RC Exhibit C (RMF)

STATE OF INDIANA

INDIANA UTILITY REGULATORY COMMISSION

JOINT PETITION AND APPLICATION OF PSI ENERGY, INC. , D/B/A DUKE ENERGY INDIANA, INC., AND SOUTHERN INDIANA GAS AND ELECTRIC COMPANY, D/B/A VECTREN ENERGY DELIVERY OF INDIANA, INC., PURSUANT TO INDIANA CODE CHAPTERS 8-1-8.5, 8-1-8.7, 8-1-8.8, AND SECTIONS 8-1-2-6.8, 8-1-2-6.7, 8-1-2-42 (A) REQUESTING THAT THE COMMISSION: (1) ISSUE APPICABLE CERTIFICATES OF PUBLIC CONVENIENCE AND NECESSITY AND APPLICABLE CERTIFICATES OF CLEA COAL TECHNOLOGY TO EACH JOINT PETITIONER FOR THE CONSTRUCTION OF AN INTEGRATED GASIFICATION COMBINED CYCLE GENERATING FACILITY ("IGCC PROJECT") TO BE USED IN THE PROVISION OF ELECTRIC UTILITY SERVICE TO THE PUBLIC; (2) APPROVE THE ESTIMATED COSTS AND SCHEDULE OF THE IGCC PROJECT; (3) AUTHORIZE EACH JOINT PETITIONER TO RECOVER ITS CONSTRUCTION AND OPERATING COSTS ASSOCIATED WITH THE IGCC PROJECT ON A TIMELY BASIS VIA APPLICABLE RATE ADJUSTMENT MECHANISMS; (4) AUTHORIZE EACH JOINT PETITIONER TO USE ACCELERATED DEPRECIATION FOR THE IGCC PROJECT; (5) APPROVE CERTAIN OTHER FINANCIAL INCENTIVES FOR EACH JOINT PETITIONER ASSOCIATED WITH THE IGCC PROJECT; (6) GRANT EACH JOINT PETITIONER THE AUTHORITY TO DEFER ITS PROPERTY TAX EXPENSE, POST-IN-SERVICE CARRYING COSTS, DEPRECIATION COSTS, AND OPERATION AND MAINTENANCE COSTS ASSOCIATED WITH THE IGCC PROJECT ON AN INTERIM BASIS UNTIL THE APPLICABLE COSTS ARE REFLECTED IN EACH JOINT PETITIONER'S RESPECTIVE RETAIL ELECTRIC RATES; (7) AUTHORIZE EACH JOINT PETITIONER TO RECOVER ITS OTHER RELATED COSTS ASSOCIATED WITH THE IGCC PROJECT; AND (8) CONDUCT AN ONGOING REVIEW OF THE CONSTRUCTION OF THE IGCC PROJECT

CAUSE NO. 43114

VERIFIED PETITION OF DUKE ENERGY INDIANA, INC. FOR AUTHORITY PURSUANT TO AN ALTERNATIVE REGULATORY PLAN AUTHORIZED UNDER I.C. 8-1-2.5 ET SEQ. AND I.C. 8-1-6.1,8-1-8.7, AND 8-1-8.8 TO DEFER AND SUBSEQUENTLY RECOVER ENGINEERING AND PRECONSTRUCTION COSTS ASSOCIATED WITH THE CONTINUED INVESTIGATION AND ANALYSIS OF CONSTRUCTING AN INTEGRATED COAL GASIFICATION COMBINED CYCLE ELECTRIC GENERATING FACILITY

CAUSE NO. 43114 S1

DIRECT TESTIMONY OF ROBERT M. FAGAN
ON BEHALF OF THE
CITIZENS ACTION COALITION OF INDIANA
SAVE THE VALLEY
VALLEY WATCH
SIERRA CLUB

PUBLIC (REDACTED) VERSION

May 14, 2007

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I. INTRODUCTION

Q. PLEASE STATE YOUR NAME, OCCUPATION, AND BUSINESS ADDRESS.

A. My name is Robert M. Fagan. I am a Senior Associate at Synapse Energy Economics, Inc., 22 Pearl Street, Cambridge, Massachusetts, 02139.

Q. PLEASE SUMMARIZE YOUR PROFESSIONAL EXPERIENCE AND EDUCATIONAL BACKGROUND.

A. I am an energy economics analyst and mechanical engineer with over 20 years of experience in the energy industry. My work has focused primarily on electric power industry issues, especially: economic and technical analysis of wholesale and retail electricity markets; analysis of electric power transmission pricing structures; assessment and implementation of demand-side resource alternatives; and review and examination of renewable energy technologies and policies including the increased market penetration and technical potential of utility-scale wind power. I hold an M.A. from Boston University in Energy and Environmental Studies and a B.S. from Clarkson University in Mechanical Engineering. My resume is included as Exhibit RMF-1.

Q. ON WHOSE BEHALF ARE YOU TESTIFYING?

A. I am testifying on behalf of the Citizens Action Coalition of Indiana (“CAC”), Save the Valley, Valley Watch and the Sierra Club – Hoosier Chapter.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A. The purpose of my testimony is to demonstrate the existence of significant quantities of certain cost-effective supply-side alternatives that are less expensive and less risky (to consumers) than the proposed IGCC coal plant. I examine the technology, potential and cost of these supply-side resource alternatives to Duke and Vectren's proposed IGCC plant. In particular, I describe certain technologies that are available to meet incremental supply-side requirements Duke Energy Indiana and Vectren may have, and I discuss the quantity available in or around the state of Indiana. I examine the likely costs of such alternatives. My focus is on wind power and efficient combined heat and power "distributed" generation options.

II. SUMMARY OF TESTIMONY

Q. PLEASE SUMMARIZE YOUR TESTIMONY.

A. Assessment of wind energy potential in the state of Indiana by the US Department of Energy indicates a technical potential of up to 198,000 MW of installed capacity at NREL (National Renewable Energy Lab, part of the US Department of Energy) class 4 and class 5 wind sites at 100-meter turbine hub heights. This potential is estimated at 42,000 MW at class 4 sites at lower hub heights of 70 meters. The existing generation interconnection queue of the Midwest Independent System Operator (MISO) indicates a current *commercial* potential for wind power of over 3,000 MW in Indiana. The same queue shows over 45,000 MW of potential wind power projects in ten other states within or within reach of the MISO region, including over 12,000 MW in adjacent states.

Tapping into even just a small fraction of this potential can provide more annual energy than the proposed IGCC coal plant at lower costs; and intelligent site selection should allow for the best wind sites – i.e., those with the best combination of high annual capacity factor, low installation cost, and proximity to the transmission grid – to be secured first.

It is not surprising that wind power holds such commercial promise for Indiana and other Midwestern states. Wind is a technologically and commercially mature technology, and is rapidly increasing its penetration into electricity markets nationwide. Wind power installations have already increased significantly in the MISO states. Wind turbine generation technology has improved dramatically over the past 20 years, bringing increased equipment reliability and a continuing decline in unit costs. Coupled with relatively high fossil fuel prices, increasing environmental and regulatory stringency, coordinated power system operation across broad regions, improvements to transmission tariff protocols and the existence of a federal production tax credit, it is only logical that wind power's commercialization has increased exponentially.

