Indiana as an Energy Exporter

"The annual labour of every nation is the fund which originally supplies it with all the necessaries and conveniences of life which it annually consumes, and which consist always either in the immediate produce of labour, or in what is purchased with that produce from other nations." Adam Smith, Wealth of Nations, 1776.

Executive Summary:

The basis of a nation's economy is its production of goods and services. What the nation consumes is equal to what it produces either through its own labor and what it imports. This is also true of states. In any economy you must produce something either for your own consumption or for export to another consumer. Obviously you also need to import what you use but don't produce. The economic comeback of the USA will depend on successfully regrowing its ability to produce goods and services for its own use and export. The USA and Indiana needs to export goods and services rather than exporting capital for the economy to grow.

It may surprise some to learn that the USA is still the largest manufacturer in the world. That is it was until 2011, when for the first time in over 100 years, the USA will not be the world's largest manufacturer, ceding that title to China. By 2016 China may well surpass the USA as the leading economy in the world. (IMF 2011)

In the late 19th and early 20th century Indiana became a manufacturing powerhouse because of its geographic location and the discovery and exploitation of huge underground stores of natural gas and high energy coal. Our economy was built on *Home Grown Energy*. In 2005 Indiana produced the "*Hoosier Homegrown Energy, Indiana's Strategic Energy Plan*" as a guideline for how to grow Indiana jobs and incomes by producing more of the energy we consume from our own natural resources, this while encouraging conservation and increasing the efficiency of the energy we use. (HHE)

Report Prepared by the Staff of the Indiana Center for Coal Technology Research
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Indiana currently imports nearly 75% of the energy we consume (on a BTU basis), but we export over 90% of our energy dollars to purchase this energy. Domestically we produce lower cost energy, coal, and import the more costly commodities of oil and gas. As stated in the *Hoosier Homegrown Energy*: **importing energy means exporting capital and jobs**. (HHE)

Currently, Indiana mines around 35 million tons of coal a year, or about 3.6% of total U.S. coal production. Looking to the future, Indiana has more energy underground in the form of coal reserves than the entire United States (including the Bakken region) does in the form of oil and gas reserves.*

The demonstrated reserve base of over 17 billion short tons is enough to maintain current level of production for over 500 years. The reserve base for the entire Illinois Basins, which includes Indiana coal, is over 130 billion tons, or 25% of total demonstrated coal reserves in the United States – and is enough to meet entire U.S. coal demands for over 100 years. (IGS)

The point of all this is that the Midwest in general, and Indiana in particular, has an enormous relatively untapped energy source which can be increasingly used as the cost of gas and oil increase. Indiana is in a prime position to produce a great deal more of the energy it consumes and to increase the amount of energy its exports. New rules from the EPA will be the stimulus for this action, but a great deal of work is needed within the state to maximize this potential.

Figures 1 and 2 summarize the current pattern of Indiana energy use and the use of coal, its imports, and exports.

**Indiana Geological Survey estimates that 17 billion tons of recoverable coal remains in Indiana. Using an average of 22 million Btu/ton, the energy content of this coal is 400 quadrillion Btu (one quadrillion = $1x10^{15}$ Btu). Total U.S. oil and gas reserves are 320 quads, according to the Energy Information Administration (EIA)*

