing world energy market conditions that will influence demand for Wyoming production. Changes in international and national environmental regulations and adoption of new technological developments in energy production could both help and harm Wyoming's competitive position in national energy markets. Current energy price increases have been fueled by increases in demand, particularly in India and China, and political uncertainty. Increasing demand has tightened global energy markets and resulted in high domestic energy prices and high energy production revenues for Wyoming. Unlike past energy booms, where price increases were driven by supply-side shocks, the current boom is driven more by demand side factors thus it may be longer lived than booms previously experienced. This bodes well for the Wyoming economy and given this difference, Wyoming may be able to benefit from current energy market conditions for some time. Investment in additional energy infrastructure including generation capacity may therefore be a wise course of action to diversify the Wyoming economy and increase the benefits of state energy production.

Environmental concerns, however, particularly regarding greenhouse gases, may create an impediment to such expansions. Concern regarding CO_2 emissions has created uncertainty regarding the potential payoffs to investments in carbon-based energy sources. New restrictions on the emissions of traditional coal-burning power-plants, even plants using low-sulfur Wyoming coal may be on the horizon, threatening Wyoming's energy-exporting competitiveness. Additionally, state mandated restrictions like those currently being considered in California on the use of energy from carbon-based generating sources threaten to eliminate potential markets for any additional Wyoming-generated electricity capacity if this electricity is produced using traditional pulverized coal (PC) generating stations.[2] Overall, potential regulatory impacts on traditional sources

[1] This line, referred to as "The Frontier Line," is a multi-state proposal to create a high voltage electricity transmission line across the Western United States, originating in Wyoming and crossing the states of Utah and Nevada, and terminating in California.

[2] California is promulgating regulatory rules, and considering legislation, to impose a green house gas emission standard on its electric power sector limiting CO2 emissions to levels produced by natural gas fired generation for all long term power purchases by certain California entities. Current California public policy may limit Wyoming's ability to market traditionally generated electricity to California, a major market for any potential electricity generation added in Wyoming.

of power generation, particular on coal-fired power-plants, could undermine the future benefits of Wyoming's primary energy export.

Of additional concern is the possibility of new technology being developed in response to high energy costs and greenhouse gas concerns that could undermine the demand for Wyoming coal. One technology may be more threatening to Wyoming in the near-term – the development of Integrated Gasification Combined Cycle (IGCC) electrical power-plants. IGCC is the name of the latest form of coal gasification technology. The use of coal gas or "town gas" has occurred for more than a century. A number of urban areas in the late 1800's used a crude form of gasification to create gas for street lamps, hence the name "town gas." After World War I, two German chemists pioneered a gasification method that led to the creation of synthetic fuels from coal. The Fischer-Tropsch gasification process was used effectively by Germany in the Second World War and later on a large commercial scale by South Africa. Interest in gasification in the United States started in the 1970s after the Arab oil embargo of 1973 and the supply crisis of 1978 brought on by the Iranian revolution and the Iran-Iraq war. Interest in this technology declined as energy prices fell in the 1980s, but has recently been revived with the advent of stable and high energy prices that have characterized the new century.

IGCC utilizes the latest chemical engineering processes to gasify coal, and then uses this fuel in the most modern clean-burning gas turbine power generation systems. The combined cycle aspect of these systems then uses the heat generated from these turbines to power proven steam turbines to gain additional efficiencies in power generation. In addition to being very efficient, an added benefit of such systems is the ability to easily and cost-effectively separate CO_2, sulfur and other pollutants from the production stream to be sequestered or sold, making IGCC very environmentally-friendly relative to traditional coal-burning pulverized coal plants. The drawback of this technology is that it is currently unproven, is relatively expensive and it lacks the decades-long track-record of traditional PC coal plants. Environmental regulations and the threat of impending regulations may force companies to look at IGCC technology in the future. IGCC may prove to be the biggest threat to Wyoming's long-term energy exporting prospects as such technology could significantly reduce the demand for PRB coal if adopted in Midwestern and Eastern markets. The advantage PRB coal has in reducing emission control costs in traditional PC plants would be mitigated in IGCC applications. Also, since Midwestern and Eastern coals have a higher energy and lower moisture content than PRB coal, without the emission-cost advantage PRB coal currently has, customers of PRB coal may substitute to cheaper and closer sources of higher quality coal in IGCC applications, reducing Wyoming's most important energy export.

Recent Federal Energy Policy legislation has included subsidies for research and development of IGCC technology. Of particular interest to Wyoming, in an effort to ensure western coal producers might also benefit from this technology, language in the recent Energy Policy Act of 2005 authorizes funding for an IGCC demonstration project at an altitude over 4,000 feet above sea-level.[3] Such a plant could be located in

[3] "The Energy Policy Act of 2005," Sec. 413 under Title IV - Coal: Western Integrated Coal Gasification Demonstration Project. This amendment authorizes the appropriation of funds to facilitate an IGCC demonstration project located above 4000 feet and using coal of less than 9000 btu/lb mined in the western United States (although the plant should be designed to operate using all types of coal produced in the

Wyoming. With this in mind, the project presented here was commissioned to determine the potential economic impact construction of such a plant could have on the State of Wyoming. The State Legislature has provided leadership in efforts to induce firms to locate IGCC plants in Wyoming, In 2005, the Legislature enacted a sales tax holiday on the sale of equipment to make coal gasification operational in Wyoming. In the upcoming 2007 session, the Legislature is expected to consider 07LSO-0282, a proposal to provide a severance tax holiday for a period of years for coal used in an IGCC facility. The central question addressed in this report is whether the cost to the State of providing these two tax holiday incentives is outweighed by the remaining benefits to the State that would accrue over time if an IGCC plant locates and operates in Wyoming.

This research project attempts to estimate the potential tax costs of such incentives, as well as the associated economic development benefits that could accrue if an IGCC plant were to locate in Wyoming to determine whether these tax incentives are economically reasonable. This study was undertaken by the researchers at the behest of the University of Wyoming, School of Energy Resources for the Wyoming Infrastructure Authority (WIA). Its purpose is to provide the WIA with timely information on the potential costs and benefits of locating one 500 megawatt IGCC generating facility in Wyoming. The report is organized as follows: Section 2 describes the prototype IGCC plant assumptions used to develop tax cost and economic development benefit estimates. Section 3 details the regional and statewide estimates of the tax costs and economic development benefits such a plant could have on the economy of the State of Wyoming over a 4-year construction period and 20-year operating horizon. Section 4 contains a summary of the study and future considerations outside the scope of this report.

II. Modeling Assumptions

To estimate the economic impact of the construction of a 500MW IGCC generating station in Wyoming, several assumptions have to be made regarding the project. Given the plant considered in this study would be a candidate for the western demonstration plant funding under the Energy Policy Act of 2005, no comparable plant has been built. Lack of detail regarding actual plants in operation was overcome through the use of recent engineering studies considering the potential construction of IGCC plants elsewhere in the United States. While the authors were not privy to current proprietary proposals under consideration by the Wyoming Infrastructure Authority (WIA) for the proposed Western Demonstration project, final plant specifications assumed here were deemed indicative of those proposals by the WIA. Plant construction and operating assumptions were primarily derived using an engineering study produced by Nexant (2005). This study, commissioned for the U.S. Department of Energy, describes a lignite-fueled IGCC generating facility in North Dakota that exports 251MW of electrical power. Operating assumptions and plant design were scaled-up to derive the operating and facility assumptions for the 500MW plant considered here. The size of the

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western United States with energy content up to 13,000 btu/lb). The plant must be capable of removing and sequestering CO2 emissions and the project may include the repowering of an existing power generation facility.
See http://frwebgate.access.gpo.gov/cgibin/getdoc.cgi?dbname=109_cong_bills&docid=f:h6enr.txt.pdf for the complete text of the law and Section 413 regarding this provision.

plant, fuel type used and use of CO_2 handling assumptions made in this report are all consistent with the conditions set forth under the Energy Policy Act, Section 413. Assumptions used regarding design, location, operating timeframe, CO_2 handling and the specific tax incentives are described below.

II.1. Base Operating Assumptions

Table 1 describes the basic assumptions made regarding plant operation. Two location scenarios are used to estimate regional and statewide economic impacts: Northeast Wyoming, specifically the Powder River Basin (PRB) represented by Campbell County, and Southwest Wyoming, represented by Sweetwater County. Both locations have ready access to coal and existing power transmission lines.[4] The primary difference between the two locations is the cost of coal; however, an additional consideration, discussed below, regards sources of water for plant operations. The estimates presented here all assume a plant that begins operation in 2012 and operates for at least 20 years. Construction is assumed to begin in 2008 and finish in 2012 when the plant begins a first year of limited operation. Table 1 details specific assumptions for this study.

Table 1. **Modeling Assumptions for Prototype IGCC Facility**

- Two plant locations: Sweetwater County or Campbell County.
- Construction to begin in 2008 with operations commencing in 2012 for 20 years.
- Plant availability of at least 87% (output generated 319 days per year).
- Mine mouth facility with minimal coal handling required.
- Adequate water resources available to operate plant.
- Access is available to existing transmission, with equivalent expansion requirements.
- Access to CO_2 pipelines for enhanced oil recovery (EOR) or sale.
- Sufficient labor pool for construction and operation of the facility.
- All permits granted without undue delay.
- Technology and equipment exist and are readily available.
- Ash disposal is available onsite.
- Sulfur does not have a ready market in Wyoming (no sulfur sales revenue considered).

Assumptions regarding transmission line and pipeline availability are not crucial to the report, and relaxing them would increase the general economic impacts if such facilities needed to be built. A study and estimation of the specific labor market impacts the construction of such a plant may create in Wyoming (specifically wage impacts for skilled labor) are outside the scope of this project.

[4] As discussed elsewhere in this report, it is likely that an expansion of the existing transmission system will be required to support an IGCC facility in Wyoming, regardless of where it is located. For purposes of this study, it was assumed that similar expansion costs would be required for both IGCC locations that were modeled, and that these costs would be supported in the commercial development of the facility. Market analysis and transmission expansion strategies and considerations are outside the scope of this study.

II.2. Tax Assumptions

We assume that two tax incentives are allowed for the plant under consideration. We do not attempt to define an optimal tax or subsidy level necessary to attract an IGCC facility and instead assume the tax incentives currently proposed. The first incentive is the tax holiday on the state portion of the sales tax on the capital cost of the plant and equipment installed that was adopted by the Legislature in 2005 (HB-0272). The second incentive is a proposed tax holiday on the 5.5% severance tax on the coal used at the plant (see 07LSO-0282). While severance taxes are charged to coal producers and not coal customers, we presume that under the proposed legislation a means will be defined by which the tax benefit is passed on to the IGCC customer.