Using Duke Energy Indiana's assumptions for key cost drivers for wind power, Indiana and Midwest region wind is a considerably less expensive energy resource than IGCC coal. The mid-range of reasonable costs for Indiana wind power is approximately $**/MWh (levelized, $2005), which is significantly ***** than the levelized cost for IGCC coal energy. Capturing the best wind resources first would likely result in even lower levelized costs initially, because higher average annual capacity factor wind sites exhibit more attractive economics. Wind power at 40% average annual capacity factor can cost less than $** per MWh (levelized) at mid-range assumptions for capital costs. Duke Energy Indiana's initial foray into utility-scale wind power on their system has resulted in 100 MW of wind power at a very reasonable cost.

Duke Energy Indiana's resource plan results in no more than *** MW of wind on their system by 2028, just ***% of their peak load projection for 2011, and less than *% of Duke Energy Indiana's projected energy annual energy consumption. This arises from the selective use of limiting assumptions within Duke Energy Indiana's Strategist modeling tool. Both the quantity of wind and the intervals at which it could be "selected" as part of an economic resource plan are limited in the Strategist base case runs. Startlingly, in contrast, current technical studies indicate that wind integration/penetration up to 20%-25% of system annual energy consumption is technically feasible at minimal integration cost for larger systems, and both Duke Energy Indiana and Vectren are indeed part of the larger MISO system. Indiana wind power can provide greater amounts of cheaper annual energy than the proposed IGCC coal plant at relative low levels of penetration onto Duke Energy Indiana's system.

There is almost 1,500 MW of potential new combined heat and power (CHP) in Indiana. CHP is a capital intensive, but economically attractive option that can both reduce peak capacity needs and provide ***** energy than IGCC coal when considering the attendant benefits on-site for serving thermal loads with "waste" heat. More careful attention to rate structures and the highest value CHP potential on Duke Energy Indiana's part can help to increase the installation of cost-effective CHP systems on the Duke Energy Indiana power system. Careful design of utility incentive structures to help overcome capital constraints at the best CHP sites can result in obtaining the most cost-effective incremental CHP resources with resulting net benefits for Duke shareholders, CHP customers and ratepayers in general.

III. WIND

A. Utility-Scale Wind Turbine Generator Technologies

Q. PLEASE SUMMARIZE THE CURRENT STATE OF UTILITY-SCALE WIND TURBINE GENERATOR TECHNOLOGY AND ECONOMIC ATTRACTIVENESS.

A. Electric utility grid-scale wind technology and economic attractiveness has improved dramatically in the past few decades. This has resulted in increased commercialization of wind power, as technological improvements have led to decreasing unit costs and improved reliability and thus increased attractiveness as a utility supply resource. The decreasing unit costs can be traced in part to increasing economies of scale. As the industry's technological sophistication advanced, the size of wind turbines increased. Exhibit RMF-2 shows the evolution of US commercial wind technology.

The overall trend of decreasing unit costs and increasing cumulative installed capacity is shown in Exhibit RMF-3. The increasing cumulative installed capacity is likely due to decreasing unit costs coupled with the presence of renewable portfolio standards in the US and the federal production tax credit for renewable generation. According to the American Wind Energy Association, as of December 31, 2006 there was 11,603 MW of installed wind capacity in the US.[1]

Q. PLEASE SUMMARIZE THE SIZE, PERFORMANCE AND RELIABILITY OF CURRENT UTILITY-SCALE WIND TECHNOLOGIES AND POWER PLANTS.

A. As seen in Exhibit RMF-2, the size of wind turbines has steadily increased since the 1980s, allowing the capture of scale economics and contributing significantly to lower per unit costs. On-shore utility scale wind farms currently utilize megawatt or multi-megawatt scale turbines on towers extending 60 to 100 meters high. While earlier wind turbines utilized simple asynchronous induction generator technology with little reactive power or voltage control, current technology includes more advanced turbine-generator components with greatly improved reactive power and voltage control and thus increased reliability.[2] The mechanical availability of generator technologies has also improved, allowing for higher energy production and reduced forced outage rates.[3]

B. Wind Potential –Indiana

Q. DOES INDIANA HAVE A SIGNIFICANT WIND ENERGY RESOURCE?

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[1] http://www.awea.org/utility/wind_overview_draft.html

[2] "Doubly-fed asynchronous generators" and "synchronous or induction generator with full-size power converter" are two of the more advanced categories of wind generators. See page 30 of "Making Connections", by Robert Zavadil, Nicholas Miller, Abraham Ellis, and Eduard Muljadi in the November/December 2005 issue of IEEE Power and Energy.

[3] James M. Lefeld, Duke Energy Indiana Share Services, Direct Testimony, IURC Cause # 43097, 6:1-9.

A. Yes. As I will demonstrate in this section, Indiana has a surprisingly large, commercially viable wind energy resource. While Indiana's wind regime is not as strong as that seen in Great Plains regions such as the Dakotas, it nonetheless has class 3, class 4 and class 5 wind regimes that would support wind turbine average annual capacity factors exceeding 30%, and up to at least 42% in some regions at 90 meter wind turbine hub heights.

Q. HAS INDIANA'S WIND ENERGY RESOURCE POTENTIAL BEEN DOCUMENTED?

A. Yes. The wind energy potential in Indiana has been documented by the US Dept. of Energy's National Renewable Energy Laboratory (NREL), in conjunction with meteorology-based numerical modeling by TrueWind Solutions. TrueWind Solutions produced a report for the Indiana Department of Commerce and a validated[4] "wind map" in March of 2004.[5] See Exhibits RMF-4 and RMF-5.

Q. PLEASE EXPLAIN EXHIBIT RMF-4.

A. Exhibit RMF-4 is a color-coded map that shows the geographical distribution of average annual wind speeds across the state. These maps have been produced and validated in many states around the country, based on meteorological data. The color-coded map illustrates the range of average annual wind power potential across the state at 50 meter heights, and shows that on average, northern Indiana contains better wind conditions for power production than southern Indiana.

Q. PLEASE EXPLAIN EXHIBIT RMF-5.

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[4] Validation consists of comparing the predicted wind speed against data from wind monitoring sites.

[5] TrueWind Solutions, "Wind Energy Resource Maps of Indiana", prepared for the Indiana Dept. of Commerce, March 15, 2004.

A. Exhibit RMF-5 is the report produced by True Wind Solutions that describes how the wind maps were produced and what they show. It describes the modeling system used to generate the maps, how the maps were validated, and contains guidelines for use of the maps.

Q. WHERE ARE INDIANA'S BEST WIND RESOURCES?

A. The report and the map indicate that the best wind resources are located in the north central part of the state, especially between Indianapolis, Kokomo (Howard county) and Lafayette (Tippecanoe county), and in Benton and White counties.[6] At this 50 meter height, the mean wind speed is predicted to be in the range of 6.5 to 7 meters/second, and the mean wind power is predicted to be 250 to 350 Watts per square meter, equivalent to an NREL class 2 to class 3 wind resource.[7]

Q. ARE THE 50 METER VALIDATED WIND MAPS THE ONLY WIND MAPS IN EXISTENCE FOR INDIANA?

A. No. Unvalidated wind maps were also produced by NREL and TrueWind for 70 meter and 100 meter heights. Commercial wind turbines currently operate at these higher hub heights – for example, the Benton County wind project uses 80 meter towers.[8] Exhibit RMF-6 shows wind maps for 100 and 70 meter hub heights, plus the 50 meter wind map.

