

**Duke/Vectren Proposed Integrated
Gasification Combined-Cycle Power Plant:
Poor Energy Planning for Indiana**

March, 2007

**Citizens Action Coalition of Indiana
5420 North College Avenue • #100, Indianapolis, Indiana 46220
Phone: (317) 205-3535 • Fax: (317) 205-3599 • www.citact.org**

Executive Summary

On September 7, 2006, Duke Energy Indiana and Vectren filed a petition with the Indiana Utility Regulatory Commission requesting permission to build a two-turbine 630 megawatt (MW) Integrated Gasification Combined-Cycle (IGCC) power plant in Edwardsport, Indiana. Duke currently owns a power plant at this location which started operation in 1918 and that currently operates units built in 1944 and 1951. It consists of 3 coal-fired boilers and 1 oil boiler, is capable of producing 160 megawatts of electricity, and operates only about 30% of the time. The proposal is to demolish the currently operating plant and replace it with the proposed IGCC plant. The new plant operations would include pulverizing and gasifying coal, and using the resulting "syngas" as fuel to run the power plant. In the event that syngas is not used as the primary fuel source, the plant is also capable of using natural gas as a fuel. The IURC's decision will most likely be made within the next six months.

Citizens Action Coalition is opposing the construction of this power plant and, instead, urging the IURC to direct Vectren and Duke Energy to begin investing in cleaner, more economic energy efficiency and renewable power alternatives.

There are many reasons to reject Duke's proposal. Economically speaking, the IURC's decision in this matter will have a direct impact on all of the ratepayers in Vectren and Duke Energy's service territories, in terms of significant increases in electric bills. These ratepayers include citizens and businesses as well as cities and towns. The construction of the power plant will cost a minimum of \$2.1 billion, which will have to be shouldered by ratepayers. Operating and maintenance costs will be at least \$104 million annually.

In contrast, ramping up energy efficiency programs to meet Duke's projected demand for electricity will only cost \$42 million per year, and will save ratepayers money. And, even if energy efficiency was not enough, the same amount of electricity can be generated by wind turbines placed in northern Indiana for the same construction cost, but for only \$39 million per year in operations and maintenance costs. In other words, diversifying the energy mix is cheaper than building the plant and can also meet electric energy demand in Duke/PSI territory.

In terms of the environment, while Vectren and Duke Energy are presenting this power plant as "clean coal technology" with the ability to capture carbon dioxide and reduce global warming emissions, they are not proposing to actually build the plant with the technology necessary to carry out this aim. The plant will be built without carbon dioxide capture equipment, and it will be added later only when federal regulations governing carbon dioxide change, and then only if it is cheaper to do so than to pay for the carbon dioxide emissions. It is important to note that if carbon capture equipment is ever added to this power plant, it will increase the cost of the project by at least 37%, while decreasing the electricity output of the plant by at least 20%. Furthermore, carbon sequestration on the commercial scale necessary has never been demonstrated or accomplished. Even if carbon capture and sequestration were viable, which has yet to be proven, retrofitting the plant with such technology would increase electric bills even more and substantially reduce the efficiency of the plant.

Regarding the health of Hoosiers, Vectren and Duke Energy are also emphasizing that IGCC technology is cleaner in terms of emissions in nitrogen oxides, sulfur dioxide, sulfuric acid, beryllium, mercury, and fluoride than traditional coal generation. However, the proposed power plant is much larger than what currently exists at Edwardsport, and will be operating more often, resulting in a 785% increase in carbon dioxide emissions, a 1,480% increase in carbon monoxide emissions, a 297% increase in particulate matter emissions, a 678% increase in volatile organic compounds, and an alarming 14,555% increase in lead emissions. Of particular concern are the increases in lead, which is especially harmful to fetuses, infants, and young children, and is known to harm the intellectual development, behavior, size and hearing of infants, at low levels of exposure. The increases in particulate matter are also alarming because of the known health impacts. The EPA's own consultants estimate that 887 deaths, 1,491 heart attacks, 114 lung cancer deaths, 21,532 asthma attacks, 845 hospital admissions, 618 cases of chronic bronchitis, and 1,274 asthma ER visits occur annually due to particulate matter emissions from coal-burning power plants in Indiana (Clear the Air, 2004).

If this IGCC power plant is built in Edwardsport, Indiana, it will have an enormous negative impact on the finances, health, and well-being of citizens across Indiana. There are much cheaper alternatives that are also cleaner and will actually save ratepayers money, such as energy efficiency and renewable sources of electricity, that Vectren and Duke Energy have not fully explored nor exploited. Citizens Action Coalition is urging the Indiana Utility Regulatory Commission to reject Vectren and Duke's request and require them to take a least cost, common sense approach focused on efficiency and renewables.