One might ask whether incentives are necessary for such a plant. We do not attempt to model the profitability of the IGCC facility assumed; however, two considerations should be made with respect to the need for any tax incentives created.[5] First, Wyoming coal has a lower energy and higher moisture content than coal produced in some of the major coal producing regions elsewhere in the country, particularly in the Eastern and Midwestern United States. These characteristics increase the relative operating costs of plants using Wyoming coal. One study recently compared the potential operating costs of using Pittsburgh #8 versus Wyodak coal and found that energy and moisture considerations in Wyoming coal increased the operating costs by approximately 10% in an IGCC facility (Buchanan, Rutkowski and Longanbach, 2003). Secondly, since IGCC technology eliminates the emission cost advantages Wyoming coal has traditionally enjoyed over other coal producers by reducing the benefits of the low-sulfur content in Powder River Basin coal, a subsidy may be necessary to attract energy producers to Wyoming over other areas if they are to operate an IGCC plant using Wyoming coal. An additional consideration regarding incentives involves the existence of subsidies offered elsewhere. If incentives are created elsewhere, then regardless of any advantages or disadvantages of operating an IGCC plant in Wyoming, a tax subsidy may be necessary to remain competitive with other regions vying for such a facility. A survey of the existing and proposed tax incentives elsewhere is difficult to create as it is difficult to ascertain how many other jurisdictions may also be considering such programs, thus such a survey is not included here. If it is the case, however, that Wyoming sees a benefit to offering such a subsidy, it may be presumed that at least some other states may also be considering similar tax subsidies to entice facilities to their jurisdictions.

II.3. Prototype IGCC Plant Description

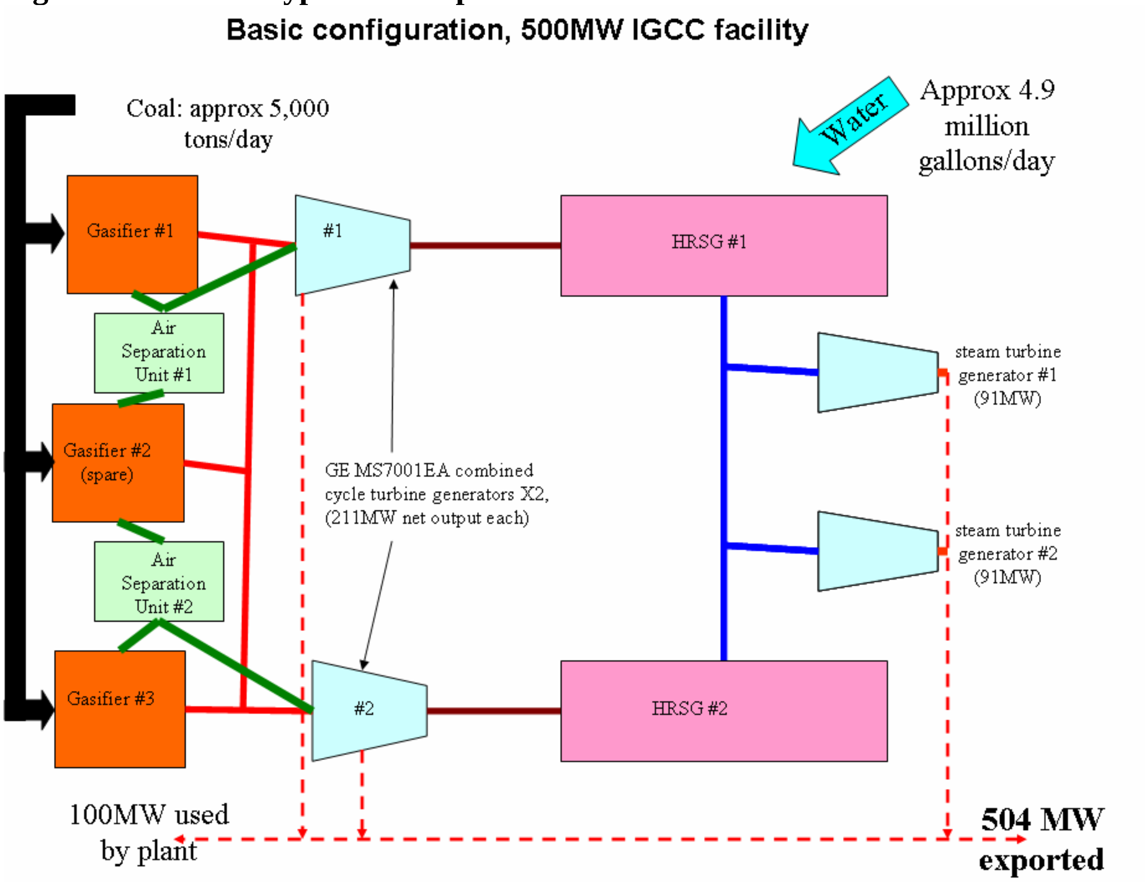
A schematic of the basic plant configuration is shown in Figure 1. Coal is assumed to be mined at an adjacent facility, mitigating any transport and preparation costs. The prototype plant developed for this report is estimated to export, on average, 504MW. To achieve this, the plant must generate a total of 604MW since it is estimated

[5] We do compare operating costs for an IGCC plant and a typical Pulverized Coal (PC) plant with and without sequestration elsewhere in the report, and these figures indicate that unless sequestration is considered, the construction and operation cost increases are significant for IGCC versus traditional PC plant thus under current regulations regarding CO_2, such a subsidy may be necessary to overcome the opportunity cost the construction and operation of such a plant presents.

that about 100MW will be used by the plant itself. Drawing from Nexant (2005), which used one combustion turbine to generate approximately 210MW and a steam turbine to generate 90MW in a single train, the prototype plant for this study scales-up this to the dual train configuration shown in Figure 1, adding a spare gasifier to increase plant availability.[6]

Following Figure 1, coal is crushed and fed into the gasifier. Steam and 95% pure oxygen are injected into the gasifier where the coal is partially combusted and converted into synthetic gas (syngas), creating a mixture of carbon monoxide (CO), carbon dioxide (CO_2), hydrogen (H_2), methane (CH_4), water and various impurities. From there, a series of processes clean the gas of impurities such as ash particulate, sulfur and any heavy metals. The clean syngas is then sent to the combustion turbine. In the combustion turbines, the syngas is diluted with nitrogen and mixed with oxygen from the Air Separation Units (ASU) and burned to produce electricity. Hot exhaust gases are directed through a Heat Recovery Steam Generator (HRSG). Water filled tubes in the HRSG capture the exhaust gas heat to create steam. Steam is then used to drive a turbine to generate additional electricity; hence the name "combined cycle."

Figure 1: Prototype IGCC Operation Assumed



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[6] These operations combine a gas-turbine and steam generator in a "train." For simplicity we presume a plant of 500MW would use existing combustion turbine components like the GE MS7001EA identified in Figure 1.

Inputs to the production process include coal, water, oxygen, electricity and natural gas.[7] Most of the power consumed by the plant is used by the Air Separation Units (ASU) to produce oxygen for gasification and the combustion turbines. Each cryogenic ASU produces 1,462 tons of oxygen per day and each of the two ASU units in the facility uses about 40MW of electrical power, or 80MW in total. These are the largest users of electric power in the facility thus the need for a total generating capacity in excess of 600MW to produce a plant output of 504MW. The amount of coal used to fuel the plant will depend on the btu content of the coal used.[8] For the Powder River Basin, sub-bituminous coals range from 7,880 to 9,750 btu/lb and average 8,330 btu/lb. Southwestern Wyoming coals are somewhat higher, ranging from 7,980 to 11,660 btu/lb (Werner, 2003). All of the coals assumed to fuel the prototype plant conform to the fuel requirements outlined in Section 413 of the Energy Policy Act of 2005 to be eligible for demonstration plant status. The project estimated coal usage by scaling-up the figure for the single train lignite system used in Nexant (2005) after consideration of the energy content differences between the fuels assumed present in Wyoming.[9]

Water is an important consideration in locating the facility since it is estimated that an IGCC plant like that proposed here will require approximately 5 million gallons per day when fully operational. Sourcing water for such a facility is beyond the scope of this project; however, its importance to any potential project dictates that it be addressed. In southwestern Wyoming, the only source water in such quantity known to the researchers is the Green River. The researchers were unable to ascertain whether or not it would be possible to use water from this source in sufficient quantity and if so, what the cost might be. Water sources in Northeastern Wyoming also potentially exist. Surplus water coming from coalbed methane production may be suitable if properly treated, but whether there is water in sufficient quantity and quality to supply an IGCC plant has not been considered. It might also be the case that sufficient ground water in the region may be available to supply such a plant, but again ascertaining this and identifying specific water sources in either location is beyond the scope of this project. The research presented in what follows simply assumes that sufficient water of suitable quality is available. We assume that any prototype plant will address this issue as part of its operation. Cost of water procurement has not been considered in our analysis.

II.4. Assumed Plant Costs

Table 2 describes the estimated costs for the Wyoming prototype plant described in the previous section. Costs are based on scaling up Nexant (2005) estimates from a single train facility to a dual train facility. Total engineering, procurement and construction (EPC) costs in the Nexant (2005) were estimated to be $410,464,000 (in 2004 dollars) to build a facility that generates 301MW of electricity and exports 251

[7] Natural gas is used to start the gasifiers and may also be used instead of syngas to power the gas-turbines if necessary. Nexant (2005) estimated a 250MW plant would use 8.93 mmbtu/hr thus a 500 MW plant could use as much as 18 mmbtu/hr.

[8] A British Thermal Unit (btu) is the Imperial measure used to describe the amount of heat required to raise one pound of water, one degree Fahrenheit.

[9] Nexant (2005) assume lignite fuel containing 6700 btu/lb is used. Southwestern Wyoming coal was assumed to have a btu content of at least 9510 btu/lb while northeastern Wyoming PRB coal was assumed to have a btu content of 8300btu/lb in this study.