Figure 1 Current Energy Use

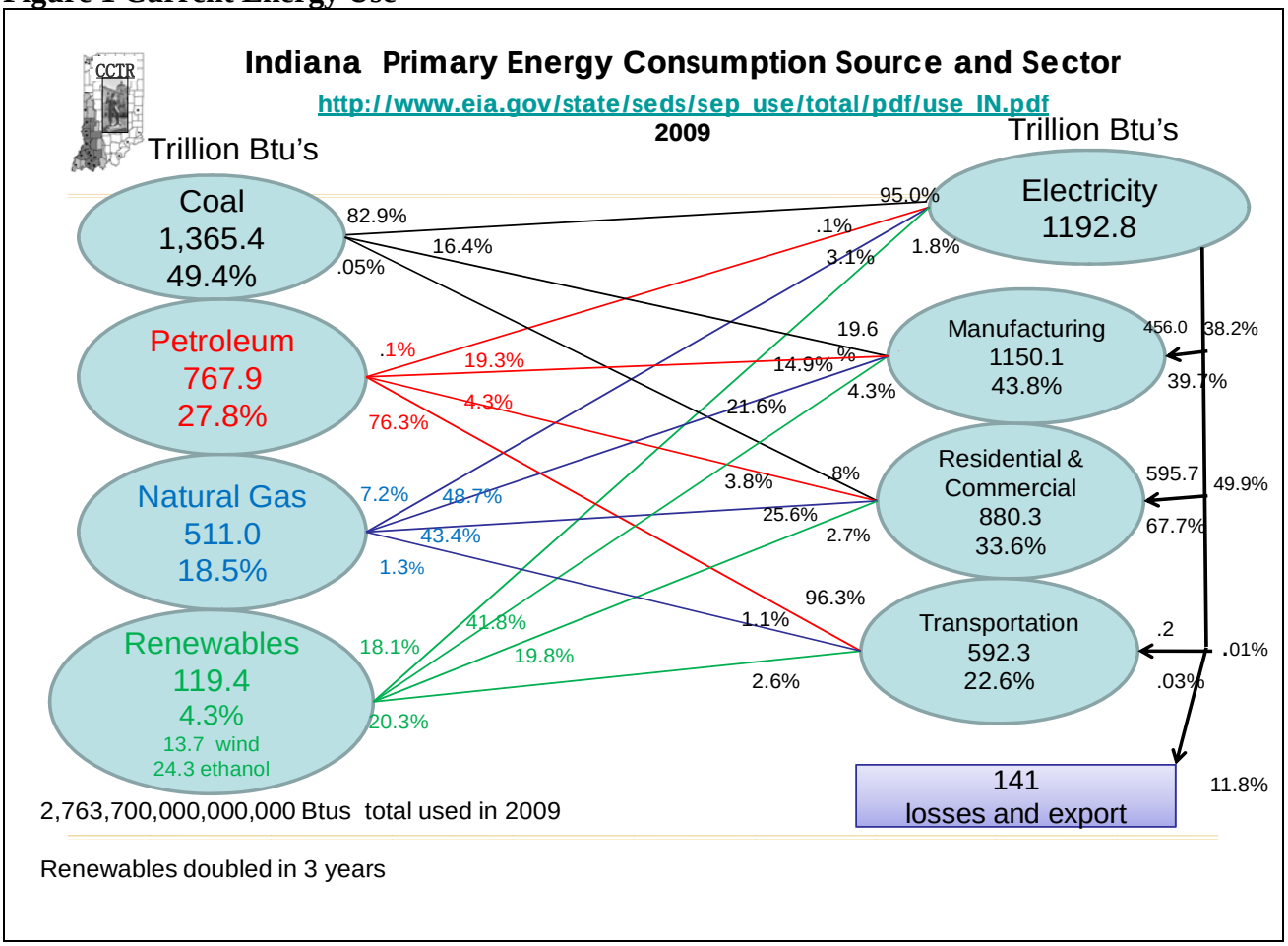

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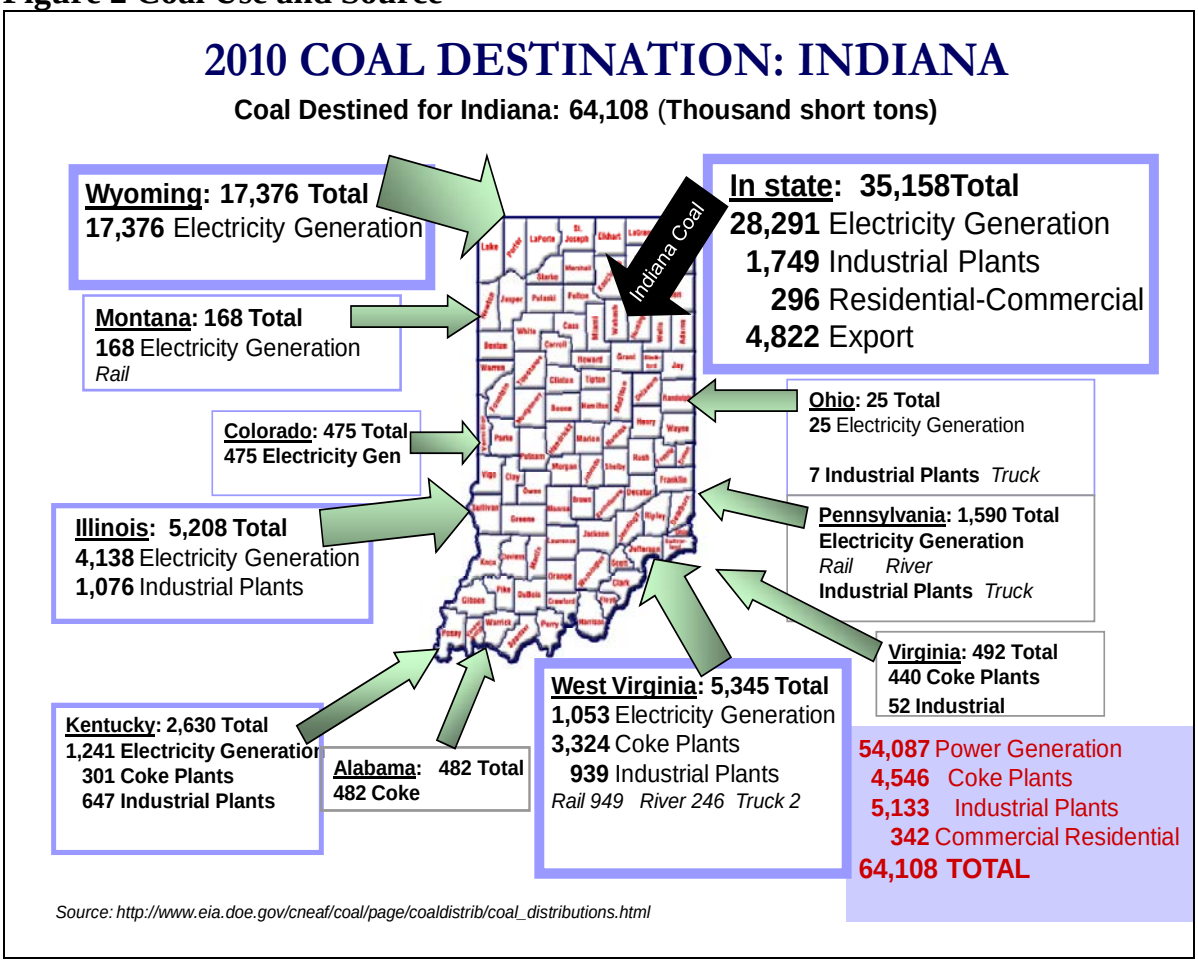
Figure 1 clearly shows that **Indiana is a coal state**. Coal makes up 49.4% of all of the energy used in Indiana, the vast majority of it in the form of electricity. **Figure 1** also shows that the manufacturing sector consumes almost 44% of all of the energy consumed in Indiana, 38% of all of the electricity produced in the state and 48% of all of the natural gas consumed. Manufacturing in Indiana is very energy intensive. Changes in cost and supply of energy have a very big impact on the manufacturing sector in Indiana. And let's be clear, **Indiana is a manufacturing state**. According to the US Bureau of Economic Analysis, 25% of Indiana's GDP is manufacturing; the USA average is 14%. This makes Indiana the most manufacturing intensive state in the nation. The next highest state is Oregon with 22% of its GDP in the form of Manufacturing. Our location and infrastructure are such that manufacturing continues to be the driving force in Indiana. But we need to recognize that manufacturing is mobile. It is relatively easy to move a manufacturing plant, or shut one down here and start up somewhere else. As energy becomes a more significant cost of manufacturing the propensity to relocate rises. (**CCTR**)

Indiana produced over 33 million tons of the 64 million tons of coal it used in 2010, most for generating electricity. **(Figure 2)** Half of the coal consumed in Indiana is imported from other states; chief among them Wyoming (17 million tons, all for electricity