Duke/Vectren Proposed Integrated Gasification Combined-Cycle Power Plant: Poor Energy Planning for Indiana

On September 7, 2006, Duke Energy Indiana and Vectren filed a petition with the Indiana Utility Regulatory Commission requesting permission to build a two-turbine 630 megawatt (MW) Integrated Gasification Combined-Cycle (IGCC) power plant in Edwardsport, Indiana (Duke, September 2006). Duke currently owns a power plant at this location which was built in the 1940's or 50's, consists of 3 coal-fired boilers and 1 oil boiler, is capable of producing 160 megawatts of electricity, and operates about 30% of the time (Duke, October, 2006). The proposal is to demolish the currently operating plant and replace it with the proposed IGCC plant. The new plant operations would include pulverizing and gasifying coal, and using the resulting "syngas" as fuel to run the power plant. In the event that syngas is not used as the primary fuel source, the plant is also capable of using natural gas as a fuel. Duke and Vectren are proclaiming that the proposed IGCC plant will have less of an impact to the environment because the process of gasifying the coal will allow them to capture emissions at the beginning of the process rather than as they are emitted from a smokestack (Duke, August, 2006). However, the proposed power plant is much larger and will operate much more often than the plant that is currently operating at Edwardsport, and therefore will emit more pollutants. Below is a table illustrating the amount of pollutants that will be emitted and how they compare to what is currently being emitted.

Comparison of Air Emissions for Currently Operating Power Plant at Edwardsport and Proposed IGCC Plant (tons/year)¹

	Average Emissions of Currently Operating Plant (tons/year)	Projected Emissions of Proposed IGCC Plant (tons/year)	Increase or Decrease (tons/year)	Percent Increase or Decrease
Carbon Dioxide (CO ₂)	440,393	3.9 million	+3.5 million	+785%
Carbon Monoxide (CO)	69.50	1,098.18	+1,028.68	+1,480%
Nitrogen Oxides (NO _x)	2,384.00	1,554.75	-829.25	-34%
Particulate Matter (PM)	302.80	1,202.35	+899.54	+297%
Sulfur Dioxide (SO ₂)	10,299.10	431.70	-9,867.40	-95%
Volatile Organic Compounds (VOC)	8.30	64.58	56.28	+678%
Sulfuric Acid (H ₂ SO ₄)	515.00	47.95	-467.05	-90%
Lead	0.00058	0.085	+0.008442	+14,555%
Beryllium	0.0029	0.00276523	-0.00013477	-4%
Mercury	0.008	0.0063462	-0.0016538	-20%
Fluorides	20.67	0.00	-20.67	-100%

As can be seen from this table, nitrogen oxides, sulfur dioxide, sulfuric acid, beryllium, mercury, and fluoride emissions will all decrease. On the other hand, carbon dioxide, carbon monoxide, particulate matter, volatile organic compounds, and lead emissions will all skyrocket. The proposed IGCC technology presents its own set of problems - both environmentally and economically - and there are other, better alternatives such as renewable energy and energy efficiency, which should be made a priority by the IURC and the utilities.

¹ See Appendix (Table 1 and Carbon Dioxide Calculations) for sources and calculations

“Clean Coal” vs. Wind Energy

Duke and Vectren are emphasizing the reduction in sulfur dioxide (SO₂), nitrogen oxides (NO_x), mercury (Hg) and sulfuric acid (H₂SO₄) emissions that the IGCC technology would create. While this is true, the proposed plant would still emit these hazardous pollutants. At the present time, Duke and Vectren are proposing an IGCC plant that does not capture carbon dioxide (CO₂), with the potential to add the carbon capture equipment down the road when carbon dioxide becomes a regulated emission (Duke, October, 2006). Carbon capture will decrease the output of the power plant by about 20% as extra energy is required to operate the carbon capture equipment (IPCC, 2006). Additionally, the cost of capturing carbon dioxide will significantly increase the costs of construction and the costs to operate and maintain the plant. On the other hand, a windfarm that would produce the same amount of electricity as the proposed IGCC plant would cost about the same to build and install, but would have a significantly smaller annual operations and maintenance cost, no fuel cost, and would not produce emissions. Below is a table comparing the energy output and the costs of Duke and Vectren’s proposed IGCC plant with and without carbon capture, and the costs of a windfarm sized to generate the same amount of energy as an IGCC plant at 85% capacity factor.