MW, resulting in a design cost of $1,658 per kilowatt. Scaling such a plant to a target 500MW output as described in the previous section allows some economies of scale to be realized since not all components need to be duplicated for a dual train facility. Some components would have to be increased in size to handle larger flows from a second train, however, and costs for enlarging component capacity were not calculated due to insufficient data being available regarding such alterations in design. Consequently, our estimates may be lower than true costs. Without a full engineering and cost study, we argue that these numbers provide the "best-guess" of relevant costs for a plant of 500MW designed as assumed here.

Table 2 presents facility components and costs listed in Nexant (2005), the scaling factor used in this project and the associated cost estimate. Note that although the Nexant (2005) IGCC facility reduces emissions of particulate, nitrogen oxides (NO_X) and sulfur oxides (SO_X), mercury and other heavy metals, it does not capture CO_2. Capture of CO_2 will be discussed below and is required to be eligible for Section 413 of the Energy Act of 2005. Of interest in Table 2 are the reduced costs for coal handling in the Wyoming facility. Nexant (2005) used North Dakota lignite coal with a moisture content of approximately 40%, necessitating the need for expensive drying machinery. Wyoming coal generally has a moisture content of about 20% - 30% and may need drying machinery, depending on the gasification process used. For purposes of this study, no drying capability was assumed, thereby lowering the coal handling costs significantly. If required, the cost of operation will increase. Such estimates are not presented here.

Table 2. **Estimated EPC costs of Prototype 500 MW facility***

	Nexant (2005) facility	% of total cost	Scale factor	Wyoming 500MW facility	% of total cost
Coal handling equipment	$43,258,000	10.5%	0.25	$10,814,500	1.65%
Air separation unit	$40,318,000	9.8%	2	$80,636,000	12.31%
Coal feeding	$6,396,000	1.6%	2	$12,792,000	1.95%
Gasification	$11,366,000	2.8%	1.5	$17,049,000	2.60%
Dust removal	$5,765,000	1.4%	2	$11,530,000	1.76%
Ash removal	$8,173,000	2.0%	2	$16,346,000	2.50%
Gas cooling	$8,556,000	2.1%	2	$17,112,000	2.61%
Particulate removal	$9,642,000	2.3%	2	$19,284,000	2.95%
Gas cleaning	$7,375,000	1.8%	2	$14,750,000	2.25%
Sour water stripper	$5,221,000	1.3%	1	$5,221,000	0.80%
Acid gas removal and sulfur recovery	$15,927,000	3.9%	1	$15,927,000	2.43%
Off sites and auxiliaries	$57,026,000	13.9%	1	$57,026,000	8.71%
Buildings	$6,589,000	1.6%	1	$6,589,000	1.01%
Gas Turbine, HRSG and steam turbine	$184,852,000	45.0%	2	$369,704,000	56.46%
Total EPC cost	**$410,464,000**			**$654,780,500**	

**2004 dollars and material costs.*

Cryogenic air separation units (ASU) are the second most expensive component cost and largest power consumers in the facility. These are required to supply oxygen to the gasifiers and combustion turbines. Building a single ASU with enough capacity to feed two gasifiers was not deemed feasible, so the Wyoming prototype is assumed to have two. This would also increase the overall availability of the plant should one ASU be unavailable due to maintenance or malfunction. The gasification process generates high temperatures and pressures (1,600 degrees F and 440 psi) and the gasifiers require considerable maintenance. Nexant (2005) included a spare gasifier to increase plant availability. The prototype plant envisioned in this study would have three gasifiers, two operating and a spare. The scale factor was therefore set at 1.5 to increase the cost by 50% for a spare gasifier. Ancillary equipment associated with each gasifier was doubled to account for two operating trains. If the third gasifier were to be brought online, it is assumed that it could be cross-connected with other operating machinery to handle normal operations for either train.

The heart of the plant where electricity is generated consists of the "power block." Major equipment in the power block consists of a combustion turbine, heat recovery steam generator (HRSG) and a steam turbine generator set. The assumed Wyoming prototype facility would have two full power blocks that could be independently operated. Combustion turbine technology is constantly evolving, but for the purposes of this report, costs included in Nexant (2005) were assumed as the best available estimates for a Wyoming prototype plant. Some plant components would not necessarily need to be duplicated when increasing plant size from 250MW to the 500MW size assumed here. These include the sour water stripper, acid gas recovery, auxiliary machinery, and buildings. Some enhanced capacity of these components would likely be necessary but are not accounted for in this study due to lack of information and the detail required.

Overall, to construct the prototype plant assumed in this report it is estimated that a peak employment of about 1,600 construction jobs would be required, and that construction would take approximately four years to complete. Construction labor costs are accounted for in the EPC figure. Financing, start-up and other associated costs are found in Table 3 and have been scaled appropriately from Nexant (2005). These costs include over $124 million in contingency, development, and start-up costs that would likely be necessary to bring the plant online. Financing costs shown in Table 3 are significant. Total project costs are estimated at $873 million for an operational facility. Further interest payments for borrowed capital would continue on for another 14 years and are not detailed here. Debt and equity ratios found in Nexant (2005) were also assumed here but any proposed project of this type may have a different debt structure in Wyoming.

Potential costs not considered in this section include the cost of CO_2 capture. These are addressed in the following sections. Additional costs that are not considered in the report include any additional transmission capacity or pipeline construction for natural gas access, CO_2 sequestration or enhanced oil recovery, or other undetermined uses.

Table 3. **Total estimated construction costs without CO_2 capture (2004 dollars)**

A. Plant costs	Cost item	Comment/source
$654,780,500	EPC cost	Scaled up from Nexant (2005)
$6,547,805	initial working capital	1% of EPC-Nexant (2005)
$72,025,855	Owner's contingency	11% of EPC-Nexant (2005)
$19,643,415	Development fee	3% of EPC-Nexant (2005)
$6,547,805	Start-up	1% of EPC-Nexant (2005)
$19,643,415	Owners cost	3% of EPC-Nexant (2005)
$779,188,795	Total capital costs	
B. Construction phase financing costs		
$76,983,853	Interest during construction	9.88% of total cap. Costs-Nexant (2005)
$16,986,316	Financing fee	2.18% of total cap. Costs-Nexant (2005)
$93,970,169	Total construction phase financing costs	
C. Total project costs		
$873,158,964	Total project costs	
D. Debt/equity		
$296,874,048	Equity	34%
$576,284,916	Debt	66%
0.08	interest rate	8%

**2004 dollars and material costs.*

II.5. Carbon Dioxide Considerations

Traditional pulverized coal (PC) technology supplies over 50% of the U.S. baseload generating capacity because it is cheap and reliable; however, fossil fuel combustion (whether from coal, natural gas or oil) results in the emission of carbon dioxide, considered the largest anthropogenic source of greenhouse gas emissions in the United States.[10] At this point in time there is no mandate on limiting CO_2 emissions, but growing scientific evidence and public concerns regarding global warming suggest it is reasonable to envision some form of regulation regarding CO_2 emissions in the future. To qualify as a commercial demonstration IGCC plant under the Energy Policy Act of 2005, carbon sequestration must be possible. Accordingly, some estimate is required of the additional cost carbon sequestration requires. Given such technologies are not well-developed, we have relied on the most recent cost estimates in the literature to identify

[10] See Sekar et al. (2005) and U.S. Greenhouse Gas Inventory Reports (2006) for additional discussion on this point.

the potential costs of incorporating CO_2 capture into the prototype plant assumed in this study.

Table 4. **Comparison of Costs and Performance for a Pulverized Coal vs. IGCC Plant with and without CO_2 Capture**

	Without CO2 Capture	With CO2 Capture	% chg
Capital Cost ($ million)			
PC	726	1,258	73.28
IGCC	759	987	30.04
Net Heat Rate (Btu/KWhe)			
PC	8,690	12,193	40.31
IGCC	8,630	10,059	16.56
Fuel Input (million MMBtus)			
PC	30.4	42.7	40.46
IGCC	30.2	35.2	16.56
Fuel Costs ($ million, at $1.5/MMbtu)			
PC	45.7	64.1	40.26
IGCC	45.4	52.9	16.52
O&M Costs ($ million)			
PC	26.3	62.1	136.12
IGCC	31.2	51.0	63.46
CO2 Emissions (tonne/MWhe)			
PC	0.774	0.108	-86.05
IGCC	0.769	0.089	-88.43
CO2 Emissions (million tonnes/year)			
PC	2.71	0.38	-85.98
IGCC	2.69	0.31	-88.48

(1) All figures are reported in 2003 US$.

(2) The kilowatt hours produced in a year are given by multiplying the capacity times the number of hours in a year: 500MW * 80% * 8760 hours = 3,504 kilowatt hours. The total Btus consumed in the year is then calculated by multiplying the 3,504 million kilowatt hours by the net heat rate. Finally, the annual fuel cost is calculated by multiplying the total Btus consumed times a price of coal per Btu. These figures assume a coal price of $1.50/MMBtu.

(3) O&M costs with CO_2 capture include transportation and storage of captured CO_2 at $5/t.

(4) Capacity assumed to be 500MW; availability 80%; discount rate 6%..

Reproduced from Table 1 of Sekar et al. (2005).

Using Sekar, et al. (2005) estimates, which are reproduced in Table 4, the cost-disadvantages of carbon capture are apparent when added to an IGCC plant. Sekar et al note that for a 500MW IGCC plant, capital costs increase by approximately 30% and operation and maintenance costs (which include transportation and storage costs) increase by approximately 64%. Using the hypothetical Wyoming prototype IGCC plant assumed in this study, capital costs alone would increase by approximately $200 million with the addition of carbon capture capability in the plant. Additionally, using Sekar et al's estimates, annual operation and maintenance costs would increase by nearly $20 million or almost 65% for a 500MW plant. It should be noted that from a cost perspective, IGCC technology becomes much more attractive than traditional PC technologies if it is assumed that carbon capture is required. As shown in Table 4, all cost categories for a 500MW PC plant are higher than a comparable capacity IGCC plant when carbon capture is included, thus if carbon capture becomes mandated in the future, it seems reasonable to assume that IGCC plants will become the preferred plant design assuming the technology becomes proven.[11]

CO_2 captured in Wyoming could be sequestered, or put to use in enhanced coal-bed methane or enhanced oil recovery. Sequestration is costly thus some use of CO_2 that could earn revenues would be beneficial to overall plant profitability. Used in coal-bed methane production, CO_2 displaces additional methane from underlying coal deposits, enhancing methane output. Enhanced oil recovery (EOR) utilizes CO_2 by pumping it into the ground to stimulate more oil production out of wells that have slowed or stopped producing. Such methods provide a substantial economic benefit as 30%-60% or more of the reservoir's original oil in place can be recovered. Both CO_2 recycling processes offer a means of both enhancing current energy production while allowing carbon sequestration to take place.