generation), West Virginia (5 million tons, mostly for coke production), and Illinois (5 million tons for electricity generation). Indiana imports over 18 million tons of low sulfur western coal for use to produce electric power. Indiana imports 6 times the amount of coal it exports – 30 million tons of imports versus 4.8 million tons of exports.

Figure 2 Coal Use and Source



While the value of the 35 million tons of coal production represented less than 1% of Indiana's Gross State Product, it is estimated that the sector contributed over $1.5 billion dollars and 3,400 direct mining jobs and 8,000 support jobs to the state's economy, (approximately $130,000 per job) primarily concentrated in the 18 southwest Indiana counties which make up the coal producing region of the state. (**CCTR/EXP**)

This calculation understates the true value of Indiana coal reserves, since it ignores the link between coal availability and Indiana's low electricity price, and the impact of these low electricity prices on Indiana's economy.(For a more detailed analysis see "*Estimating the State and Regional Benefits of the Mining and Use of Illinois Basin Coals*, F.T. Sparrow, CCTR 2009. Increasing the production of Indiana coal increases jobs both directly from coal mining and from the indirect affect of the mining

support structure. Increasing the use of indigenous energy retains more of the energy capital within the state. Increasing the use of Home Grown energy by $1 million not only adds $1 million dollars to the state's economy but reduces the export of capital by $1 million. This is a $2 benefit for every $1 increase in use of Home Grown Energy.