Q. PLEASE EXPLAIN EXHIBIT RMF-6

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[6] Op. Cit., page 9.

[7] See for example, NREL Classes of Wind Power Density at 10 m and 50 m, Table 1-1, at http://www.nrel.gov/gis/wind.html.

[8] Testimony of James M. Lefeld, Cinergy, Cause # 43097, page 7, lines 10-12.

A. The wind maps shown in Exhibit RMF-6 illustrate the changing nature of the wind resource as the hub height (the tower height) at which the wind turbine is located is increased.

Q. WHY AREN'T THESE MAPS "VALIDATED"?

A. The maps are not validated because there is limited data from "tall tower" meteorological measurement sites, although tall tower measurement did began in 2004 at 5 sites in Indiana (the sites are located at Goodland, Geetinsville, Carthage, La Grange, and Haubstadt).

Q. WHAT ARE "TALL TOWER" METEOROLOGICAL MEASUREMENT SITES AND WHY ARE THEY IMPORTANT TO ESTIMATING WIND ENERGY POTENTIAL IN INDIANA?

A. Tall tower meteorological measurement sites are those locations where wind speed data has been gathered with enough granularity to estimate the average annual capacity factor of a wind turbine installed on towers that are taller than 50 meters (the Benton county wind farm is to be installed on 80 meter towers). Taller tower installation generally means access to higher wind speeds and thus greater energy production and more attractive economics for a given wind turbine or wind farm. Tall towers are important to measuring the wind energy potential because commercial scale wind turbines can be installed at these higher "hub heights" and take advantage of the greater amount of energy present in the wind compared to the wind energy available at lower heights. In general, structures and vegetation on the ground obstruct wind flow and effectively "slow down" the wind at lower heights. Since the power available from a wind stream for electrical production is exponentially proportional to wind speed (it varies as the cube of wind speed), increased tower heights can result in significantly improved electrical production for a relatively minimal incremental cost – i.e., a slightly taller tower catches more wind and produces exponentially more electric power.

Q. WHAT DO THE DATA SHOW FOR TALL TOWER WIND SPEEDS IN INDIANA?

A. The tall tower locations and average wind speed data for 2004 are shown in Exhibit RMF-7.[9] In particular, this exhibit shows the Goodland area tall tower wind speed average of 7.7 m/s at a 99 meter height. The wind maps of Exhibit RMF-6 indicate estimated mean wind speeds from 7-7.5 meters/second (70 meter hub height) to 7.5-8.2 meters/second (100 meter hub height) across the best (i.e., windiest) areas of Indiana, a significant increase in average wind speed that translates to considerably increased wind power potential.

Q. WHAT IS THE SIGNIFICANCE OF THE 70 AND 100 METER WIND MAPS?

A. Increased wind speeds translate to increased average annual capacity factors for wind turbines, and in general improved economic characteristics. At the 70-meter height, the class 4 wind areas exhibit annual average capacity factors ranging from 30% to 36%, and the class 5 wind areas at 100 meter heights exhibit annual average capacity factors ranging from 36% to 41%.[10]

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[9] Dennis Elliot, NREL, "Wind Resource and Wind Shear Characteristics at Elevated Heights", presentation at Wind Power America Summit Meeting, June 8, 2006, Pittsburgh, PA. See Exhibit RMF-8.

[10] Ibid.

Q. WHAT IS THE TOTAL INSTALLED CAPACITY POTENTIAL AT 100 METER HUB HEIGHTS?

A. Indiana's total installed capacity potential as estimated by NREL is 198,000 MW, an order of magnitude greater than the peak load of the entire state.

Q. WHAT IS THE TOTAL INSTALLED CAPACITY POTENTIAL AT 70 METER HUB HEIGHTS?

A. Indiana's total installed capacity potential as estimated by NREL is 42,000 MW.

Q. WHAT IS THE TOTAL INSTALLED CAPACITY POTENTIAL AT 50 METER HUB HEIGHTS?

A. The NREL report did not report Indiana's total installed capacity potential at 50 meter hub height. Logically, it would be significantly less than the 42,000 MW computed for the 70 meter hub height. However, a 50-meter hub height potential is somewhat irrelevant, since it is unlikely that commercial scale wind farms would fail to take advantage of the greater wind speeds and improved economics associated with higher hub heights. As noted, the Benton county wind farm is installed on 80 meter towers.

Q. HOW WAS THE POTENTIAL ESTIMATED?

A. Exhibit RMF-8 is a presentation made by NREL at the Wind Powering America Summit Meeting in Pittsburgh, PA on June 8, 2006. It describes how NREL made the estimates of Indiana's wind resource potential at 70 and 100 meter heights. They excluded potentially sensitive environmental land area, incompatible land uses such as urban area land, and other factors that might render a location incompatible with wind power, such as land with slopes greater than 20%. Based on these land exclusions, the predicted wind speeds, and an assumption of 5 MW of installed wind capacity per square kilometer, they estimated Indiana's wind electric potential at 70-meter heights in class 4 wind areas as 42,000 MW. They estimated a total of 198,000 MW of potential at 100-meter hub heights, consisting of 161,000 MW in class 4 wind areas, and 37,000 MW in class 5 wind areas.

Q. WHAT ARE THE KEY CONCLUSIONS DRAWN FROM THE WIND SHEAR AND TALL TOWER DATA ANALYSIS?

A. The authors draw three main conclusions:

- "At these [tall tower] locations, Class 3 [wind] sites at 50 meters can have Class 4-5 equivalent wind resource at 80-100 meter heights and gross capacity factors exceeding 40%"
- Additional tall-tower data are needed.
- Variations of annual wind shear exist.

Q. WHAT DO YOU CONCLUDE FROM THESE ESTIMATES OF WIND RESOURCE POTENTIAL IN INDIANA?

A. I conclude that this estimate of wind resource technical potential is for hub heights consistent with commercial wind turbine installations, and thus it is not an unreasonable starting point for the purpose of gauging the potential for Indiana's winds to provide economical energy for Indiana's native load. It demonstrates that Indiana's installed capacity potential far exceeds Indiana's peak electric load. It illustrates that there are likely many areas from which more site-specific analysis can be conducted to determine suitability for utility-scale wind power generation.

C. Cost of Indiana Wind Energy

Q. HOW MUCH DOES UTILITY-SCALE WIND ENERGY COST IN INDIANA?

A. Duke Energy Indiana (as Cinergy) received six responses to a 100 MW renewable energy RFP that were based on wind farm proposals in "four different states". Those responses included five with "bid amount per MWH" costs to Duke that ranged from $****/MWh (***** cents per kWh) to $*****59/MWh for delivered energy, each with an "annual escalation rate" of either **% or **%. One of the six bids was a ***********/MWh (***9 cents/kWh) for delivered energy, with *************. This information was provided as confidential Attachment CAC 3.17-A in response to a discovery request. It is unknown to me which of these proposals became the approved Benton County wind farm.