Cost Comparison for an IGCC Power Plant and a Comparably Sized Wind Farm²

	IGCC	IGCC w/ Carbon Capture	Wind
Net Electricity Production	4.7 million MWh/yr	3.8 million MWh/yr	4.7 million MWh/yr
Construction & Installation Cost	\$2.1 billion	\$2.8 billion	\$2.5 billion

Annual Costs of Electricity Production

	IGCC	IGCC w/ Carbon Capture	Wind
Operations & Maintenance (including cost to capture, transport, and store carbon)	\$28.6 million/yr	\$120.3 million/yr	\$38.2 million/yr
Fuel	\$74.5 million/yr	\$74.5 million/yr	\$0
SO₂ emissions	\$225,973/yr	\$225,973/yr	\$0
NO_x emissions	\$1.6 million/yr	\$1.6 million/yr	\$0
Total Annual Costs:	\$104.9 million/yr	\$196.6 million/yr	\$38.2 million/yr

Cost of Electricity to Ratepayers

	IGCC	IGCC w/ Carbon Capture	Wind
Cost of Electricity	\$0.05/kWh	\$0.07/kWh	\$0.05/kWh

As can be seen, the annual costs of an IGCC plant without carbon capture are more than double that of a windfarm sized to produce the same amount of electricity, and with carbon capture, the costs are over quadruple the costs of the windfarm. In the future, the differences will become even more dramatic. Although the costs of emissions allowances is currently dropping, as the U.S. Congress examines the possibility of tightening SO₂ and NO_x regulations, the costs of the allowances for these emissions is expected to rise dramatically (EIA, 2001). Also, although there currently is no mercury allowance trading, the market is already beginning to take shape (Ammirato, 2006). The table below reflects the current and projected allowance costs for the Duke/Vectren proposed IGCC plant.

² See Appendix for calculations

Projected Future Allowance Costs for Duke/Vectren Proposed IGCC Plant

	IGCC Power Plant			Wind Farm		
	Current Costs	2010	2020	Current Costs	2010	2020
SO₂	\$225,973/yr	\$98,658/yr	\$337,786/yr	\$0	\$0	\$0
NO_x	\$1,600,000/yr	\$2,146,386/yr	\$1,968,705/yr	\$0	\$0	\$0
Mercury	N/A	\$213,889/yr	\$312,561/yr	N/A	\$0	\$0
Total	\$1.8 million/yr	\$2.45 million/yr	\$2.61 million/yr	\$0	\$0	\$0

It is important to note that carbon dioxide emissions will be regulated in the future, and there will most likely be allowance costs for CO₂ as well. Even with carbon capture equipment, the IGCC plant will only capture at most about 86% of the carbon dioxide created by the plant, (IPCC, 2006) and Duke will most likely be able to choose how much carbon dioxide they want to capture up to that amount. In order for carbon capture technology to be economically used in power plants, the price of carbon dioxide reductions would have to exceed \$25 – \$30 per ton of CO₂. (IPCC, 2006) If future CO₂ allowances are structured to be below this threshold, it may end up being cheaper for Duke to simply pay for the CO₂ they are emitting instead of adding the carbon capture equipment they are proposing. If this ends up being the case, the carbon dioxide emitted by the proposed IGCC plant will not decrease at all.

Carbon storage also adds an environmental impact component to “clean coal”. The technology that is being developed is called Carbon Capture and Storage (CCS). CCS begins with separating the carbon dioxide from the coal (in an IGCC plant, at the beginning of the gasification process rather than as an emission at the end of the process). Next, the carbon dioxide is stored and transported as necessary. The process ends with storing the carbon dioxide long term one of two ways: either deep underground in oil and gas fields, unminable coal seams, or deep saline formations; or at the bottom of the ocean. Since this technology has never been used on a large scale there will also be environmental consequences to consider when it begins to be used.³

“Clean Coal” vs. Energy Efficiency

Energy Efficiency Resource Standards (EERS)

According to Nadel’s report entitled *Energy Efficiency Resource Standards: Experience and Recommendations* (2006), the “U.S. Department of Energy’s national laboratories estimate that increasing energy efficiency throughout the economy could cut national energy use by about 20% in 2020.” (2006, p. 2, citing Interlaboratory Working Group, 2000) “Unlike other resources such as renewable energy and coal, energy-saving opportunities are distributed throughout the 50 states.” (p. 1)

Efficiency can be deployed much more quickly than new power plants can be built. As an example, in the summer of 2001, as a response to the energy crisis, “California homeowners and businesses reduced energy use by 6.7% relative to the year before (after adjusting for economic growth and weather).” (2006, p. 2-3, citing CEC, 2001) “The energy savings averaged a cost of about 3 cents per kWh, far less than the typical retail or wholesale cost of electricity.” (2006, p. 3, citing Global Energy Partners, 2003)

Many states have conducted energy efficiency studies and have found that efficiency can be used in a cost-effective way to reduce energy use by 10% or more over a 10-year period and 20% or more over a 20-year period. In order to achieve this, states can introduce energy efficiency policies that create targets to reduce energy use by 1% a year. “In order to provide more certainty for resource planners and power providers, the policy targets should extend for at least ten years, with periodic reviews and the option to make refinements.” (p. 31)

³ Should the sequestered CO₂ leak, the side effects could be disastrous. According to the Intergovernmental Panel on Climate Change (2006), in underground geologic storage, the effects “could include lethal effects on plants and subsoil animals and the contamination of groundwater” and “could lead to local high CO₂ concentrations in the air that could harm animals or people. Pressure build-up caused by CO₂ injection could trigger small seismic events.” (p. 12) On the ocean floor, CO₂ will alter the local chemical environment by increasing the acidity, causing the mortality of ocean organisms, and altering the ecosystem. Long term effects of either type of CO₂ storage have not yet been studied and are not fully understood.