We do not attempt to estimate the economic value of captured CO_2; however, it could be significant. Current carbon emission trading prices for sequestered carbon in 2006 ranged from $3.10/ton and $4.60/ton using Carbon Financial Instrument (CFI) contracts reported on the Chicago Climate Exchange. Recent legislative discussions have suggested potential carbon taxes of $10.82/t CO_2 could be in place by 2015.[12] Overall, the types of carbon reductions possible using IGCC technology could result in savings of millions of dollars if these emissions become regulated. Used to enhance production of oil or methane, the value of captured CO_2 could be even greater. As of November 2006, CO_2 is currently being purchased at $2/mcf or $35.60/ton (WPA, 2006) for such uses.

III. Regional and State Economic Impact Analysis

III.1 Regional Economic Impacts

The following section summarizes the regional economic impacts of locating a 500MW IGCC facility with CO_2 capture as described in the previous sections in two potential areas of Wyoming. For context, this impact is compared to the regional impact of a simple increase in production and exportation of coal in an amount equal to that assumed used to fuel the 500MW plant. The analysis assumes that the 500MW facility is located either in Southwest Wyoming or Northeast Wyoming.

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[11] According to the figures reported in Table 4, a plant producing 500MW with traditional PC technology and without CO_2 capture would emit 2.71 million tons/year of CO_2, while a 500MW producing plant with IGCC technology and CO_2 capture technology would emit 310,000 tons/year, resulting in a reduction of 2.4 million tons/year of CO_2, or an 89% reduction in total emissions. The environmental benefits of IGCC technology extend to traditional pollutants as well. In addition to enabling CO_2 emissions to be more readily separated from the syngas stream than from flue gas in a PC plant, gasification also allows NO_X, SO_X and particulates to be more easily handled relative to traditional PC plants.

[12] Sekar et al (2005) describe potential regulatory efforts recently discussed in the United States.

In both locations there are regional resource and market differences that could impact a firm's strategic and operational preferences. These issues are outside the scope of this study. On the input side, coal in Southwest Wyoming has a higher BTU content than the PRB but is more expensive to mine. Output considerations could also affect plant location preference as a plant in southwestern Wyoming would most likely supply California and southwestern United States markets, while a plant located in northeastern Wyoming would more likely supply Midwestern and Front Range markets.

Our analysis evaluates the economic and fiscal effects of locating a 500MW plant in either of the two regions. We place the plant in Sweetwater County or Campbell County for the analysis, but recognize that other counties in those respective regions may be equally reasonable locations for an actual plant. Capital costs are assumed to be the same in either region, while operating costs are different due primarily to the different coal BTU levels and prices in Southwest Wyoming and the Powder River Basin.

Regional models were developed for each region using IMPLAN and its 2004 database for Wyoming (MIG, 2004). The power generation sector for each model was modified to reflect IGCC production structure. Output was based upon estimates derived from Nexant (2005) production estimates described elsewhere in this report, and electricity prices were an average taken from Energy Information Agency, Form 861 Wyoming Data (EIA 2006). Other assumptions used in structuring the scenarios include water availability, CO_2 sales demand, and access to the regional electric grid (and corresponding buyers of electricity) in both regions.

Total construction costs assumed for the plant with CO_2 capture are presented in Table 5.[13] To measure regional economic impacts we assume total EPC costs including CO_2 capture of $1.128 billion using estimates of prices and materials costs in current dollars. Construction costs were derived from those in Nexant (2005) scaled to the plant size considered here as described previously. CO_2 capture clearly increases the cost of such an operation when compared to costs without CO_2 capture presented previously. Other investment costs in Table 5 do not affect regional impacts but are important factors related to the ultimate economic feasibility of the project. Construction is assumed to take four years and impacts are spread evenly over each year.

Table 5: Capital Costs for a 500MW Plant

Plant costs		Comment/source
$1,127,751,714	EPC cost	Scaled from Nexant (2005)
$342,836,521	CO2 capture equip.	Buchanan et al. (2003)
$1,470,588,235	**Total EPC cost w/ CO2 capture**	
$14,705,882	intial working capital	1% of EPC - Nexant (2005)
$161,764,706	Owner's contingency	11% of EPC - Nexant (2005)
$44,117,647	Development fee	3% of EPC - Nexant (2005)
$14,705,882	Start-up	1% of EPC - Nexant (2005)
$44,117,647	Owners cost	3% of EPC - Nexant (2005)
$1,750,000,000	Total capital costs	

**Estimated 2008 dollars and material costs.*

[13] Note that figures in Table 5 differ from those in Tables 2 and 3 due to the addition of CO_2 capture costs.

Economic impacts of construction are calculated for both regions assuming local and non-local labor are available. Impacts with non-local labor imply that household re-spending does not contribute to the regional multiplier. Operating impacts are estimated in both regions assuming EIA Form 861 average power prices to value production, and 160 plant-production jobs. These jobs are all assumed to be local thus household re-spending contributes to the economic multiplier.

Economic impacts of operation are compared with simply exporting coal out of the region. It is assumed that without the IGCC plant coal would simply be exported. An important qualification here is that we are not comparing the IGCC with a traditional pulverized coal-fired power plant, only coal exportation. Comparison to a PC plant while interesting, is outside the scope of our study but could be the basis for a more in-depth future analysis.[14] We refer to Sekar (2005) and Sekar, et al (2005) for analyses that compare IGCC with a pulverized coal power plants.

III.2 Southwest Wyoming

The following section summarizes the regional economic impacts of locating a 500 MW IGCC facility with CO_2 capture compared with simple exportation of coal as the baseline. The analysis uses IMPLAN (MIG, 2004) to evaluate the regional economic impacts of the facility and REMI to evaluate the economic impacts to the State. Fiscal impacts are estimated based in part on the economic impacts. Two functional economic areas are chosen in this analysis: Southwest Wyoming, comprising Sweetwater, Lincoln, Uinta, and Sublette Counties; and the Powder River Basin, comprised of Campbell, Sheridan, and Johnson Counties. Both locations are used in this analysis because of coal resource availability and potential CO_2 utilization. We place the plant in Sweetwater County or Campbell County for the analysis, but recognize that other counties in those respective regions may be equally reasonable locations for an actual plant. In both locations there are regional resource and market differences that affect a firm's market and operational structure.

Regional models were developed for each region using IMPLAN and its 2004 database for Wyoming (MIG 2004). The power generation sector for each model was modified to reflect IGCC production structure. Output was based upon the Nexant production described in the previous section and electricity prices were an average taken from Energy Information Agency Form 861 Wyoming Data (EIA 2006). Other assumptions used in structuring the scenarios include water availability, CO_2 sales demand, and access to the regional electric grid (and corresponding buyers of electricity) in both regions.

Construction costs for the plant total with CO_2 capture are presented in Table 5. To measure regional impacts we use total EPC costs including CO2 capture of $1.217 billion. Construction costs were to equal the value of the equipment and building estimates based upon Nexant. CO_2 capture clearly increases the cost of such an operation to a considerable degree. Other investment costs in Table 5 do not affect regional impacts but are important factors related to the ultimate economic feasibility of the project. Construction is assumed to take four years and impacts are divided evenly for each year.

[14] Such a comparison would require an estimate of specific PC plant operations and debt structures.

Construction impacts are summarized in Table 6. Economic impacts in Southwest Wyoming range from 2,370 jobs assuming non-local labor to 2,923 jobs assuming local labor. Labor income ranges from $96 million to $109 million in the region. Average annual earnings per job (AEPJ) directly in the construction industry are approximately $42,500. Total average annual earnings per job range from $37,227 to $40,629.

Table 6: Construction Impacts – Southwest Wyoming

	Annual Job and Labor Income	
	All Local	Non-Local
Direct Jobs	1,912.0	1,912.0
Indirect Jobs	457.9	457.9
Induced Jobs	552.9	0.0
Total Jobs	2,922.8	2,369.9
Direct Earnings	$81,275,721	$81,275,721
Indirect Earnings	$15,010,195	$15,010,195
Induced Earnings	$12,519,890	$0
Total Earnings	$108,805,806	$96,285,916
Employment Multiplier	1.53	1.24
Earnings Multiplier	1.34	1.18
Direct AEPJ	$42,508	$42,508
Indirect AEPJ	$32,783	$32,783
Induced AEPJ	$22,644	NA
Total AEPJ	$37,227	$40,629

Economic impacts in Southwest Wyoming of the operation itself starting in year 5 are estimated in Table 7. An IGCC operation supports 160 direct jobs and supports another 177 jobs in the surrounding economy. A total of 337 jobs are supported in the regional economy. Total labor income generated is $21,379,930. Average annual income per job is $93,586 in the industry and $63,425 overall. Indirect and induced jobs tend to be more service and retail sector jobs and thus have lower average annual earnings.

The value added aspect of an IGCC plant is illustrated in Table 7 by comparing the impacts of the IGCC operation with simply exporting the coal. Substantially more jobs are generated through an IGCC and more labor income than simply exporting the same amount of coal. An IGCC plant generates 187 more jobs and over $13 million more in labor income. This increase represents the value added benefits to the Southwest Wyoming economy and the State.

Table 7: Economic Impact of IGCC in Southwest Wyoming over Coal Exportation

	Generation	Coal Export	Net Increase	Pct. Increase
Direct Jobs	159.9	65.5	94.4	144.2%
Indirect Jobs	75.9	42.6	33.3	78.1%
Induced Jobs	101.3	41.9	59.4	141.7%
Total Jobs	337.1	150.0	187.1	124.7%
Direct Earnings	$14,968,450	$5,697,210	$9,271,240	162.7%
Indirect Earnings	$3,976,991	$1,648,774	$2,328,217	141.2%
Induced Earnings	$2,434,489	$949,241	$1,485,248	156.5%
Total Earnings	$21,379,930	$8,295,225	$13,084,705	157.7%
Employment Multiplier	2.11	2.29		
Earnings Multiplier	1.43	1.46		
Direct AEPJ	$93,586	$86,980		
Indirect AEPJ	$52,405	$38,704		
Induced AEPJ	$24,042	$22,655		
Total AEPJ	$63,425	$55,302		

*AEPJ = Average Earnings per Job

Over the course of the construction and operation plan (24 years) jobs and income spike during construction and then level off to a stable level in the years following as shown in Figures 2a and 2b. Overall, the job and income change over simply exporting the same amount of coal used by the IGCC plant is significant as shown in the Figures. The increased complexity of the facility as well as the value-added aspect of an IGCC facility has a more positive effect on the local economy than traditional energy export. Assuming mostly non-local jobs, over 2500 more jobs and $100 million more in labor income are generated the first four years. Then after the plant begins operation and shifts to permanent employment (year 5 through year 24), 187 more jobs per year are supported than would occur with simply exporting coal out of the region.