Q. HOW MUCH DOES THE BENTON COUNTY WIND FARM COST?

A. The power purchase agreement between Cinergy and the developer of the Benton County wind farm is confidential, and Duke Energy Indiana has not yet provided a copy of that PPA to CAC. I understand that the IURC would likely know these costs as they were approved in Cause No. 43097 in December, 2006.

Q. ARE THE BID PRICES FROM THE RESPONSES TO THE RFP LIKELY TO REPRESENT THE RANGE OF PRICES FOR ADDITIONAL WIND ENERGY IN INDIANA?

A. Not necessarily, but possibly. Costs to construct wind farms has increased in the last few years due to fundamental supply and demand issues, which has led to increases in costs for wind farm components. However, utility-based financing of wind farms could help to mitigate some of this increase, and technological improvements have the potential to continue to bring unit costs down over time.

Q. WHAT IS THE LIKELY RANGE OF COSTS FOR ADDITIONAL WIND ENERGY IN INDIANA?

A. While it is difficult to estimate the exact costs of any particular wind farm that might be built in Indiana (or built elsewhere with the energy imported into Indiana), it is reasonable to estimate a range of levelized costs based on a range of assumptions for installation costs and average performance of wind farms, two of the more critical variables in estimating wind energy costs. Using Duke Energy Indiana's financing assumptions[11] of **%/**% debt-to-equity, ***4% return on equity, and ***% cost of debt, the range of levelized costs ($2005) for wind energy after accounting for the 10-year federal production tax credit is $**/MWh to $**/MWh. Exhibit RMF-9 (included below) shows the range of costs based on the two key variables, installed cost and average annual capacity factor, using the stated financial assumptions. The middle of this range uses Duke Energy Indiana's assumption for capital costs of $*****/kW and a reasonable annual average annual capacity factor of 35%, resulting in levelized costs of $**/MWh.

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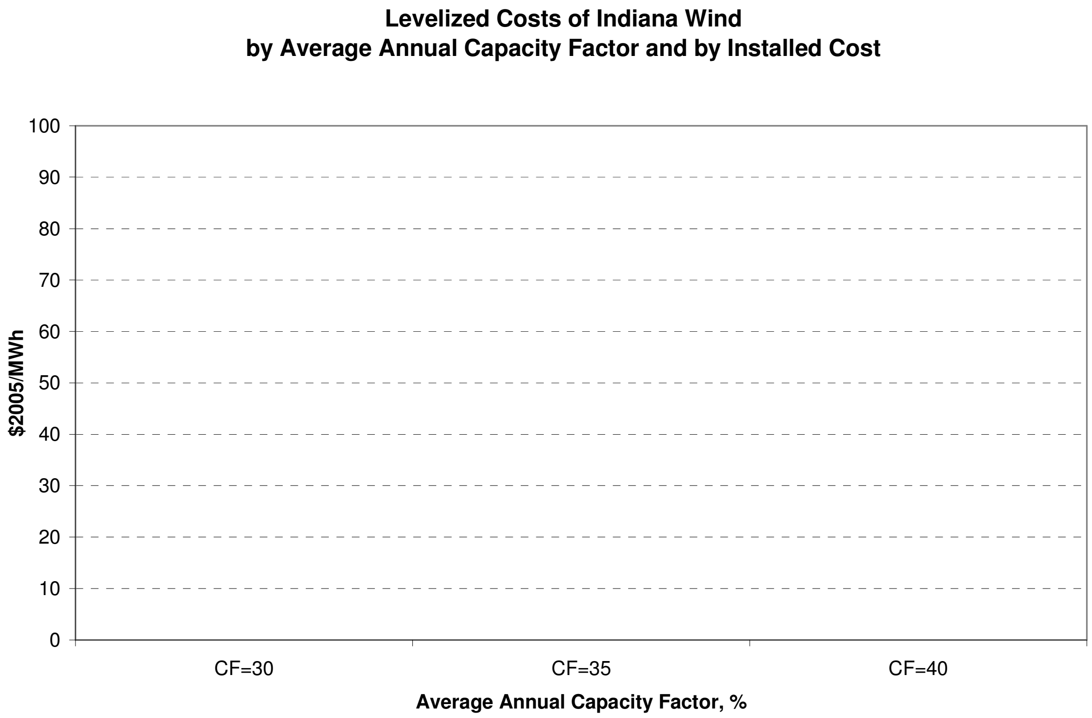
[11] Confidential response to CAC 7-3C.

Exhibit RMF-9 - Levelized Costs of Indiana Wind Energy



The "LowCapCost" scenario represents installed capacity costs of $**** per kW, the "MedCapCost" scenario is $*****/kW, and the "HiCapCost" is $*****/kW. For each of these scenarios, levelized costs are computed for a range of average annual capacity factors of 30% to 40%.

Q. ARE THE FINANCING, INSTALLED COST AND CAPACITY FACTOR ASSUMPTIONS REASONABLE FOR THE CURRENT WIND ENERGY MARKET AND TECHNOLOGIES?

A. Yes. While there are other sources that might show different values than the ones Duke Energy Indiana provided, the financing and capital cost assumptions used area reasonable.[12] MISO treats existing wind resources in the region as producing at 32% capacity factor, and is considering using 40% capacity factor for future installations.[13] The NREL estimate of capacity factors for wind installations in the best places in Indiana support such a range; in fact, NREL estimates that the best sites could exhibit capacity factors up to 45% (Exhibit RMF-6).

Q. ARE THERE OTHER SOURCES OF WIND ENERGY FROM LOCATIONS OUTSIDE THE STATE OF INDIANA THAT COULD BE UTILIZED TO SERVE DUKE ENERGY INDIANA'S LOAD?

A. Yes. One broad indicator of wind energy availability for the region is the current queue of wind generators applying to MISO for transmission interconnection studies. As of April 16, 2007, the MISO queue consisted of almost 49,000 MW of potential wind plants in the MISO region, over 3,000 MW in Indiana alone. These proposed plants are distributed across the MISO states, as illustrated below.

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[12] For example, there is a set of financial assumption and capital cost values used in the MISO's planning assumptions for its 2008 Transmission Expansion Plan, available in a file named "Strategist Feb Workshop Summary 5_9_2007.pdf" at http://www.midwestiso.org/publish/Folder/7be606_10b7aacd66e_-76cd0a48324a?rev=1.

[13] *Ibid.*, Slide 11.

Summary of Wind Generation Projects in MISO Interconnection Request Queue

State	Maximum Summer Output, MW
IA	4,596
IL	10,547
IN	3,010
MI	1,533
MN	6,775
MO	1,100
MT	580
ND	3,310
OH	740
SD	14,498
WI	2,022
Total	48,711

Source: MISO, summary tabulation by Synapse.

Q. HOW MUCH WOULD IT COST TO SERVE INDIANA'S NATIVE LOAD WITH WIND ENERGY SOURCED FROM OUT OF STATE?

A. The cost to serve native load in Indiana from resources located outside of Indiana would be equal to the cost of building and operating (or contracting for) the wind energy plus the cost of using the regional transmission grid to deliver the energy to Indiana. The cost of building and operating facilities outside of Indiana would be somewhat similar to building and operating those facilities in Indiana, since the technologies are the same, though the per unit cost of energy might be lower if the non-Indiana sites exhibited better wind regimes than Indiana's best sites.