An energy efficiency resource standard could be created on a state-wide level (or even a national level) that would affect 3 classes of measures. The first class is comprised of “end-use efficiency measures at customer facilities” (ranging “from efficient residential appliances to efficient commercial lighting systems to more efficient industrial processes”). (p. 27) These measures will save customers money, reduce the demand for electricity, reduce the electric load on transmission and distribution lines, and reduce the amount of emissions created by burning coal to generate electricity.

The second class is comprised of “transmission and distribution improvements that improve efficiency, such as superconducting transmission technology and high-efficiency transformers.” (p. 27) This will reduce the amount of electricity lost in the course of transporting electricity to the end users, and thus reduce the amount of electricity needing to be generated.

The third class is “distributed generation efficiency measures at end-user sites, such as fuel cells, combined heat and power, and recycled energy technologies.” (p. 27) Many industrial customers have the potential to use waste heat to generate electricity to either be used at their own facilities, or to be returned to the grid, thus reducing the amount of electricity needing to be generated by electric utilities.

Many states (including Texas, Hawaii, Nevada, Connecticut, California, Vermont, Pennsylvania, Illinois, New Jersey, and Colorado) have implemented or begun to implement energy efficiency resource standards and programs. Each state has a different program, providing policymakers with a variety of options in creating a program that works for a specific area.

Energy Efficiency and its Impact on Natural Gas

According to the Kushler, Witte, and York study entitled *Examining the Potential for Energy Efficiency To Help Address the Natural Gas Crisis in the Midwest* (2005), because the Midwest region is so reliant on imported natural gas, end-use energy efficiency would not only help consumers to save money on their electric bills and natural gas bills, it would also help to bring down the wholesale price of natural gas. The study states that if the Midwest works to achieve “a 5% reduction in both electricity and natural gas customer use over 5 years” (p. iii), by 2010 customers could be saving \$2 billion annually on electric bills, another \$2 billion annually on natural gas bills, as well as producing over 30,000 net new jobs and \$750 million in worker wages. Over 15 years, those results increase to over 66,000 net new jobs and nearly \$1.8 billion in worker wages.

Kushler, Witte, and York indicate that if the Midwest region were to spend \$310 million annually for natural gas energy efficiency and \$800 million annually for electricity energy efficiency, of which Indiana’s portion would be \$35 million annually for natural gas efficiency and \$113 million annually for electricity efficiency, the cost savings for Indiana would be staggering. These results are illustrated in the table below:

Savings for Indiana in Each Individual Year due to Energy Efficiency Implementation (p. 24 – 30)

	2006	2010	2015	2020
Projected Net Natural Gas Customer Dollar Savings	\$77 million	\$122 million	\$182 million	\$303 million
Projected Net Electricity Customer Dollar Savings	\$98 million	\$223 million	\$398 million	\$596 million
Dollar Savings Impacts of Natural Gas Price Reduction	\$62 million	\$164 million	\$346 million	\$380 million
Dollar Savings Impacts of Natural Gas Price Reduction for Power Generation	\$7 million	\$10 million	\$124 million	\$138 million
Total Savings	\$244 million	\$518 million	\$1,051 million	\$1,417 million

Even if the entire Midwest region does not invest in energy efficiency at the same time that Indiana does, though the cost savings may not be as dramatic as the projected savings above, they would still be significant. These savings could be achieved through a mix of efficiency programs including a “utility and/or public benefits fund supported energy efficiency programs; building energy codes; equipment standards” for manufacturers; etc. (p. 34). “A portfolio of electric energy efficiency programs can save electricity at a cost of 3 cents per kWh, and a portfolio of natural gas efficiency programs can save natural gas at a cost of \$1.50 per Mcf.” (2005, citing Elliott et al, 2003, p. 32)

Conclusion

According to Duke's testimony submitted to the IURC on October 24, 2006, they expect their demand for electricity to grow by about 0.4% per year. Even if Indiana does not create a policy to implement energy efficiency state-wide, Duke can begin implementing efficiency measures that would completely offset their customer load growth and reduce or eliminate the need for new generation at a third of the cost of new generation. If new generation is needed, Indiana has more than enough wind capacity to begin building windfarms (NREL, 2006) and meeting the needed demand for electricity at a fraction of the cost of a new coal-burning power plant and with little or no impact to the environment. The bottom line here is that if ratepayers and utilities have to spend money, it should be spent on measures such as renewable energy and energy efficiency that will be economical and sustainable in both the short- and long-term rather than measures such as new baseload coal-burning power plants that will produce more electricity in the short-term and further damage ratepayers, public health, and the environment in the long-term.