The following analysis will look at the technologies that will enable Indiana to use more of its indigenous energy and retain more of its expended energy capital. It will also show how technologies can be used to keep the availability of energy high and cost as low as possible. It is also necessary to recognize that technology alone is not sufficient to guarantee future use; time and capital are equally needed. These technologies are not cheap and the time factor is significant. To paraphrase Thomas Sowell's Basic Economics, page 307; *someone who shines shoes is paid immediately after the shoes are shined, but a decade or more can elapse between the time an electric utilities begins planning the power plant and electricity comes out and earns money to begin repaying the cost incurred*.

Indiana as an Energy Exporter, Options for Growth

Expanding Existing Use

In the short run, Indiana coal use can be expanded in many ways:

(1) Expand the Exports of Indiana Coal.
(2) Substitute Indiana coals for imported coals.
  A: Illinois Basin Coal for Powder River Basin Coal
  B: Indiana Coal for Coking Coal from West Virginia
(3) Expand the Export of Electricity Generated from Indiana Coals (Coal by Wire)
(4) Indiana Coal as a Feedstock for Substitute Natural Gas and Petroleum (Coal by Pipeline)
(5) Coal to Diesel/Jet fuel
(6) Coal to Gasoline
(7) Wind/Coal Hybrid Systems; Biomass Coal Co-firing
(8) Transportation Issues
(9) Shale Resources for Natural Gas and Oil
(10) Coal Technologies Projects in Indiana
(11) Recommendations/Conclusion
(12) Appendix

(1) Expand the Exports of Indiana Coal

Increasing exports of Indiana coals to surrounding states is a major opportunity for increasing Indiana coal production. Historically, Indiana has exported much more coal than the 4.8 million tons exported in 2010. In 1990, exports were over 10 million tons, with the total gradually falling to present levels over the intervening years. Currently, the exports are to Kentucky, Alabama, Ohio, noticeably absent is Michigan. It should be noted that Indiana uses more Illinois produced coal than does Illinois. (EXP)

Michigan imports 32 million tons of coal a year (22 million in the form of western coals); Wisconsin, 22 million tons (20 million from Wyoming); Ohio, 18 million tons (16 million in eastern coals); Kentucky, (13 million, mostly eastern coals) and Illinois, 8 million (7 million from Wyoming). Thus,

the total present export market for coal in neighboring states is over 100 million tons. Indiana's current market share of this total is less than 4%. (EXP)

Clearly, the economic trade–off between the higher transportation costs of non-Indiana coal and the lower cost of Indiana coal will drive opportunities to increase exports. The impact of EPA's Flu Gas Desulfurization scrubber mandate has significant potential for Indiana coal. Other possible environmental legislation aside, this one rule will allow for reduction of the use of Powder River Basin Coal since the scrubber negate the low sulfur benefit of PRB coal.

One limitation is the coal transportation network. Access to Michigan markets are limited by the lack of rail lines going north and south compared to most of Indiana's rail line which move east and west. CCTR is currently working with Prof. Thomas Brady, of Purdue, North Central, and a private engineering firm, to assess the coal rail system in Indiana. For example: the amount of Indiana coal needed to replace the western coal used by NiSource's Schahfer plant in northwest Indiana is of itself not of sufficient volume to necessitate any modification of the current rail structure. But adding Michigan coal fired power plants to the mix plus increasing the viability of Burns Harbor to export coal to Europe via the Great Lakes may in fact lead to a need for expanding or rehabbing rail lines. Rail lines can be rehabbed to meet a future market in a way that will not require the train to go through the Chicago or Gary interchanges. Michigan is a powerful market that is waiting for Indiana to respond. This market potential could exceed Indiana's current level of production. *(A Prescriptive Analysis of the Indiana Coal Transportation Infrastructure, Dr. Thomas Brady, CCTR May 2007).*

The European market is growing and has great potential. Europe needs high BTU coal and is willing to pay a premium for it. Burns Harbor is an excellent port ready to facilitate the loading of coal onto ocean going ships, along with barges that can access the ports along Lake Michigan which serve the Michigan coal fired power plants.