Figure 2a: Net Change in Jobs for Southwest Wyoming over Exporting Coal

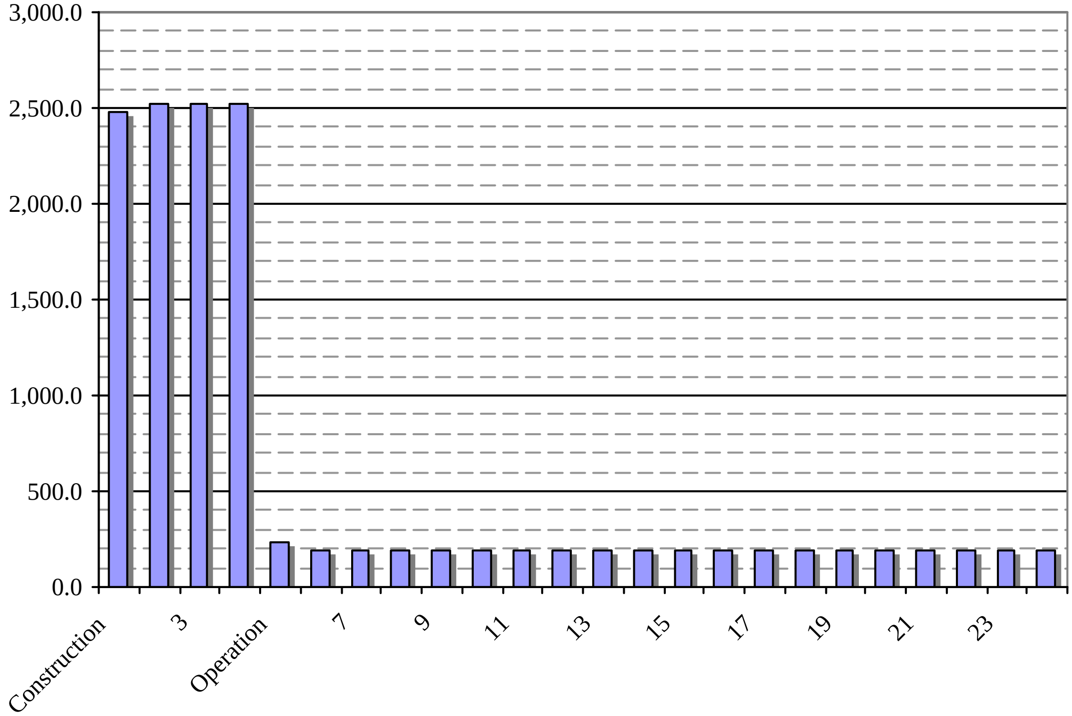
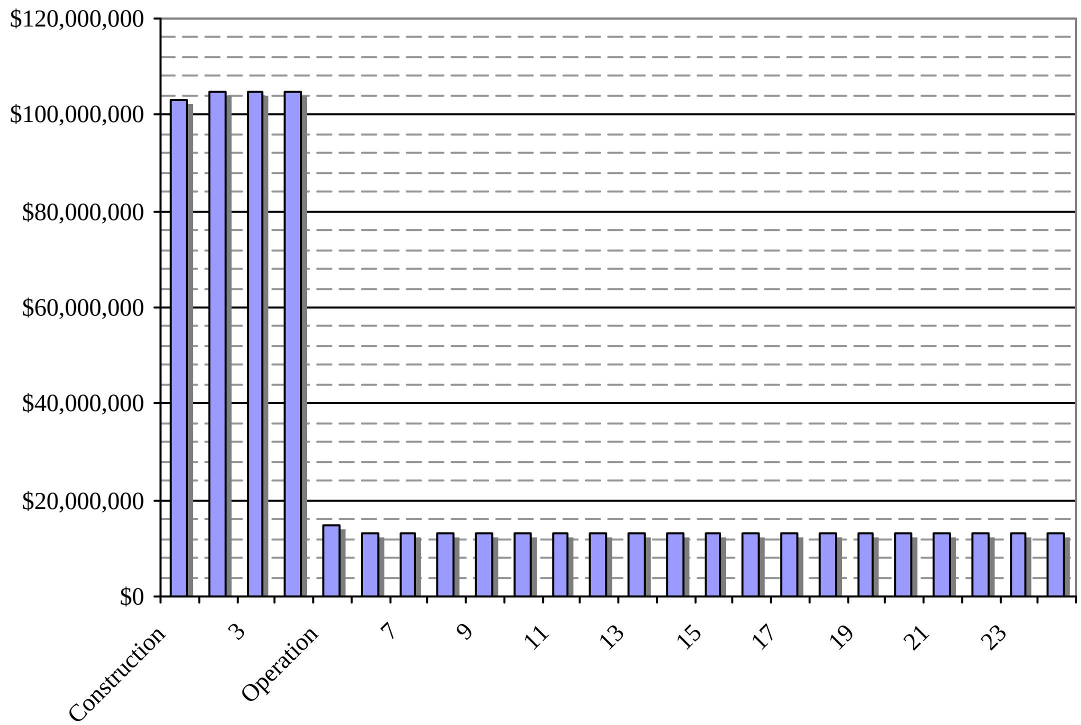


Figure 2b: Net Change in labor Income for Southwest Wyoming over Exporting Coal



III.3 Northeast Wyoming - Powder River Basin

Like Southwest Wyoming, local economic impacts for the construction and operation of an IGCC plant are considerable. Construction impacts described in Table 8 range from 2,300 jobs generated assuming all non-local labor is used, to 2,804 jobs if all local labor is used. Labor income generated ranges from over $89.2 million to $101.2 million annually. Average earnings per job range from $36,095 to $38,517 per year. Additional economic impacts for the operation of an IGCC facility are as substantial in northeast Wyoming as they are in southwest Wyoming. The 160 direct jobs in the Powder River Basin generate almost 300 additional jobs in the regional economy and $20 million in new labor income. This exceeds simply exporting the same amount of coal outside the State. Average earnings per job, including the secondary effects is $68,378 versus $58,779 generated from simple coal export. Like southwest Wyoming, the increased jobs and labor income suggest that there are significant benefits to the construction and operation of an IGCC plant in northeast Wyoming.

Table 8: Construction Impacts – Northeast Wyoming

	Annual Job and labor income effects of an IGCC plant in the Powder River Basin	
	All Local	Non-Local
Direct Jobs	1,912.0	1,912.0
Indirect Jobs	405.8	405.8
Induced Jobs	485.9	0.0
Total Jobs	2,803.6	2,317.8
Direct Earnings	$75,967,277	$75,967,277
Indirect Earnings	$13,306,182	$13,306,182
Induced Earnings	$11,924,498	$0
Total Earnings	$101,197,957	$89,273,459
Employment Multiplier	1.47	1.21
Earnings Multiplier	1.33	1.18
Direct AEPJ	$39,732	$39,732
Indirect AEPJ	$32,792	$32,792
Induced AEPJ	$24,542	NA
Total AEPJ	$36,095	$38,517

Construction impacts are summarized in Table 8. Economic impacts in the Powder River Basin range from 2,318 jobs assuming non-local labor to 2,803 jobs assuming local labor. Labor income ranges from $89 million to $101 million in the region. Average annual earnings per job (AEPJ) directly in the construction industry are approximately $39,732. Total average annual earnings per job range from $36,095 to $38,517. Differences in impacts between Southwest Wyoming and the Powder River Basin are due to subtle differences in wage structures across the two regions.

Economic impacts in the Powder River Basin of the operation itself starting in year 5 are estimated in Table 9. As in the previous analysis an IGCC operation generates 160 direct jobs and supports another 177 jobs in the surrounding economy. A total of 296 jobs are supported in the regional economy. Total labor income generated is $20,221,453. Average annual income per job is $93,559 in the industry and $68,378 overall.

As in the previous regional impact analysis the value added aspect of an IGCC plant is also exemplified in the Powder River Basin. Comparing the impacts of the IGCC operation with simply exporting the coal substantially more jobs and labor income are generated through an IGCC operation than simply exporting the same amount of coal. For the Powder River Basin an IGCC plant generates 263 more jobs and over $18 million more in labor income. This increase represents the value added benefits to the Powder River Basin economy and the State.

Table 9: Economic Impact of IGCC in northeast Wyoming over Coal Exportation

	IGCC Generation	Export Coal	Net Change	Percent Change
Direct Jobs	160.1	13.5	146.6	1086.2%
Indirect Jobs	45.2	9.8	35.4	361.2%
Induced Jobs	90.4	9.0	81.4	904.4%
Total Jobs	295.7	32.3	263.4	815.6%
Direct Earnings	$14,982,252	$1,176,000	$13,806,252	1174.0%
Indirect Earnings	$2,884,551	$500,553	$2,383,998	476.3%
Induced Earnings	$2,354,650	$222,012	$2,132,638	960.6%
Total Earnings	$20,221,453	$1,898,565	$18,322,888	965.1%
Employment Multiplier	1.85	2.39		
Earnings Multiplier	1.35	1.61		
Direct AEPJ	$93,559	$87,111		
Indirect AEPJ	$63,820	$51,077		
Induced AEPJ	$26,048	$24,668		
Total AEPJ	$68,378	$58,779		

Over the course of the construction and operation plan (24 years) jobs and income increase due to construction and then level off to a stable level in the years following as shown in Figures 3a and 3b. Overall, as shown in Figures 3a and 3b, the job and income change over simply exporting the same amount of coal used by the IGCC plant is significant. The increased complexity of the facility as well as the value-added aspect of an IGCC facility has a more positive effect on the local economy than traditional energy export. Assuming mostly non-local jobs over 2,300 more jobs and $90 million more in labor income are generated the first four years. Then after the plant begins operation and shifts to permanent employment (year 5 through year 24), 263 more jobs per year are supported than would occur with simply exporting coal out of the region.