Appendix

**Table 1 - Proposed Duke/Vectren IGCC Plant⁴
Summary of Net Emission Increase of Regulated Criteria Air Emissions - Syngas Operation**

Proposed Edwardsport IGCC Project Data (Duke, August 2006)

	Potential to Emit Air Emission Rates (tons/year)											
	CO	NO _x	PM	PM ₁₀	PM _{2.5}	SO ₂	VOC	H ₂ SO ₄	Lead	Beryllium	Mercury	Fluorides
Two combustion turbines on syngas ⁵ (Table 2-7a)	692.50	1254.34	291.12	291.12	291.12	215.90	24.57	47.65	0.085	0.002754	0.006103	-
Natural gas fired gasification pre-heaters (Table 2-11)	0.60	1.00	0.40	0.40	0.40	0.00	0.20	-	-	0.00000223	0.0000482	-
Flare pilot (Table 2-9)	0.18	0.21	0.02	0.02	0.02	0.001	0.01	-	-	-	-	-
Thermal oxidizer (Table 2-10)	1.40	1.70	0.10	0.10	0.10	87.00	0.10	-	-	-	-	-
Startup and shutdown emissions (Tables 2-8a and 2-8b)	338.00	180.10	9.80	9.80	9.80	127.80	35.00	0.30	-	-	-	-
Auxiliary boiler (Table 2-12)	61.80	102.90	5.60	5.60	5.60	0.60	4.00	-	-	0.000009	0.000195	-
Emergency generator (Table 2-13)	3.00	7.20	0.40	0.40	0.40	0.20	0.40	-	-	-	-	-
Emergency fire pump (Table 2-14)	0.70	3.30	0.20	0.20	0.20	0.20	0.30	-	-	-	-	-
Cooling tower (Table 2-15)	-	-	28.00	28.00	28.00	-	0.00	-	-	-	-	-
Fugitive emissions (Tables 2-3, 2-4a, 2-4b, 2-5a, 2-5b, 2-6a, 2-6b, 2-6c, and 2-6d)	-	-	77.40	59.00	59.00	-	-	-	-	-	-	-
Total Projected Emissions	1098.18	1554.75	413.04	394.64	394.64	431.70	64.58	47.95	0.085	0.00276523	0.0063462	0.00
Current Average Emissions⁶ (Tables 2-2 and 2-2a)	69.50	2384.00	207.40	47.70	47.70	10299.10	8.30	515.00	0.00058	0.0029	0.008	20.67
Increase or Decrease in Emissions	+1028.68	-829.25	+257.02	+398.32	+398.32	-9867.40	+56.28	-467.05	+0.08442	-0.0001347	-0.001653	-20.67
Percent Increase or Decrease	+1,480%	-34%	+124%	+835%	+835%	-95%	678%	-90%	+14,555%	-4%	-20%	-100%

⁴ The data in this table comes from Table 2-7a in Duke's Significant Source Modification Filing with the Indiana Department of Environmental Management, August 2006.

⁵ Duke's data regarding the projected air emissions data for the proposed IGCC plant was derived with the assumption that the plant will be running 8,760 hours per year (which is 24 hours a day, 365 days a year, or 100% capacity). Since in reality the plant is expected to be operating at 85% capacity, the data for the "Two combustion turbines on syngas" are derived by multiplying the numbers in Duke's Table 2-7a by .85

⁶ Duke's data regarding the current average air emissions was derived by recording the emissions from the currently operating coal-fired power plant for a two year period from June 2002 through May 2004.

Calculations

A base assumption for all of these calculations is that the proposed IGCC plant will operate 85% of the time (Blankinship, 2006)

- $365 \text{ days/yr} \times 24 \text{ hrs/day} = 8760 \text{ hrs/yr}$
- $85\% \text{ of the time} = 8760 \text{ hrs/yr} \times .85 = 7446 \text{ hrs/yr}$

Kilowatt Hours per year

- $630 \text{ MW} \times 7446 \text{ hrs/yr} = 4,690,980 \text{ MWh/yr} \times 1000 \text{ kWh/MWh} = 4,690,980,000 \text{ kWh/yr}$

Carbon Dioxide Calculations

Projected Carbon Dioxide Emissions for Proposed Duke/Vectren IGCC Plant

- The average emission rate of carbon dioxide for an IGCC power plant without carbon capture is $.773 \text{ kgCO}_2/\text{kWh}$ (IPCC, 2006, p 25)
- $4,690,980,000 \text{ kWh/yr} \times .773 \text{ kgCO}_2/\text{kWh} = 3,626,127,540 \text{ kgCO}_2/\text{yr}$
- $3,626,127,540 \text{ kgCO}_2/\text{yr} \times 2.2 \text{ lbs/kg} = 7,977,480,588 \text{ lbsCO}_2/\text{yr}$
- $7,977,480,588 \text{ lbsCO}_2/\text{yr} \times 1 \text{ ton} / 2000 \text{ lbs} = 3,988,740 \text{ tonsCO}_2/\text{yr} = 3.9 \text{ million tons CO}_2/\text{yr}$