Recent article show the potential demand for USA coal.

> ***German coal import price remains high***
> *05 Dec 2011 14:56 GMT*
> *Hanover, 5 December (Argus) — German steam coal import prices in the third quarter of this year remained at the high level of the first half of this year, federal office for business and export control Bafa said today.*
>
> *The average price was €106.22/t ($143.11/t) of steam coal equivalent, just under 1pc higher than in the first and second quarters of this year, and the highest average price since 2008.*
>
> *Coal import volumes were 7.5mn t, or 6.41mn t in coal equivalent terms — 3pc up on the preceding quarter, and 33pc up on the third quarter of 2010. Bafa uses the term steam coal equivalent and importers must convert imported coal into steam coal equivalent using a formula based on the coal's calorific value. Bafa uses the average import price as the basis for the subsidies it pays the domestic coal mining sector. The office only takes steam coal imported from outside the EU into account, as opposed to the monthly coal import figures compiled by German statistics office Destatis.*

Importers must notify Bafa of the prices they pay, including transport to the German border. Transport in Germany is taken into account only in times of low water levels on the Rhine River, which limits navigation. Importers must use standard rates — for instance Bafa sets the transport rate from an ARA port to the border in Emmerich at €1.53/t, to which surcharges such as those applying in times of low water levels, may be added. Likewise, Bafa sets the transport distance for coal imported by train from an ARA port at 190km, and at 75km for coal imported from the Polish port of Gdansk.

More on transportation in Section 8

(2) Substituting Indiana Coal for Imported Coal

For more than 25 years Indiana has imported more than half of the coal used in the state. There are two major markets for imported coals in Indiana – coals imported to generate electricity (roughly 30 million tons, 17 million tons from Wyoming alone) and coal used to produce coke for Indiana's steel producers (4-6 million tons, mostly from West Virginia).

A) Indiana currently imports over 30 million tons of coal for the production of electricity, nearly 60% of that (18 million tons) in the form of western coal, primarily from the Powder River Basin. (**Figure 2**) This is due to the low sulfur content of PRB coal, but some of this has to do with the transportation infrastructure in place in Indiana. The 18 million tons of western coal can be replaced with 14 million tons of Indiana coal, due to the higher heat content of Illinois Basin coal. The mandate for scrubbers on existing power plants makes this substitution feasible. As of now an estimated 6.8 million tons of Indiana coal can be used with power plants that are tentatively scheduled for scrubber technology (**Figure 3**). The remaining portion of the western coal used by Indiana power plants may be a more difficult market to capture.

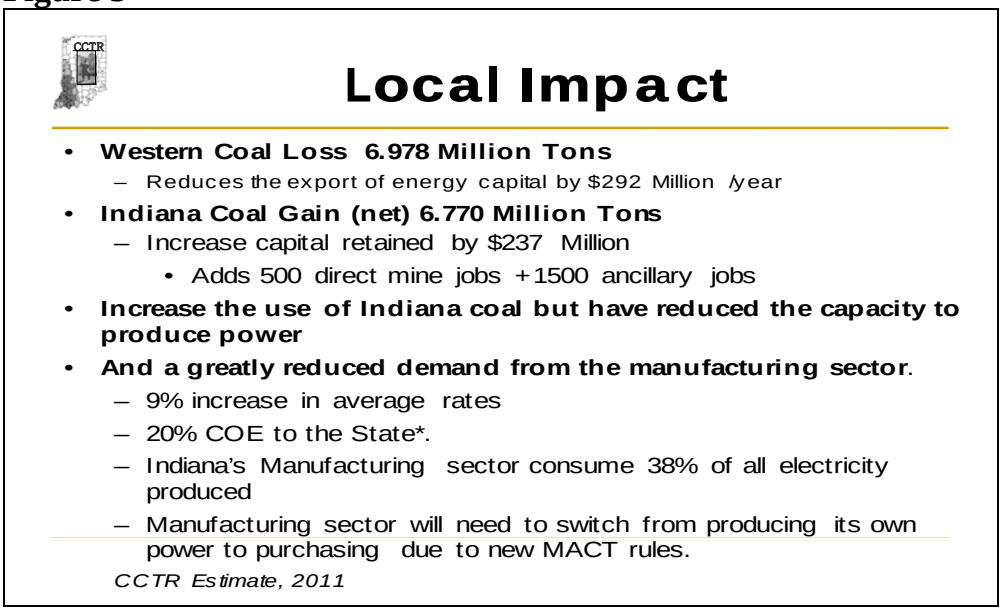
I&M's plant at Rockport, currently uses nearly 11 million tons of western coal. It is within easy access of Indiana coal mines and has in place the rail system needed to access Indiana coal. But I&M's Tanners Creek and IKE's Clifty Creek are accessible only by river barge. Clifty Creek, which uses over 4 million tons of both western and eastern coal, is situated such that rail links cannot be made. Tanners Creek could make a rail connection, but at great expense. To make these to facilities accessible for Indiana coal will require a modification of the barge loading and offloading and coal blending systems down river.