Figure 3a: Net Change in Jobs for Northeast Wyoming over Exporting Coal

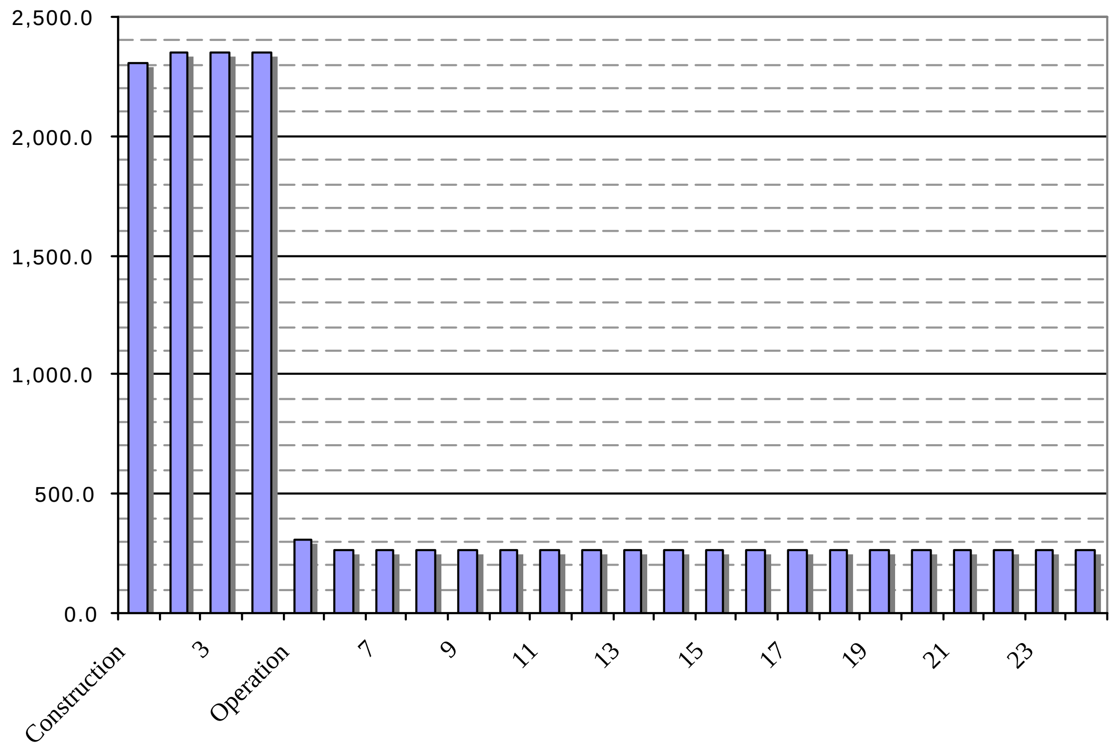
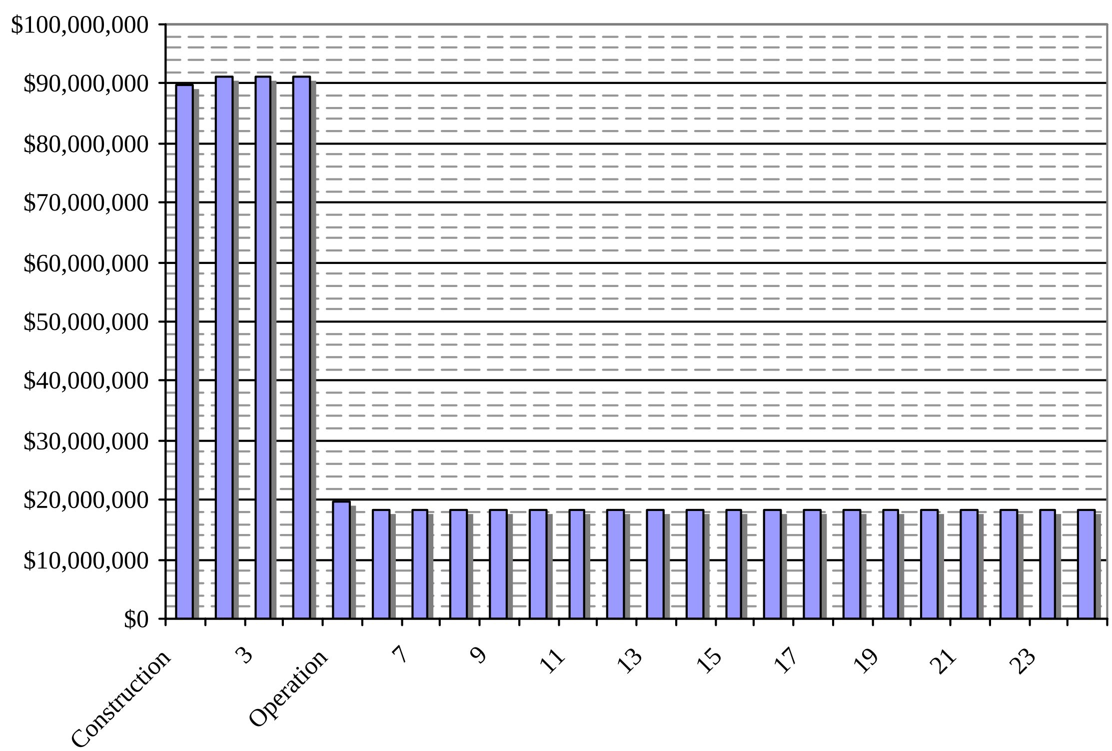


Figure 3b: Net Change in Labor Income for Northeast Wyoming over Exporting Coal

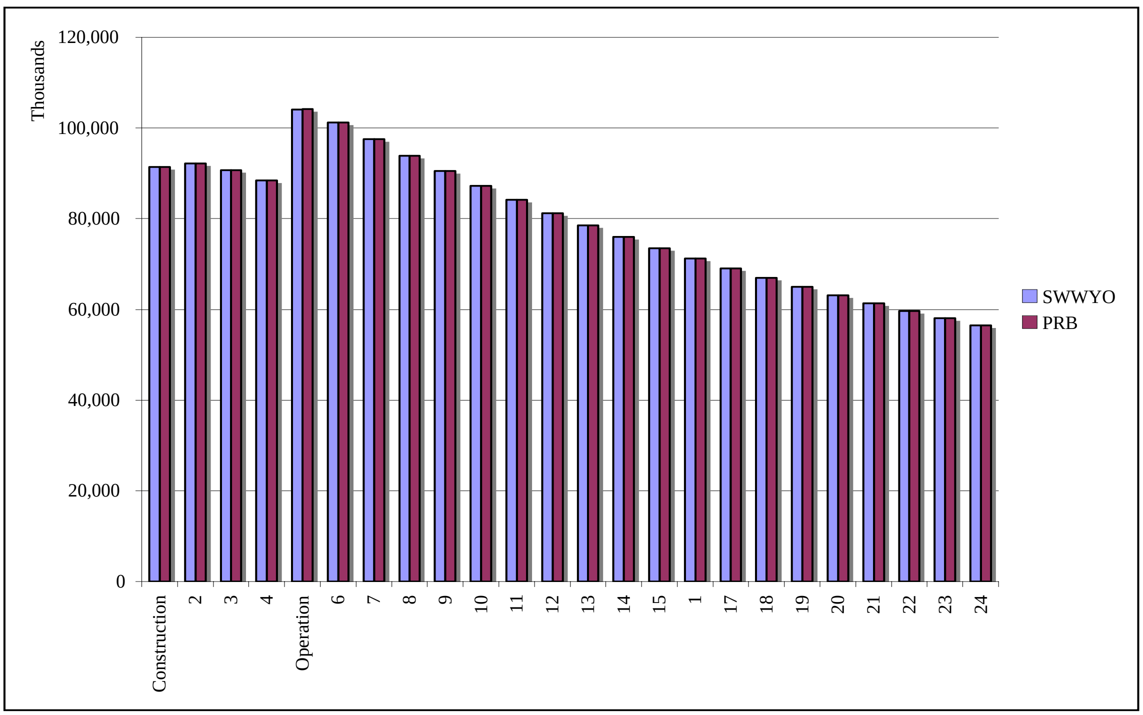


III.4 Statewide Economic Impacts

The effects on gross state product for the construction of a 500MW IGCC generation plant with carbon capture were estimated using the State of Wyoming REMI model.[15] Gross state product (GSP) effects of an IGCC plant compared to exporting the coal used are summarized in Figure 4. Both locations considered affect the State economy in very similar ways. GSP increases due to construction effects, peaking at year 5, and then as secondary effects of construction subside, operational effects replace them. Annual GSP increases to over $104 million and then subsides to $56 million at the end of the planning cycle (measured in real dollars using 2000 as the base year).

The employment impacts for the construction of an IGCC facility are shown in Figure 5. Similar to the GSP effects, annual net job effects for the construction of an IGCC plant compared to the export of coal alone show a statewide spike in annual job growth, and then a subsidence to a stable number of jobs corresponding to the increase caused by the plant operation. Overall, both locations have very similar effects on the state economy in terms of GSP and employment.

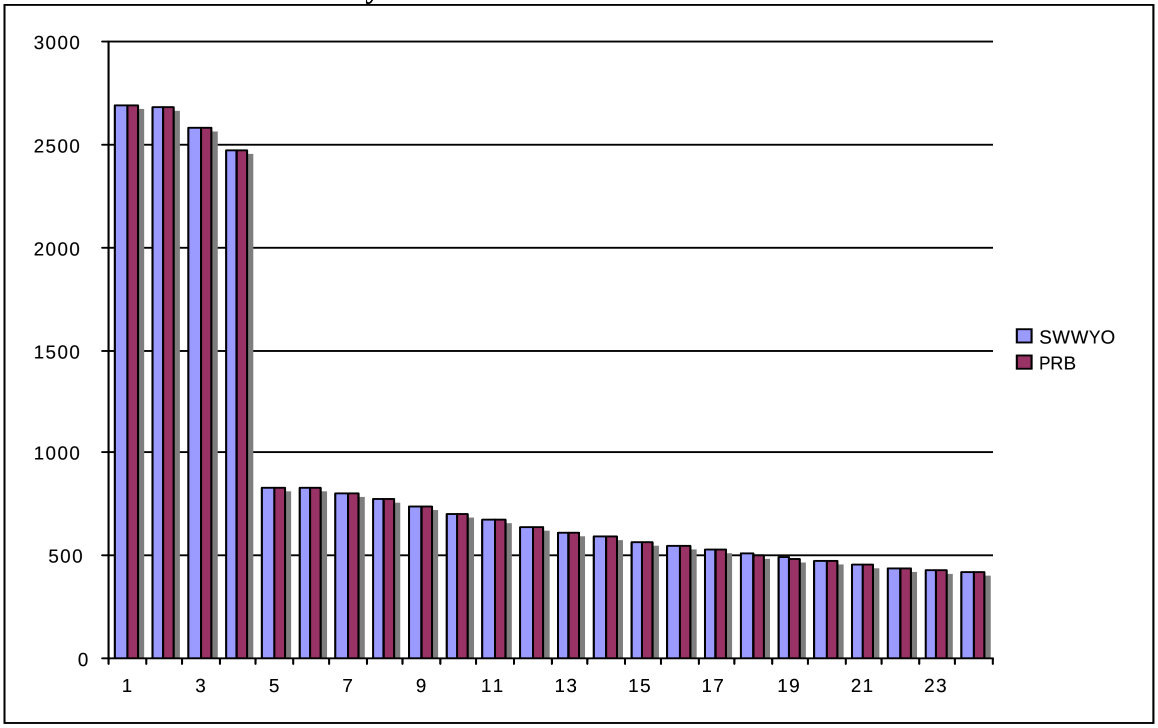
Figure 4: Wyoming Gross State Product changes from construction and operation of a 500MW IGCC facility



Source: REMI computations prepared for this report

[15] REMI estimates were performed by the Wyoming Department of Administration and Information, Division of Economic Analysis.