Duke and Vectren are part of MISO, which uses the coordinated transmission grid and a single transmission tariff to deliver energy sourced anywhere in the MISO region to Indiana load. Thus the primary difference between the costs for wind located in Indiana compared to the costs for wind resources located outside of Indiana are variable delivery costs associated with losses and congestion on the regional transmission grid. Those costs are reflected by the spot price differences between MISO regions; the historic costs can be readily examined.

On average, the cost differential for energy delivered to the Duke control area and sourced in different parts of the MISO region can be summarized by average MISO day ahead and real-time spot market costs around the region. MISO summarizes these for five "hubs": Duke Energy Indiana (Cinergy), Michigan, Minnesota, First Energy and the Wisconsin area ("WUMS"). In 2005, the average annual price difference between the Cinergy hub and Minnesota hub was $4.20 per MWh (MISO day-ahead spot market) and $5.81/MWh (MISO real-time spot market).[14] Other hubs were closer in price to Cinergy. Thus, on average it might likely cost on the order of several dollars per MWh to deliver energy to Indiana. The exact amount would depend upon the location of the wind farm and the overall pricing patterns in the MISO spot markets. Notably, this effect could potentially be offset by the availability of wind resources outside of Indiana that exhibit higher average annual capacity factors, and thus a lower average cost of energy. A portion of these costs are also hedgeable, by obtaining financial transmission rights between the source and sink locations.

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[14] 2005 MISO State of the Market Report, page 30.

D. Integrating Wind Energy to Serve Indiana Native Load

Q. CAN WIND ENERGY BE USED TO MEET ALL OF DUKE ENERGY INDIANA'S NATIVE LOAD, AS A SUPERFICIAL EXAMINATION OF INDIANA'S WIND POTENTIAL MIGHT INDICATE?

A. Probably not, for a few reasons. First, the installed capacity potential would only be reached if maximum turbine rating wind speeds were seen at all wind plants throughout the state at the same time. Wind turbines are sized to take advantage of high wind speeds and produce energy at their maximum rated capacity, but for many hours of the year the turbine's output will be less than the full rated capacity. Second, wind energy is not as inherently dispatchable as more traditional forms of generation in Indiana - gas, oil and coal facilities. While advanced wind forecasting tools can help to minimize wind speed (and thus turbine output) prediction error, and advanced technologies can provide a measure of dispatchability for wind resources[15], other sources of more controllable generation are required to maintain system balance and provide capacity and energy to complement wind farms' production profiles.

Q. BUT COULD WIND RESOURCES BE USED TO ECONOMICALLY MEET A SIGNIFICANT FRACTION OF INDIANA'S ENERGY NEEDS?

A. Yes, absolutely. Wind resources are an economic source of energy. While they have less capacity value than traditional fossil technologies, they can be used to displace energy that would otherwise be sourced from fossil-fueled plants, and

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[15] At any given moment, a wind turbine's output or the aggregate of a wind farm's output could be operationally decreased; and it is possible to withhold maximum output of a wind farm for reliability purposes and thus allow for limited incremental output upon a signal to increase. These control alternatives exist with current wind technology, although they have not been used yet to any significant commercial extent.

they still do provide capacity, usually on the order of 15-20% of the installed capacity rating, in the Midwest region.

Q. HOW MUCH WIND ENERGY COULD BE INTEGRATED ONTO DUKE ENERGY INDIANA AND VECTREN'S SYSTEMS?

A. One current study conducted in the MISO region indicates that up to 25% of system energy needs – which translates to a higher percentage by installed capacity[16] - might be met by wind without jeopardizing system reliability and without incurring significant integration costs. Exhibit RMF-10 is volume I of a study conducted for the Minnesota Department of Commerce that describes the wind integration costs and concerns with integrating wind up to a level where 25% of retail energy is provided by wind resources.[17] At those levels of penetration, some additional reserve and regulation costs could be imposed on the MISO's centrally dispatched system, which includes the Duke Energy Indiana and Vectren regions, but the technical capability exists to control the system and provide for the reliable supply of energy. Notably, much or all of any increased integration costs associated with such a penetration level can be covered by existing capacity resources. The reports estimates $4.11/MWh of integration costs if the full 25% of Minnesota retail electric energy needs are met by wind. At lower levels of penetration, this cost is lower.

Q. COULD EVEN HIGHER LEVELS OF WIND ENERGY PENETRATION BE POSSIBLE ON MISO OR INDIANA TRANSMISSION SYSTEMS?

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[16] Meeting 25% of a system's annual energy needs with wind might require up to 35% or 40% of the system's installed capacity to be wind.

[17] The exhibit is volume I of the study. The rest of the study can be downloaded here: http://www.uwig.org/opimpactsdocs.html.

A. Yes. Additional transmission infrastructure and ancillary service capability (i.e., controllable generation capacity) could allow for even greater levels of wind energy penetration. For example, some European power systems see considerably greater penetration levels for at least some periods of time on at least some portions of their power system. Exhibit RMF-11 is a summary of the wind energy penetration levels of European countries with the highest levels of penetration. Such higher levels of wind penetration are not particularly technically relevant to this application, because Duke and Vectren's systems currently have so little wind and thus can absorb large quantities of wind resources before significant operational complexities become a factor.

Q. IS DUKE ENERGY INDIANA ANYWHERE NEAR THE 25% PENETRATION LEVEL REFERENCED ABOVE?

A. No, not at all. Duke will have 100 MW of wind installed on its 7,000 MW peak load system when the Benton County wind farm becomes operational, less than 2% by capacity and less than 1% by energy needs[18]. While all systems are not alike and thus wind penetration affects systems differently, using the conservative criteria of 20% penetration by peak load (which would be less than 20% by energy), Duke Energy Indiana could have an additional 1,300 MW of wind installed on its system with no significant operational or reliability constraints (20% of 7,000 MW = 1,400 MW, less the Benton county 100 MW wind farm = 1,300 MW additional).

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[18] Duke Energy Indiana's 2011 total energy needs are approximately 36,000,000 MWh. A 100 MW wind farm operating at 35% capacity factor would produce 306,600 MWh, or approximately 0.9% of system energy needs.

Q. HOW MUCH ENERGY PER YEAR WOULD AN ADDITIONAL 1,300 MW OF WIND ENERGY GENERATE FOR INDIANA?

A. If this incremental wind resource was to operate in aggregate at an annual capacity factor of 35%, it would produce 3,986 GWh (3.986 million MWh) per year (1,300 MW x 8,760 hours/year x .35 / 1000). Duke Energy Indiana's total system would then produce 4,292 GWh per year (1,400 MW x 8,760 hours/year x .35 / 1000).

Q. HAS MISO STUDIED WIND PENETRATION AND INTEGRATION ISSUES IN THE MIDWEST REGION?

A. Yes, extensively. In particular, in the 2006 MISO Transmission Expansion Plan ("MTEP06"), MISO studied the possibility of 20% wind energy in the state of Minnesota and 10% wind energy throughout the rest of the MISO region.