Modifying the barge systems could result in and additional 3.5 million tons of Indiana coal just from the two sites mentioned above. The major issue in the substitution of Indiana coals for imported coals for power generation is identical to the issue of increasing Indiana coal exports for power generation, new environmental regulations actually favoring the use of Illinois basin coal. This could also lead to increased market access to the Northern Kentucky power plants in Louisville and Trimble County Kentucky. (**CCTR**)

B) The substitution of Indiana coals for coal now imported by Indiana's steel industry faces a different set of issues. The particular characteristics required for coking coals limit the use of most Illinois

Basin coal. This was true until CCTR's sponsored work on a specific technology that resolves the problem

Figure 3



CCTR sponsored the technology developed by Dr. Robert Kramer of Purdue North-West that is currently under review for potential patentability. The coal used for the proposed coking process would be a mix of the Indiana Brazil seam and other Indiana coals, as previously identified by the Indiana Geological Survey (*Characterization of Indiana's Coal Resources, IGS 2004, 2007*), blended with some eastern coals to meet metallurgical and emissions requirements. (*Development of Coking / Coal Gasification Concept to Use Indiana Coal for the Production of Metallurgical Coke and Bulk Electric Power, CCT;* 2005, 2007, 2012)

Environmental emissions are often cited as one reason why Indiana coal is not used in the production of coke. This technology presents a different option that inverts the classic coke production paradigm. This project proposes to develop a process in which clean coal technology is used at the mine mouth to produce coke, rather than transporting coal from sources outside Indiana to a non-attainment area for coke production. Gas streams from the coking process will be collected and used for subsequent production of electricity at the site or possibly the production of liquid transportation fuel. This process will result in a net transportation savings, as well as a value stream from co-generated electricity. Such a facility will provide base load electric generation, but will also have the capability to supply shoulder and peaking power, in addition to, potentially ancillary services.

This leverages experience from current coking facilities in Indiana. This effort will extend these technologies for use in a mine mouth coking facility. This approach significantly increases the probability that an actual productive facility could be operational within a 5 year time frame. The option of mine mouth coke production with co-generation provides many advantages over current

production and transportation methods. Due to current market shortages and the price volatility of coke internationally, there is an opportunity to market Indiana coal in a new way in the form of coke to a variety of new markets both within and outside Indiana.

Mine mouth operation would have significant advantages to the Indiana steel industry. First by moving the coking process to the mine mouth you reduce the emissions currently associated with the coke ovens in Northwest Indiana, counties. This would allow the area to be better situated to maintain its hard earned status as an attainment area.

Secondly by moving the coke process to the mine mouth you reduce transportation cost. This is because coke process reduces the volume of the coal by 20% therefore you are only moving 80% of the material you had moved before. Coking of Indiana coal will not substitute for all of the eastern coal now used, approximately 5 million tons, but is can reduce the amount needed by 50%. Some eastern coal is still needed to be blended with the Indiana coal to make usable coke.