- The average emission rate of carbon dioxide for an IGCC power plant with carbon capture is $.108 \text{ kgCO}_2/\text{kWh}$ (ibid., p 25)
- $4,690,980,000 \text{ kWh/yr} \times .108 \text{ kgCO}_2/\text{kWh} = 506,625,840 \text{ kgCO}_2/\text{yr}$
- $506,625,840 \text{ kgCO}_2/\text{yr} \times 2.2 \text{ lbs/kg} = 1,114,576,848 \text{ lbsCO}_2/\text{yr}$
- $1,114,576,848 \text{ lbsCO}_2/\text{yr} \times 1 \text{ ton}/2000 \text{ lbs} = 557,288 \text{ tons CO}_2/\text{yr}$

- If used to its maximum potential, carbon capture reduces CO_2 emissions by an average of 3.4 million tons/yr (3.9 million tons $\text{CO}_2/\text{yr} - 557,288 \text{ tons CO}_2/\text{yr}$), which is about an 86% reduction.

Costs of Carbon Capture

- Carbon capture would require about a 20% increase input in energy (IPCC, 2006, p 25) – or a 20% drain on plant energy output. This would take the proposed Duke IGCC plant from a 630MW plant to a 504MW plant. In other words, it would go from 4.6 million MWh/yr to 3.8 million MWh/yr.
- The capitol required for carbon capture would increase by 37% (ibid., p 25). That would take the capitol required to build the proposed IGCC plant from \$2.1 billion to about \$2.8 billion.
- The average cost of captured carbon dioxide for an IGCC plant is \$23 per ton of CO_2 (ibid., p 25).
- Taking this average cost, the cost per year for carbon capture for the proposed Duke IGCC power plant would be: $\$23/\text{tCO}_2 \times 3,988,740 \text{ tonsCO}_2/\text{yr} = \$91,741,020/\text{yr} = \$91.7 \text{ million/yr}$

Costs of the proposed IGCC plant

Fuel Costs

- The December, 2006 spot market price for Illinois Basin coal was \$34/ton (EIA, 2006)
- 2.19 million tons of coal per year will be purchased for the proposed IGCC plant (Duke, August 2006)
- 2.19 million tons/yr X \$34/ton = \$74.5 million per year in fuel (coal) costs

Operations & Maintenance Costs

- O&M costs for an IGCC plant will range from 7.9 mills/kWh in 2000 to 6.1 mills/kWh in 2012 (David, 2000)
- 6.1 mills/kWh = \$.0061/kWh = \$6.1/MWh → \$6.1/MWh X 4,690,980 MWh/yr = \$28,614,978/yr O&M costs
- O&M for an IGCC plant with carbon capture would be \$28,614,978/yr + \$91,741,020/yr = \$120,355,998/yr

Costs of SO₂ and NO_x emissions

According to Evolution Markets, Inc (2006), the average cost of SO₂ and NO_x trading allowances dropped over the course of 2006. SO₂ allowances began 2006 at about \$1,600 and at the end of the year the monthly average cost of SO₂ allowances for December, 2006 was \$481. NO_x vintage 2007 allowances began 2006 at about \$2,400 and at the end of the year the average monthly cost for December was \$926. Assuming the December prices for SO₂ and NO_x allowances, and using Duke's emission numbers from Table 2-16a in their *Significant Source Modification* filing with IDEM on August 18, 2006 for SO₂ (469.8 tons/yr) and NO_x (1776.81 tons/yr), the allowance costs for the proposed IGCC plant would be as follows:

- SO₂ allowances: \$481/ton X 469.8 tons/yr = \$225,973/yr
- NO_x allowances: \$926/ton X 1776.81 tons/yr = \$1,645,326/yr or \$1.6 million/yr

Although the cost of SO₂ and NO_x allowances continues to drop, according to the Energy Information Administration's *Reducing Emissions of Sulfur Dioxide, Nitrogen Oxides, and Mercury from Electric Power Plants* (2001) report, emission allowance costs are projected to increase as the caps of NO_x, SO₂, and mercury (Hg) are tightened. The report analyzes 3 scenarios:

- Scenario 1: Reduce NO_x by 75% below 1997 levels, SO₂ emissions by 75% below full implementation of Title IV of the Clean Air Act Amendment of 1990, and Hg emissions by 75% below 1999 levels by 2012, with half the reductions for each of the emissions occurring by 2007.
- Scenario 2: Reduce NO_x by 65% below 1997 levels, SO₂ emissions by 65% below full implementation of Title IV of the Clean Air Act Amendment of 1990, and Hg emissions by 65% below 1999 levels by 2012, with half the reductions for each of the emissions occurring by 2007.
- Scenario 3: Reduce NO_x by 50% below 1997 levels, SO₂ emissions by 50% below full implementation of Title IV of the Clean Air Act Amendment of 1990, and Hg emissions by 50% below 1999 levels by 2012, with half the reductions for each of the emissions occurring by 2007.