Q. IS THE DUKE + VECTREN ENERGY SYSTEM THE PROPER AREA TO EVALUATE WHEN CONSIDERING HOW MUCH WIND ENERGY DUKE AND VECTREN MAY BE ABLE TO USE TO MEET A PORTION OF THEIR NATIVE LOAD REQUIREMENTS?

A. No, a larger region is the more appropriate scale to assess because most generation and transmission use is coordinated on a regional basis, not a service-territory specific basis. Thus, the MISO region, or at least certain portions of the MISO region, are the more appropriately scaled regions to analyze to determine how much wind might be integrated before beginning to bump up against reliability concerns.

E. Applicants' Representation of Wind Resources in Modeling

Q. DOES DUKE ENERGY INDIANA RECOGNIZE THE POTENTIAL FOR WIND TO MEET MORE THAN A TOKEN FRACTION OF ITS NATIVE LOAD SUPPLY NEEDS?

A. No. Based on the assumptions used and the results of its modeling, and given the current costs of wind energy, Duke Energy Indiana does not appear to recognize the vast potential and the relatively attractive economics of wind generation resources. In its use of the Strategist model, Duke Energy Indiana limits the quantity of wind that can be taken by the model.

Q. WHAT EVIDENCE DO YOU HAVE THAT DUKE ENERGY INDIANA'S MODELING LIMITS THE ABILITY OF WIND ENERGY TO BE SELECTED AS A RESOURCE CHOICE?

A. Duke Energy Indiana's response to discovery request CAC 3.22 describes how the Strategist Input Summary Report contains the information on the maximum amount of wind that could be considered over the 2006-2028 period. The response states in part:

> "**
> **
> **
> **
> **."

The pertinent pages of the Input Summary Report associated with the Strategist modeling runs conducted in support of Witness Diane Jenner's Supplemental testimony show a cumulative maximum of *************** **** MW wind project over the 2006-2028 period, in addition to the 100 MW wind PPA resource already approved by the IURC. Those pages also show that the model limits the additional wind alternative (beyond the existing 100 MW PPA) to selection in years ****, ****, **** and ****. The two pages of the Input Summary Report are included here as Exhibit RMF-12.

Thus, Duke Energy Indiana's modeling does not allow for more than a total of *** MW of wind on their system through 2028, even though the best wind energy resource sites in Indiana likely far exceed *** MW and would result in ************* energy than the IGCC coal plant. The model also doesn't reflect the reality that wind can indeed be procured much more frequently than at the rate and intervals assumed in the modeling.

Q. BUT AREN'T THERE LIMITATIONS ON THE AMOUNT AND RATE AT WHICH A SYSTEM CAN ABSORB WIND GENERATION?

A. Yes, but those limitations do not materially impact operations until more significant penetration levels are reached (***0 MW of wind is only ***% penetration by peak load on Duke Energy Indiana's system).[19] Duke Energy Indiana's system has such a low penetration of wind (after the 100 MW wind PPA goes into operation) that technical limitations to initial wind additions are practically non-existent.

The overall variation of Duke's hourly "net load" (i.e., hourly load net of the output of all wind resources) at very low penetration levels such as ***% is likely statistically indistinguishable from the net load with no wind on the

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[19] See for example, "Wind Plant Integration, Costs, Status and Issues", by Edgar DeMeo, Willam Grant, Michael Milligan and Matthew J. Schuerger, IEEE Power and Energy Magazine, November/December. That article summarizes the integration impacts examined in six separate, major studies of wind integration on US utility systems.

system.[20] As its wind resource percentage begins to increase, there may be a need for increased levels of operating reserve and regulation, but even those incremental requirements will be minimal at first, especially since Duke Energy Indiana operates within the regional MISO system.

Q. WHAT ARE THE KEY TECHNICAL FACTORS ASSOCIATED WITH INCREASED INTEGRATION OF WIND TURBINE GENERATOR RESOURCES ONTO THE POWER GRID?

A. A number of key technical factors drive the extent to which WTG can be integrated into any given power system. They include:

1. **Temporal wind and load patterns**. The relationship of the temporal wind patterns (and thus the hourly energy output patterns of wind resources) to the temporal variations in load: operationally, these patterns affect the level of required regulation, load following and contingency resources necessary for reliable grid operation[21];
2. **Spatial diversity of wind resources**. The spatial diversity (or geographic dispersion) of wind resources and thus the pattern of aggregate wind power output in a region at any given moment: operationally, spatially diverse wind resources generally result in reduced temporal variation of

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[20] While all power systems are different, some of the more recent wind integration studies illustrate how “net load” variation changes with increased wind penetration and one can be used for illumination. For example, the GE New York study (The Effects Of Integrating Wind Power On Transmission System Planning, Reliability, And Operations, Report on Phase 2: System Performance Evaluation, Prepared for The New York State Energy Research And Development Authority, Albany, NY. John Saintcross, Senior Project Manager. Prepared by: GE ENERGY - ENERGY CONSULTING, Richard Piwko, Project Manager, Xinggang Bai, Kara Clark, Gary Jordan, Nicholas Miller, Joy Zimberlin. March 4, 2005) concludes that at 10% penetration (10% of peak load) there are minimal impacts on power system regulation requirements and very little impacts on operating reserve needs because of the relatively small change in variability of net load (see for example Section 5.5.1 on conclusions related to net hourly load variability and operating reserve impacts).

[21] *Wind Integration Study – Final Report*, prepared for the MN DOC and Xcel Energy by EnerNex and Wind Logics, Sept. 10, 2004. See, for examples, the discussion and figures on pages 91-102 in the section entitled “Impact of Wind Generation on Generation Ramping – Hourly Analysis”.

aggregate wind plant output (in effect, a "smoothing" of aggregate regional wind output)[22], when compared to temporal variation associated with a single wind plant;

3. **Wind output forecasting systems**. The type of wind forecasting systems in place, and thus degree of error around the "predictability" of wind output in various advance time frames (e.g., 20 minutes ahead of real-time, hour-ahead, 12-hours ahead, day-ahead, etc.)[23]; operationally, the use of state of the art forecasting improves wind power output scheduling and reduces prediction errors that contribute to the bulk of wind integration costs.
4. **Transmission availability**. The availability of transmission to carry wind power to market.
5. **Scale of Regional Coordination**. The scale of the controlled region, i.e., the relative size of the "system" onto which a given block or blocks of wind power is injected. This scale influences whether or not limitations on the ability to inject more wind are related to actual technical constraints, or to the institutional frameworks that define the size of the system. For example, injecting the output of, say, 1,400 MW of wind plants onto a "system" the size of the Duke Energy Indiana system – approximately 7,000 MW of projected peak load in 2012 - is a penetration level of 20% of peak load. But 1,400 MW of wind is only 3.4% penetration by peak load when considering the 40,926 MW peak load of the Central planning region of MISO (3.4% = 1,400/40,926).[24]

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[22] *Characterization of the Wind Resource in the Upper Midwest*, Task 1 of the Wind Integration Study prepared for the MN DOC and Xcel Energy by EnerNex and Wind Logics, Sept. 10, 2004, see the discussion on pages 39-41 and the subsequent graphs and figures.