Figure 5: Wyoming Statewide job effects from construction and operation of an IGCC facility.



Source: REMI computations prepared for this report

III.5: Fiscal Effects

The following section evaluates the local and state fiscal impacts of an IGCC plant. The analysis considers only tax revenue effects and not local or state expenditure effects that could accrue through any additional economic activity created. As in the previous section we compare the construction and operation of an IGCC plant with exportation of coal and without a tax holiday on the severance tax. We assume that the facility will be located in either Sweetwater County or Campbell County and therefore use property and sales tax rates relevant to each county. As noted above though, this does not suggest that there may be more compelling reasons to locate the facility in another county. The question of the optimal location of such a facility to maximize statewide effects was outside the scope of this study given the timeframe the report was prepared in. Sales taxes are computed based upon the total labor income impact. Workers and households that directly or indirectly receive income pay sales taxes when they purchase many items (food is excluded).

Southwest Wyoming

An IGCC facility generates substantially more tax revenues than simply exporting the same amount of coal used to fuel such a plant. The higher fiscal impacts caused by the construction and operation of an IGCC plant compared to only the export of coal are described in Table 10. Including both state and local tax generation, an IGCC facility generates a total of $14.9 million in revenues per year while exporting the coal generates

$3.99 million per year. That represents a 274% increase in tax revenues across both levels of government. The state sees a drop in severance tax revenues (and corresponding drop in severance tax distributions to local government), but sees an increase in sales taxes from labor earnings. The state also sees an increase in the 12 mill portion of the property tax that is dedicated to K-12 education. Local government sees the largest increase in revenues due mostly to increases in property taxes generated. The amount of severance tax distributions falls, but based upon the 2005 Treasurer's report allocations, this is a very small amount of the total tax revenues to counties and cities and is negligible to the analysis presented here.[16]

Table 10: Southwest Wyoming IGCC Tax Change Summary using 2006 Rates and Revenues

	Generation	Exporting Coal	Net Change	Percent Increase
Annual Taxes				
Property Tax – Coal	$1,063,746	$1,063,746	$0	0.0%
Property Tax – IGCC	$11,947,206	$0	$11,947,206	N.A.
Coal – Severance	$0	$1,254,312	-$1,254,312	-100.0%
Sales Tax – Earnings	$426,335	$165,414	$260,921	157.7%
FMR	$1,508,312	$1,508,312	$0	0.0%
Total	$14,945,600	$3,991,785	$10,953,815	274.4%
Local Government				
Property Tax – Coal	$848,722	$848,722	$0	0.0%
Property Tax – IGCC	$9,532,206	$0	$9,532,206	N.A.
Coal – Severance	$0	$3,149	-$3,149	-100.0%
Sales Tax – Earnings	$190,998	$74,106	$116,893	157.7%
FMR	$4,047	$4,047	$0	0.0%
LG Total	$10,575,973	$930,023	$9,645,950	1037.2%
State Government				
Property Tax - Coal*	$215,025	$215,025	$0	0.0%
Property Tax - IGCC*	$2,415,000	$0	$2,415,000	N.A.
Coal – Severance**	$0	$1,251,163	-$1,251,163	-100.0%
Sales Tax - Earnings	$235,337	$91,838	$143,499	156.3%
FMR**	$1,504,265	$1,504,265	$0	0.0%
State Total	$4,369,627	$3,062,291	$1,307,336	42.7%
Grand Total	$14,945,600	$3,992,315	$10,953,285	274.4%

* State School Foundation Program 12 mills

** Includes funding going to counties and cities outside the county

[16] Our estimates indicate the drop in revenues from this effect is over 1000 times less than the total impact.

Northeast Wyoming, Powder River Basin

As in Southwest Wyoming, fiscal impacts to both state and local government are large. Property taxes increase by $11 million when an IGCC facility is built because, while producing coal alone generates property taxes, the IGCC facility increases total property taxes as shown in Table 11. As in Southwest Wyoming, sales taxes are estimated based upon total labor earnings generated directly and indirectly from the economic impacts. Sales taxes increase by $423,396 with a net change of $383,644 over coal export alone. Local government receives a much larger tax effect with an IGCC facility than the State as the State needs to account for the entire loss of the severance tax under the proposed tax holiday, while the county and cities lose only the relatively small amount that would have been redistributed back to them.

Table 11: Fiscal impacts of an IGCC plant compared to exporting coal in the Powder River Basin.

	IGCC Generation	Export Coal	Net Change	Percent Change
Annual Taxes				
Property Tax - Coal	$471,113	$471,113	$0	0.0%
Property Tax - IGCC	$11,869,121	$0	$11,869,121	N.A.
Coal - Severance	$0	$559,166	-$559,166	-100.0%
Sales Tax - Earnings	$423,396	$39,752	$383,644	965.1%
FMR	$672,397	$672,397	$0	0.0%
Total	$13,436,027	$1,742,428	$11,693,599	671.1%
Local Government				
Property Tax - Coal	$375,256	$375,256	$0	0.0%
Property Tax - IGCC	$9,454,121	$0	$9,454,121	N.A.
Coal - Severance	$0	$1,035	-$1,035	-100.0%
Sales Tax - Earnings	$200,690	$18,842	$181,847	965.1%
FMR	$1,868	$1,868	$0	0.0%
LG Total	$10,031,935	$397,002	$9,634,933	2426.9%
State Government				
Property Tax - Coal*	$95,857	$95,857	$0	0.0%
Property Tax - IGCC*	$2,415,000	$0	$2,415,000	N.A.
Coal - Severance**	$0	$558,131	-$558,131	-100.0%
Sales Tax - Earnings	$222,706	$20,910	$201,797	965.1%
FMR**	$670,529	$670,529	$0	0.0%
State Total	$3,404,092	$1,345,427	$2,058,666	153.0%
Grand Total	$13,436,027	$1,742,428	$11,693,599	671.1%

Long run net tax impacts are presented in Figure 6a and 6b for the two regions and for the State. The figures net out the tax effects of exporting coal. Local government (county and municipality) clearly gain the most, due primarily from increased property taxes. The State, while losing revenue from the severance tax, gains through the school fund 12 mill levy and state sales taxes from labor earnings. The net difference for Southwest Wyoming local government shows a steady increase until year 4 then a stable level at approximately $9.649 million in taxes. Similarly Powder River Basin levels out for local government at $9.635 million in taxes.

State government sees a smaller but still positive change in tax collections versus coal exportation. During construction, impacts from sales taxes, labor earnings, coal severance taxes, and 12 mill levy increase the difference. After the severance tax holiday starts the State sees a reduction, but still positive difference (due primarily to the state sales taxes from labor earnings). When the holiday ends state tax collections increase again.

Figure 6a. Tax impacts for state and local government in Southwest Wyoming over the planning period.