The report was prepared in 2001 and uses 1999 dollars for the following projected costs of allowances (EIA, 2001):

	2010 Projected Allowance Costs			2020 Projected Allowance Costs		
	50% reduction	65% reduction	75% reduction	50% reduction	65% reduction	75% reduction
SO ₂	\$210/ton	\$415/ton	\$296/ton	\$719/ton	\$1,390/ton	\$1,737/ton
NO _x	\$1,208/ton	\$1,491/ton	\$2,072/ton	\$1,108/ton	\$1,457/ton	\$2,825/ton
Hg	\$14,452/lb	\$20,124/lb	\$31,923/lb	\$21,119/lb	\$41,190/lb	\$85,225/lb

Although there currently is no mercury allowance trading, the market is already beginning to take shape and the above table reflects the projected costs for mercury emissions. Assuming a 50% reduction scenario, assuming the above prices, and again using numbers from Duke's *Significant*

Source *Modification* filing with IDEM on August 18, 2006 for SO₂ (469.8 tons/yr) and NO_x (1776.81 tons/yr), and mercury (.0074 tons, which equals 14.8 pounds), the 2010 projected allowance costs of the proposed IGCC power plant would be as follows:

- SO₂: \$210/ton X 469.8 tons/yr = \$98,658/yr
- NO_x: \$1,208/ton X 1776.81 tons/yr = \$2,146,386/yr or \$2.1 million/yr
- Mercury: \$14,452/lb X 14.8 lbs/yr = \$213,889/yr

And the projected allowance costs for 2020 would be as follows:

- SO₂: \$719/ton X 469.8 tons/yr = \$337,786/yr
- NO_x: \$1,108/ton X 1776.81 tons/yr = \$1,968,705/yr or \$1.9 million/yr
- Mercury: \$21,119/lb X 14.8 lbs/yr = \$312,561/yr

Cost of Energy for Ratepayers

The figures below are taken from the Intergovernmental Panel on Climate Change (2006):

- The cost of electricity for an IGCC plant without carbon capture ranges from \$0.041/kWh to \$0.061/kWh. The average is \$0.051/kWh
- The cost of electricity for an IGCC plant with carbon capture and geologic storage ranges from \$0.055/kWh to \$0.091/kWh. The average is \$0.073/kWh.

Costs of a Wind Project

In order to calculate how many windmills it would take to equal a 630MW power plant, there are some factors that have to be taken into account. The figures below regarding the cost of wind power were taken from the Northwest Power & Conservation Council (July, 2006):

- The proposed Duke IGCC plant would operate about 85% of the time, therefore its output can be adjusted to 535.5 MW
- A windmill will produce electricity about 30% of the time. Therefore, 1,674 MW of capacity would be needed to produce 535.5 MW of energy.
- An average wind turbine is rated to produce about 1.5 MW of electricity. It would take 1190 wind turbines at 1.5 MW to create 1785 MW of electric capacity.
- The capital required for building a wind project is assumed to average \$1,500/kW. This includes project development, owner's costs, and typical transmission interconnection costs.
- For a 1,674 MW (1,674,000 kW) wind project, the capital cost would be 1,674,000 kW X \$1,500/kW = \$2,511,000,000, or \$2.5 billion.
- Fixed operations & maintenance (O&M) costs are \$20/kWh/yr. \$20/kWh/yr X 1,674,000 kW = \$33,480,000/yr = \$33.5 million/yr
- Variable O&M costs are \$1.00/MWh. 4,690,980,000 kWh/yr X 1MW/1000kW = 4,690,980 MWh/yr. So, for a 1,674 MW wind project, variable O&M costs would be \$1.00/MW X 4,690,980 MWh/yr = \$4,690,980/yr = \$4.7 million per year
- Total O&M costs (fixed + variable) for a 1,674 MW wind project would be \$33,480,000/yr + \$4,690,980/yr = \$38,170,980/yr = \$38.2 million/yr
- According to the American Wind Energy Association, the cost of electricity from wind power is about \$0.04 - \$0.06 per kilowatt hour. The average is \$0.05/kWh. (AWEA, 2005)
- There are no fuel or emissions costs associated with wind power