23 See, for example, *Overview of Wind Energy Generation Forecasting* submitted to New York State Energy Research and Development Authority and the New York State Independent System Operator, Prepared By: TrueWind Solutions, LLC and AWS Scientific, Inc., December 17, 2003.

[24] The Central Planning region of MISO is comprised of the systems of Hoosier Energy, Duke Energy Indiana, Vectren, IPL, and other systems in Illinois and Missouri areas of MISO and in 2011 the peak load is projected to be almost 41,000 MW (MISO 2006 Transmission Expansion Plan, Table 6.1-1).

Q. AT WHAT RATE COULD 1,300 MW OF ADDITIONAL WIND BE ADDED TO DUKE ENERGY INDIANA'S SYSTEM?

A. There likely are no particular operational barriers to adding up to 1,300 MW of wind to the Duke Energy Indiana system, based on the Minnesota Department of Commerce integration study cited earlier. In that study, the 25% (by energy) aim was to be achieved by 2020. By rough extrapolation, 20% wind capacity equates to approximately 12% by energy sales (assuming 35% capacity factor, and 60% system load factor), or half of the Minnesota aim of 25% by energy by 2020. Thus it is reasonable, if not conservative, that a 20% penetration by peak load in Indiana could be accomplished more quickly than by 2020. Thus a conservative ten-year integration (2009 – 2018) schedule would lead to the following generation of energy by wind in Indiana:

Year	MW per year	Cap. Factor	GWh / Yr	Cum GWh/yr.
2007	0	NA	0	0
2008	100	0.35	307	307
2009	130	0.35	399	705
2010	130	0.35	399	1,104
2011	130	0.35	399	1,502
2012	130	0.35	399	1,901
2013	130	0.35	399	2,300
2014	130	0.35	399	2,698
2015	130	0.35	399	3,097
2016	130	0.35	399	3,495
2017	130	0.35	399	3,894
2018	130	0.35	399	4,292

F. Duke Energy Indiana's Acknowledgement of the Viability of Wind Energy Resources

Q. DOES DUKE ENERGY INDIANA ACKNOWLEDGE WIND AS A TECHNICALLY AND ECONOMICALLY APPROPRIATE SUPPLY-SIDE

ENERGY RESOURCE TO MEET SOME PORTION OF NATIVE LOAD REQUIREMENTS?

A. Yes. In its application for approval by the IURC of a 100 MW purchased power agreement between Duke and a wind plant in Benton county, Duke Energy Indiana was clear in its assessment of the benefits of wind power. Citing just a few of many examples, in the testimonies of Mr. Lefeld and Ms. Jenner, Duke Energy Indiana stated that:

- "…over the course of a typical year the capacity factor of current large-scale wind generation technology that is properly sited is high enough to allow it to be considered as part of a broad, robust resource portfolio". (Lefeld, 5: 12-15)
- Turbine availability has increased considerably since the early 1980s, and there have been significant improvements in turbine design. "Future improvements to turbine design are expected to further reduce the cost of wind energy". (Lefeld, 6: 1-20)
- "However, in recent years it has been determined that higher off the ground wind speeds pick up dramatically through much of the Midwest, including Indiana. Small increases (or decreases) in average wind speed from one location to the next can account for significant changes in electricity generation." (Lefeld, 7: 4-6)
- "We believe that the wind project purchase provides environmental benefits and supports a more diverse portfolio of resource options for Duke Energy Indiana, and for these reasons, it should be pursued at this time." (Jenner, 23: 10-12)

Q. DID DUKE ENERGY INDIANA'S WIND CONSULTANT AGREE THAT WIND REPRESENTS A VIABLE ENERGY RESOURCE FOR THE DUKE ENERGY INDIANA SYSTEM?

A.*** *** ***********.[25]

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[25] Attachment CAC 3.24-A, Confidential response to CAC 3.24, "State of Indiana Wind Power Resource Assessment", prepared by Kevin Walter, National Science Foundation IGERT Fellow and Ph.D Candidate,

IV. COMBINED HEAT AND POWER

A. In-State Combined Heat and Power – Potential and Economics

Q. WHAT IS COMBINED HEAT AND POWER?

A. Combined heat and power is a form of distributed generation that uses waste heat generated from the production of electricity to supply a portion of the thermal requirements of certain facilities, usually large commercial or industrial facilities with certain load and process characteristics and a demand for thermal energy. Combined Heat and Power allows for greater overall fuel utilization (i.e., higher efficiency of fuel use) because a portion of the heat produced by the electricity generation process is used to heat water or make steam for other facility end uses. This increases the overall economic favorability of installing distributed generation because the benefit is not limited to just the production of electricity.

Q. IS THERE ANY COMBINED HEAT AND POWER IN INDIANA TODAY?

A. Yes. Based on a database maintained by Energy and Environmental Analysis[26] and supported through the US Dept. of Energy, Indiana has approximately 2,074 MW of Combined Heat and Power generating capacity, primarily in the major industrial sectors of primary metals and refining. A second source, a “Baseline Analysis” report by the Midwest Combined Heat and Power Application Center at the University of Illinois[27], indicates that Indiana has 30 installations with a total

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Wind Science and Engineering Research Center, Texas Tech University, Lubbock, Texas. Prepared for Cinergy Corp., December 1, 2005. See for example, page 16 of the report.

[26] http://www.eea-inc.com/chpdata/States/IN.html.

[27] “Baseline Analysis for the CHP Market in Indiana”, Prepared by the Midwest CHP Application Center at the University of Illinois at Chicago – Energy Resources Center, under Oak Ridge National Laboratory Contract # 4000007633. September, 2005.

capacity of approximately 2,129 MW. These CHP installations range from kilowatt-scale units to large industrial facilities in the hundreds of MW.

Q. IS THERE POTENTIAL FOR ADDITIONAL COMBINED HEAT AND POWER IN INDIANA?

A. Yes. A study conducted by ONSITE SYCOM Energy Corporation for the US DOE/EIA identified a market potential of 1,491 MW in Indiana.[28] This potential is highest in office buildings, schools, hospitals and nursing homes, as much of the industrial potential in Indiana has been exploited. The data in the following table is taken from the ONSITE report, and shows the breakdown of market potential across sectors:

Business Sector	Potential Capacity, MW	% of Total
Hotel/Motel	71	4.8%
Nursing Homes	156	10.5%
Hospitals	184	12.3%
Schools	342	23.0%
Colleges and Universities	91	6.1%
Commercial Laundries	9	0.6%
Car Washes	6	0.4%
Health Clubs / Spas	61	4.1%
Golf Clubs	29	1.9%
Museums	8	0.5%
Correctional Facilities	50	3.3%
Water Treatment/Sanitary	30	2.0%
Extended Serv. Restaurant	65	4.4%
Supermarkets	24	1.6%
Refrigerated Warehouses	14	1.0%
Office Buildings	352	23.6%
Total	1,491	100%

Source: ONSITE Report, Table B-1, pages 57-58.

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[28] "The Market and Technical Potential for Combined Heat and Power in the Commercial/Institutional Sector", Prepared for the US Dept. of Energy, Energy Information Administration. Prepared by ONSITE SYCOM Energy Corporation, January 2000 (Revision 1), Table B-1, pages 57-58.