3) Expand the Export of Electricity Generated from Indiana Coals (Coal by Wire)

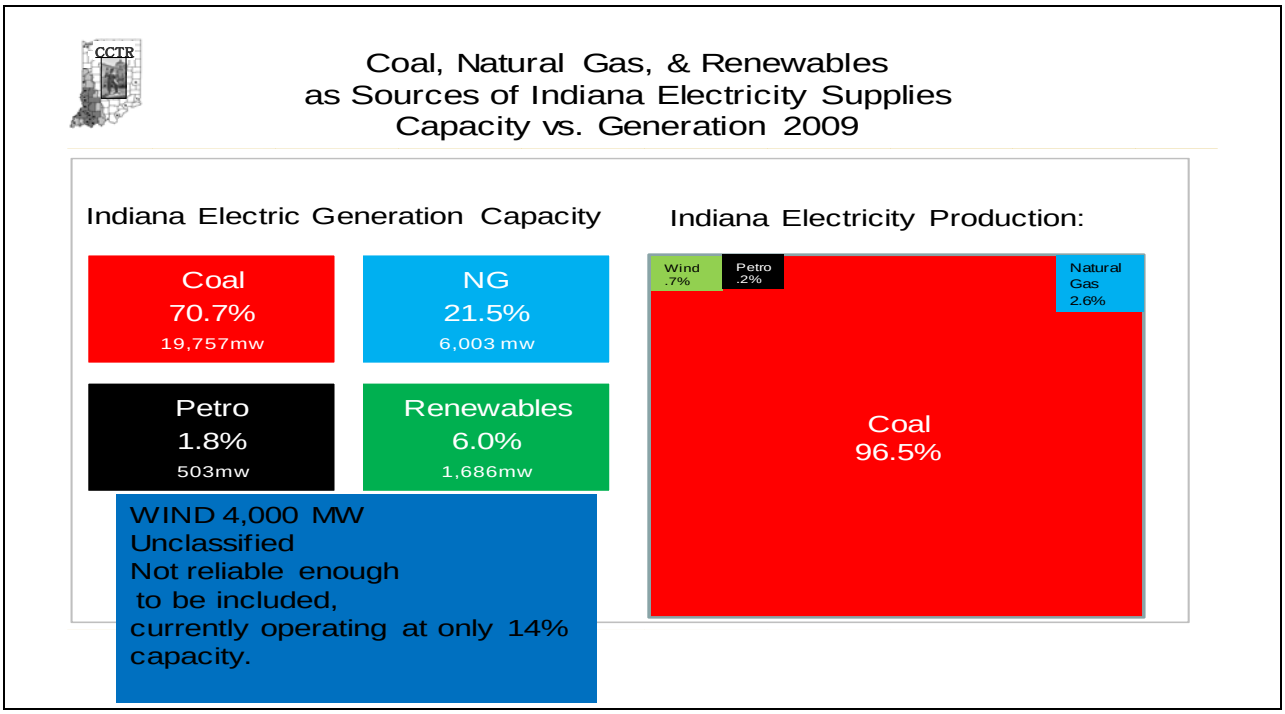
Currently, Indiana electric utilities "export" about 614 megawatts of base load coal-fired electricity capacity from of the State Line Energy LLC power plant to users in Chicago. This facility which has been operating for 80 years will close down due to the inability to meet the EPA emission standards. While the plant used all western coal, the impact will be the loss of 614 Mw of generation power and no short term means of replacing it. This plant was the equivalent of about 2 million tons of coal exported "by wire," i.e., Indiana coal's energy sent to another state in the form of electricity generated by coal-fired plants in Indiana. (**SUFG**) Most of this is generated using western coal. In addition, IKE's Clifty Creek's, a 1,300 megawatts coal fired power plant located in Indiana, sends almost its entire capacity is sent to the owners, a consortium of Ohio utilities. 99.9% of the coal used in this plant is brought in from Wyoming and the eastern coal regions via river barge. I & M's 2600 Mw Rockport facility and 1101 Mw Tanners Creek plant receive almost all of their coal via Ohio River barge. Tanners Creek will most likely shut down one-half of its capacity due the inability to recover the cost of adding advanced environmental controls. Rockport may temporarily mothball 1300 Mw of capacity and add scrubbers to the other 1300 Mw unit. This would make Indiana coal a viable option and could add an additional 11 million tons of Indiana coal exported by wire.

One needs to consider how the grid system works. Currently excess power is moved on to the grid in a least cost method. One utility that has excess capacity can offer to put it onto the grid if another company determines that it is cheaper to purchase this excess power than it is to produce its own. This method allows for production of low cost power through shared excess capacity. This could work in Indiana's favor.

If Indiana utilities can get their scrubbers up and running first it offers a great advantage over utilities in other states. The other states that use coal to produce electricity are under the same EPA rules as is Indiana. Those utilities in other states will also need to shut down certain power plants in order to meet the EPA requirements. Indiana power plants could be in a position to supply these other states with electric power during the time they have shut down their own coal fired units and before the new technology is added. The use of a least emission dispatch will enable the increased use of the Indiana plants and at the same time charge out of state user some of the cost of the plants reconstruction.