References

- Ammirato, Philip and Peter Zaborowsky. 2006. *Mercury Trading Takes Form*. Retrieved December, 2006, from http://www.evomarkets.com/assets/evobriefs/nw_1161964117.pdf. White Plains, NY: Evolution Markets, Inc.
- [AWEA] American Wind Energy Association. 2005. *The Economics of Wind Energy*. Retrieved March, 2006, from <http://www.awea.org/pubs/factsheets/EconomicsOfWind-Feb2005.pdf>. Washington, D.C.: American Wind Energy Association.
- Blankinship, Steve. 2006. *Coal Gasification: Players, Projects, Prospects*. Retrieved December, 2006 from http://pepei.pennnet.com/Articles/Article_Display.cfm?Section=ARCHI&ARTICLE_ID=260509&VERSION_NUM=2&p=6. Tulsa, OK: Power Engineering International.
- Clear the Air. 2004. *Indiana's Dirty Power Plants*. Retrieved February, 2007 from <http://www.cleartheair.org/regional/factsheets/factsheetINfinal.pdf>. Washington, D.C.: Clear the Air.
- David, Jeremy and Howard Herzog. 2000. *The Cost of Carbon Capture*. Retrieved December, 2006, from http://sequestration.mit.edu/pdf/David_and_Herzog.pdf. Cambridge, MA: Massachusetts Institute of Technology (MIT).
- Duke Energy Indiana, Inc. and Vectren Energy Delivery of Indiana. 2006. Filing to the Indiana Utility Regulatory Commission, September 7. Retrieved December, 2006, from <http://www.in.gov/iurc/portal/Modules/IURC/CategorySearch/viewfile.aspx?contentid=0900b631800b7209>. Indianapolis, IN: IURC.
- Duke Energy Indiana, Inc. and Vectren Energy Delivery of Indiana. 2006. Filing to the Indiana Utility Regulatory Commission, October 24. Retrieved December, 2006, from <http://www.in.gov/iurc/portal/Modules/IURC/CategorySearch/viewfile.aspx?contentid=0900b631800bd2ff>. Indianapolis, IN: IURC.
- Duke Energy Indiana, Inc. 2006. Significant Source Modification filing to the Indiana Department of Environmental Management, August 18. Retrieved December, 2006, from http://valleywatch.net/valleywatch/index.asp?id_nav=3. Indianapolis, IN: IDEM.
- [EIA] Energy Information Administration. 2001. *Reducing Emissions of Sulfur Dioxide, Nitrogen Oxides, and Mercury from Electric Power Plants*. Retrieved December, 2006 from <http://www.eia.doe.gov/oiaf/servicerpt/mepp/index.html>. Washington, D.C.: U.S. Department of Energy, Energy Information Administration.
- [EIA] Energy Information Administration. 2006. *Coal News and Markets, December 20, 2006*. Retrieved December, 2006 from <http://www.eia.doe.gov/cneaf/coal/page/coalnews/coalmar.html#spot>. Washington, D.C.: U.S. Department of Energy, Energy Information Administration.
- Evolution Markets, Inc. 2006. *Monthly Market Update. NO_x Markets, December 2006*. Retrieved December, 2006, from http://www.evomarkets.com/assets/mmu/mmu_nox_dec_06.pdf. White Plains, NY: Evolution Markets, Inc.
- Evolution Markets, Inc. 2006. *Monthly Market Update. SO₂ Markets, December 2006*. Retrieved December, 2006, from http://www.evomarkets.com/assets/mmu/mmu_so2_dec_06.pdf. White Plains, NY: Evolution Markets, Inc.
- [IPCC] Intergovernmental Panel on Climate Change. 2006. *Carbon Dioxide Capture and Storage*. Retrieved December, 2006 from http://arch.rivm.nl/env/int/ipcc/pages_media/SRCCS-final/ccsspm.pdf. Geneva2, Switzerland: World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP), Intergovernmental Panel on Climate Change.
- Jenner, Diane L., and Robert D. Moreland. 2006. Testimony on behalf of Duke Energy Indiana, Inc. before the Indiana Utility Regulatory Commission, October 24. Retrieved December, 2006, from <http://www.in.gov/iurc/portal/Modules/IURC/CategorySearch/viewfile.aspx?contentid=0900b631800bd2f0>. Indianapolis, IN: IURC.
- Kushler, Martin, Patti Witte, and Dan York. 2005. *Examining the Potential for Energy Efficiency to Help Address the Natural Gas Crisis in the Midwest*. Retrieved December, 2006 from

<http://aceee.org/pubs/u051full.pdf?CFID=1950888&CFTOKEN=82024595>. Washington, D.C.: American Council for an Energy-Efficient Economy.

Nadel, Steven. 2006. *Energy Efficiency Resource Standards: Experience and Recommendations*. Retrieved December, 2006 from <http://aceee.org/pubs/e063.pdf?CFID=1950805&CFTOKEN=44560308>. Washington, D.C.: American Council for an Energy-Efficient Economy.

[NPCC] Northwest Power & Conservation Council. *Biennial Review of the Cost of Wind Power*. Retrieved March, 2006 from http://www.bpa.gov/Energy/N/projects/post2006conservation/doc/Windpower_Cost_Review.doc. Portland, OR: Northwest Power & Conservation Council.

[NREL] National Renewable Energy Laboratory. 2006. *Indiana – 70 m Wind Speed*. Retrieved January, 2007 from <http://www.in.gov/energy/technologies/windpower1-1-13speed70mcap.pdf>. Golden, CO: U.S. Department of Energy, National Renewable Energy Laboratory.