Q. IS COMBINED HEAT AND POWER A COST-EFFECTIVE ENERGY AND CAPACITY SUPPLY RESOURCE?

A. Yes, it can be, given the underlying thermodynamic efficiency gains that can be seen by utilizing what is otherwise a "waste" energy stream. Traditional fossil-fueled power plants only convert a fraction of the fuel input into electricity[29] – the remainder is discharged to the environment as waste heat. Using fairly traditional power generation and heat recovery technologies, the economics of CHP can be favorable to customers with thermal loads, such as hot water needs in schools, hospitals and nursing homes and cooling loads in large office buildings that can be served by absorption chiller technologies.[30]

Q. WHY HASN'T MORE OF THE MARKET POTENTIAL FOR CHP BEEN CAPTURED IN INDIANA?

A. There are two primary reasons. Firms can often be reluctant to invest capital in CHP projects because energy production is not their business. They seek quick payback periods – i.e., they demand a high return on investment - and have competing uses for their capital.[31] This behavior is also seen in end users' reluctance to invest in economically attractive energy efficiency. Second, in states such as Indiana, with historically low average electric costs, the perceived economic attractiveness for smaller installations has not been high.[32]

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[29] This fraction varies depending on the type and the vintage of the technology, and is based on underlying thermodynamic fundamentals. Older coal-fired power plants may only achieve efficiencies on the order of 33% (i.e., a "heat rate" of about 10,340 BTU/kWh). Newer combined-cycle and even single-cycle gas turbines can achieve efficiencies of 40-50% (i.e., heat rates of approximately 6,800 to 8,500 BTU/kWh).

[30] While most air conditioning loads are served by electric-driven refrigeration equipment, absorption chillers use a heat source instead of a motor-driven compressor to complete the thermodynamic refrigeration cycle and obtain chilled water for building cooling purposes.

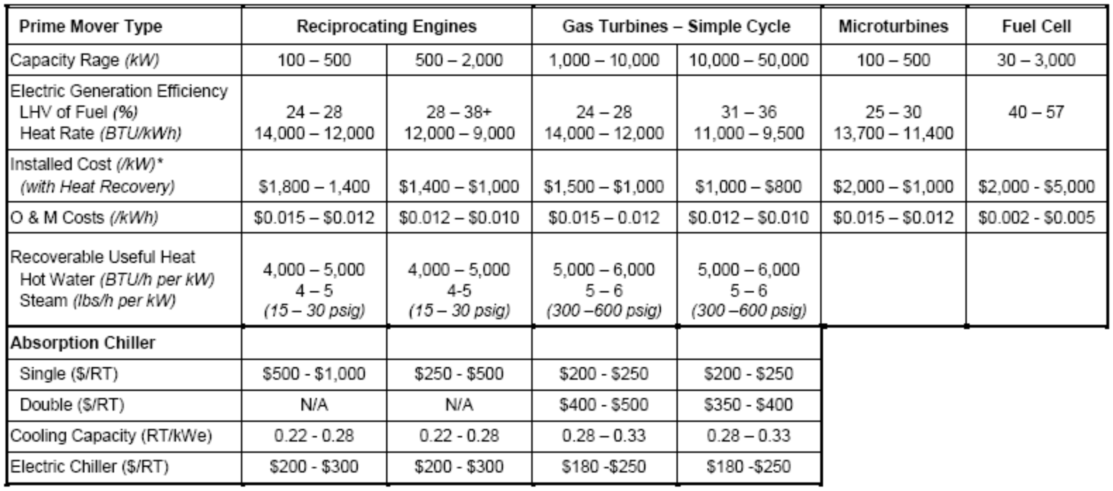
[31] "Baseline Analysis" report, page 15, "Capital costs and payback time frames are of concern".

[32] See for example the "Baseline Analysis", Current Pricing Issues, pages 7-8.

Q. WHAT IS THE INSTALLED COST OF COMBINED HEAT AND POWER SYSTEMS?

A. The cost of CHP systems depends on the technology and size. The table below is taken from the "Baseline Analysis" report for Indiana. It shows a range of installation costs for relatively mature commercial technologies – reciprocating engines and gas turbines - from $800/kw (larger gas turbine) to $2,000/kw (microturbines). It also includes fuel cells, which can cost up to $5,000/kw to install. Overall costs for a CHP system are very site specific, and can include additional costs for equipment such as absorption chillers or heat exchangers associated with delivery of the "waste" heat to thermal loads.

Table 4-1 CHP Technologies



Prime Mover Type	Reciprocating Engines		Gas Turbines – Simple Cycle		Microturbines	Fuel Cell
Capacity Rage *(kW)*	100 – 500	500 – 2,000	1,000 – 10,000	10,000 – 50,000	100 – 500	30 – 3,000
Electric Generation Efficiency LHV of Fuel *(%)* Heat Rate *(BTU/kWh)*	24 – 28 14,000 – 12,000	28 – 38+ 12,000 – 9,000	24 – 28 14,000 – 12,000	31 – 36 11,000 – 9,500	25 – 30 13,700 – 11,400	40 – 57
Installed Cost *(/kW)** *(with Heat Recovery)*	$1,800 – 1,400	$1,400 – $1,000	$1,500 – $1,000	$1,000 – $800	$2,000 – $1,000	$2,000 - $5,000
O & M Costs *(/kWh)*	$0.015 – $0.012	$0.012 – $0.010	$0.015 – 0.012	$0.012 – $0.010	$0.015 – $0.012	$0.002 - $0.005
Recoverable Useful Heat Hot Water *(BTU/h per kW)* Steam *(lbs/h per kW)*	4,000 – 5,000 4 – 5 *(15 – 30 psig)*	4,000 – 5,000 4-5 *(15 – 30 psig)*	5,000 – 6,000 5 – 6 *(300 –600 psig)*	5,000 – 6,000 5 – 6 *(300 –600 psig)*		
Absorption Chiller						
Single ($/RT)	$500 - $1,000	$250 - $500	$200 - $250	$200 - $250		
Double ($/RT)	N/A	N/A	$400 - $500	$350 - $400		
Cooling Capacity (RT/kWe)	0.22 - 0.28	0.22 - 0.28	0.28 – 0.33	0.28 – 0.33		
Electric Chiller ($/RT)	$200 - $300	$200 - $300	$180 -$250	$180 -$250		

Source: "Baseline Analysis" page 6.

Q. WHAT DO YOU RECOMMEND THAT DUKE ENERGY INDIANA AND VECTREN DO WITH RESPECT TO COMBINED HEAT AND POWER POTENTIAL IN INDIANA?

A. Duke and Vectren can consider inventive programs to help the best candidate facilities finance and invest in cost-effective CHP systems. The utility system benefits from having a relatively lower cost block of capacity on their system, because CHP customers are likely to pay for much if not all of the facility. Ratepayers benefit because the avoided costs associated with CHP-provided supply can outweigh the expense associated with any incentives the utility may provide (e.g., to help with financing). Lastly, this can be a win for utility shareholders if incentive programs are structured properly (as with some DSM programs) to address issues of lost profit or lost revenue.

Q. DOES THIS CONCLUDE YOUR TESTIMONY.

A. Yes.