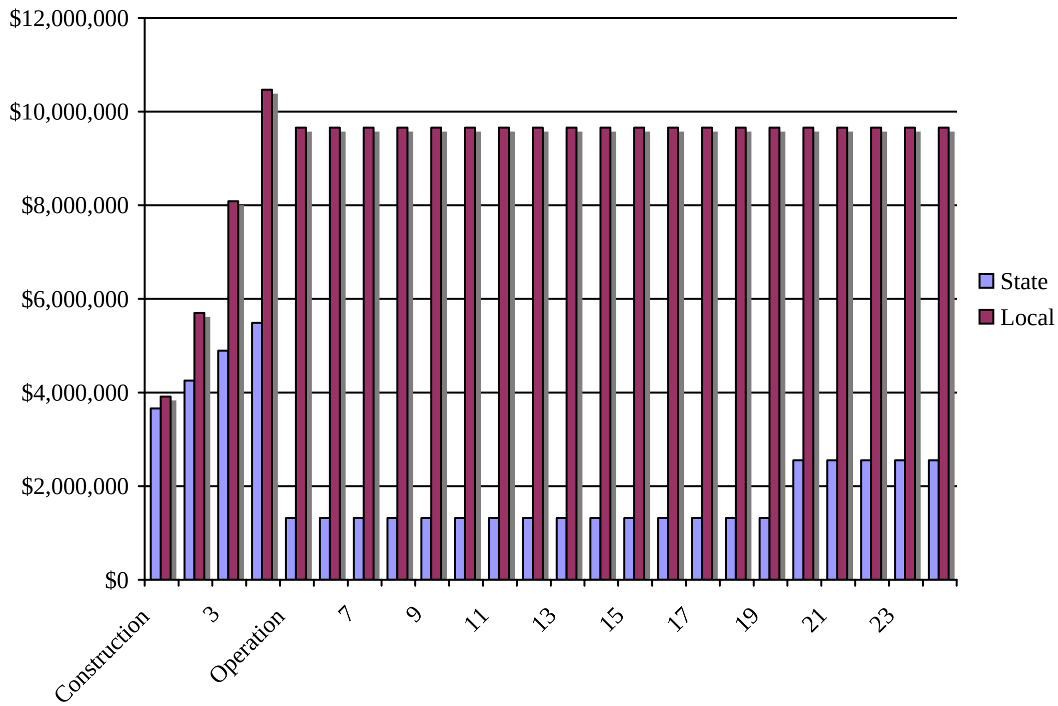
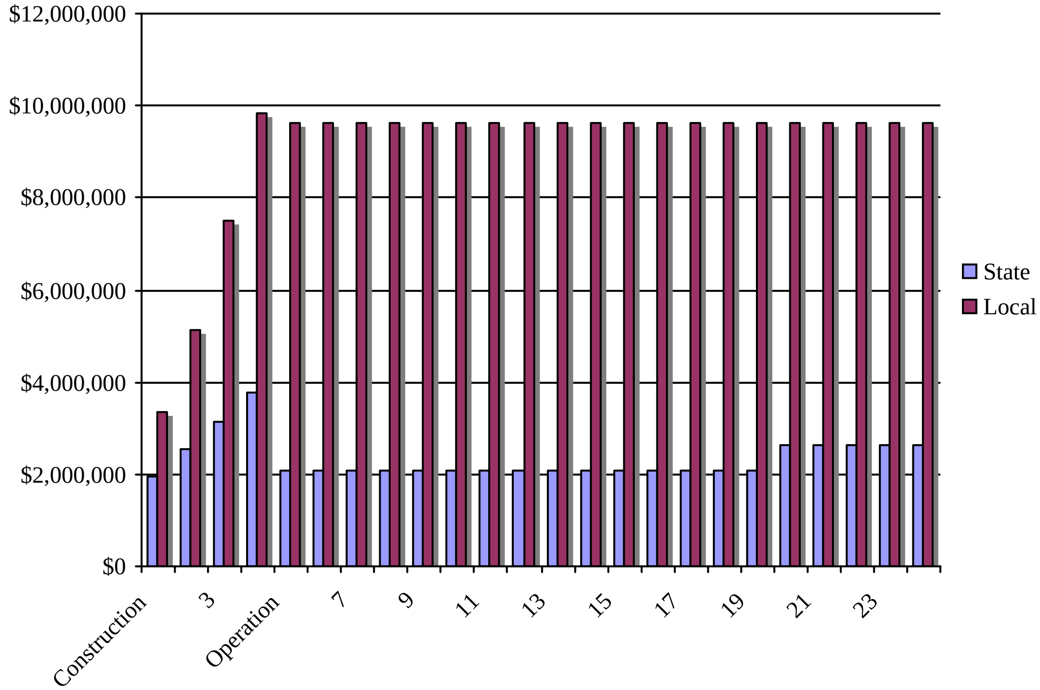


Figure. 6b. Tax impacts for state and local government in the Powder River Basin over the planning period.



Conclusion

This report was written to estimate the potential economic impact of construction of a 500MW IGCC (integrated gasification combined cycle) plant eligible for Section 413 funding under the Energy Policy Act of 2005 as an IGCC western demonstration project. The State of Wyoming is currently considering two tax holidays to attract such a project to the state, specifically a tax holiday on the state share of sales taxes that could be generated from the construction of such a plant (2005 Legislation HB-0272), and a 15-20 year holiday on the severance tax charged on the coal used by such a plant (proposed bill 07LSO-0282). For the analysis presented here, a 20-year holiday was assumed. While Wyoming has benefited greatly from the upsurge in revenues caused by current high energy prices, there is concern that Wyoming does not benefit as much as it could from energy exports because it currently exports unprocessed energy commodities in the form of coal, natural gas and oil. It has been suggested that if Wyoming were to facilitate the utilization of coal to produce electricity or other value-added commodities, and shipped these commodities to market, the State could reap additional benefits by creating jobs, tax base, and other value-adding activity within the State. While such planning makes intuitive sense, this report was commissioned to determine whether this reasoning is actually supported by an economic study.

There are other reasons to consider and promote the development of new energy technologies inside the State. Concerns regarding future regulations on greenhouse gases suggest it may be prudent to consider newer technologies that allow carbon capture if such generation facilities are to be built in Wyoming, particularly IGCC technology. This technology would not only qualify for potential aid under Section 413 of the Energy Policy Act of 2005, but would also ensure that Wyoming energy will continue to be demanded by the marketplace. Such actions might also protect Wyoming's competitive position in national coal markets. IGCC could threaten demand for Wyoming coal as this technology allows low-cost separation of sulfur from the exhaust stream, undermining the emissions-cost savings advantages Powder River Basin coal currently offers users. Additionally, due to the lower energy and higher moisture content of Wyoming coal, if IGCC were to become a major part of the generation infrastructure of the United States, demand for Wyoming coal could be further reduced due to the higher cost this coal creates in energy production. Simply put, new regulations and new technologies may threaten Wyoming's current market advantages in the coal market. Given these concerns, the construction of IGCC power generation facilities in Wyoming could partially offset these potential threats by creating permanent demand for Wyoming coal. Since IGCC facilities are significantly more expensive than traditional plants to build, this may be a justification for offering an incentive for such plants to locate in Wyoming.

To estimate the potential economic benefits of construction of a 500MW IGCC generating station in Wyoming, this report assumed that the plant would be located in either southwest or northeast Wyoming (specifically Sweetwater or Campbell counties respectively). While other sites may be equally attractive or more compelling as locations for such a plant, the purpose of this report was not to identify the optimal location, but to estimate the impact of such a plant on the Wyoming economy. To determine the potential economic impact the construction and operation of such a plant could create, the report also had to make assumptions regarding plant design, construction, and operating costs estimates since IGCC plants are not well developed. Our estimates indicate that construction of such a plant would require a capital investment of just over $1.75 billion dollars, which is approximately 2.5 times more than an equivalent generating facility using traditional pulverized coal technology and lacking carbon capture would cost. Under current legislation and proposals, such a facility would require an implied annual subsidy from the State in lost severance taxes (assuming the coal used to fuel the plant was instead exported) of between approximately $560,000 year and $1.25 million/ year depending on the location (the southwest location is more expensive due to the higher value of coal in that region). The cost of the sales-tax holiday to the state is between $22.2 and $22.6 million.

While these are large costs to State revenues, the estimated benefits created by the new economic activity the construction and operation of such a plant would create relative to the export of the coal assumed to be used to power the plant are significant. Specifically, while the results are dependent on where the plant is located, the construction of the plant is estimated to create in excess of 2,300 jobs in either region in the four years it would take to construct the plant (both in jobs directly and indirectly related to construction), and at least 295 new jobs in the years afterward when the plant is in operation, including 160 high-paying technical jobs at the plant itself. These new jobs would create between $90 and over $100 million annually in additional labor income during the first four years of construction, and an additional $13 million to $18 million annually in State labor income once the plant is in operation. Total statewide impact in jobs would be larger due to the multiplier effect, creating in excess of 2,500 jobs during the construction phase and then over 800 new jobs in the first year after the plant began operation, declining to just over 400 new jobs 20 years later. Gross state product (GSP) observes a maximum annual increase of $104 million, falling to $56 million by the end of the 20-year planning horizon considered.

Far from costing the state, if it is assumed the tax subsidies offered cause a plant to locate in Wyoming, the additional economic activity the plant generates results in additional revenue to the State net of the subsidies of between $11 million and $11.7 million annually. The majority of these additional revenues accrue to local governments, with the state seeing an increase in revenue for the subsidy investment of approximately $1.3 million to over $2 million annually, depending on where the plant locates. Given these results, it is the conclusion of this report that if the proposed tax subsidies offered result in a 500MW plant locating in Wyoming, the additional economic activity generated will more than cover the subsidy cost and result in significant job creation within the State.

While we are confident that these results are the best estimates that can be derived given the current level of information regarding IGCC technology, potential plant designs, and economic conditions and current and future tax policies within the State, several areas of consideration were outside the scope of this report and could impact the results reported here. These considerations omitted from the report include the following:

1) Water: Operation of such a facility will require significant amounts of water. We did not attempt to determine whether such water sources were available in the

locations considered, nor were the potential implications water could have on operating costs included in the report.

2) Carbon regulation: The ability to sequester carbon is required for a plant to be eligible for Energy Policy Act support as a western demonstration project. Additional economic benefits to carbon sequestration could be derived if future greenhouse gas regulations include carbon taxes or carbon trading programs. We did not attempt to estimate the potential economic benefits the ability to sequester carbon would have under these circumstances. We also did not attempt to fully estimate the potential benefit of carbon dioxide sales for the use of enhanced oil or methane recovery could create. A plant of the size considered here could potentially create in excess of 3 million tons of carbon dioxide annually. We do not consider any pipeline costs that would be associated with the construction of such a plant nor carbon dioxide exports such a plant could create.

3) We have not considered any additional technological benefits locating this new technology in Wyoming could have, particularly in the area of synthetic fuel production. We also have not considered the potential gasification has in developing hydrogen capture technologies. Such spin-off impacts could be dramatic, and could create an additional use for Wyoming coal reserves. We have also not considered how altitude could impact the productivity of such a plant. Current evidence appears to indicate, however, that altitude should not be a major factor in the operation of an IGCC facility.

4) Labor market impacts: The impact on construction jobs in the State could be significant. Our job estimates in the construction phase would amount to almost an 8% increase in total construction jobs in the State. Clearly, such demand could have an impact on already tight construction labor markets. To estimate the wage impact such a shock to the labor market would have is beyond the scope of this report and would not be an insignificant undertaking.

5) Coal market impacts: While suggested in this report, full development of IGCC technology nationwide could have a significant impact on coal markets and Wyoming coal and other energy exports. Consideration of such ideas is worthy of future research. Similarly, we have not fully explored the potential impacts of future regulatory changes on the market for energy and Wyoming energy exports.

6) Transmission capacity: We do not include the costs of additional transmission line development that may be necessary to support additional transmission capacity in the state. It is assumed additional capacity would be financed commercially as part of the overall project. Additional transmission capacity will almost certainly be necessary for any additional generation capacity added in the State regardless of the type.

7) Location: There are several issues that would have to be considered in locating a plant in Wyoming. First, there are the economics of locating closer to markets

versus closer to resources. If the marginal benefits of locating closer to markets out weigh the benefits of locating closer to resources then location may not actually occur in the State. Second, if carbon sequestration is an important factor in the economics of the operation as well as penetrating certain markets, then the market for CO_2 and its associated transportation costs at least in part will drive location decisions. Finally, other factors such as the labor pool or federal and other state subsidies may drive location as much as any resource-based factor. Firms may choose locations where state assistance is higher and where the labor they need is readily available. Given the operational complexity of the operation specialized labor and financing will be critical for this industry.

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