4) Indiana Coal as a Feedstock for Substitute Natural Gas and Petroleum (Coal by Pipeline)
(For an examination of Indiana's historic role as a coal oil and gas producer see appendix A)
The ability of to generate power is different from the production of power. The mix of generation capacity is currently used on a least cost dispatch. Utilities dispatch the lower cost coal fired boilers first, and keep the gas turbines on reserve for use during peak demand periods. A 2009 **SUFG** study indicates that Indiana power plants have a combined 6,000 Mw of gas turbine capacity. (**Figure 4**) Gas turbines represent nearly 25% of the total capacity of the state to produce power, but account for only 3% of the actual power produced. Gas turbines are used to meet the peak demands of electric power primarily during the hottest part of the summer and the coldest parts of the winter.

Figure 4



Perhaps one of the most significant risk factors will be taking the existing units out for maintenance to install the needed compliance equipment. Given the tight window for compliance, much of the capacity on the MISO system will need to take their maintenance outages concurrently. The need to take

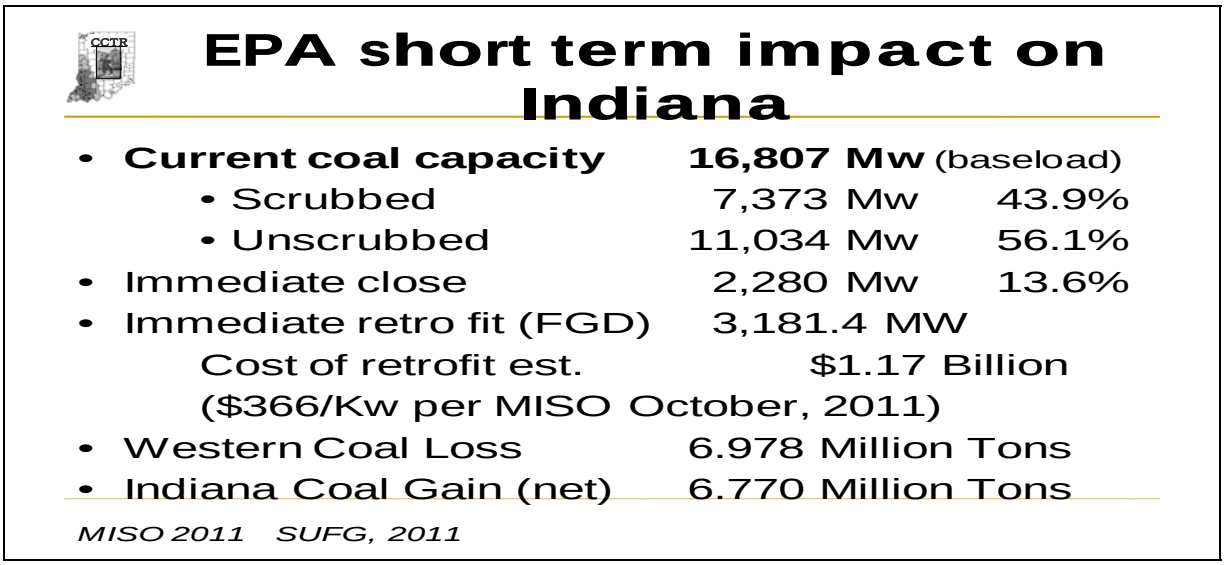
multiple units out of service on extended outage has significant potential to impact resource adequacy, ***MISO*****, 2011.**

The Midwest Independent System Operators (MISO) determined that the new environmental rules will force the shutting down and mothballing a great deal of older coal fired power. (**Figure 5**) In the short run this will mean that the gas turbines will be needed to offset this loss of this base load capacity. (*EPA Impact Analysis, MISO, October 2011).* But the obvious question is "**what will be the source of the natural gas that will be used in these turbines.**"

It will take an increase equal to 25% of total natural gas now consumed in the state for the gas turbines already in place to offset the loss of coal capacity. There currently exists no source of natural gas capable of meeting this vast increase in demand. (**Figure 6**) Note this same situation will be faced by Illinois, Kentucky, Ohio, Missouri and most states where coal is the primary source of electric power. (**CCTR**)

Shale gas is expected to account for 45% of the gas the USA consumes in the future. (**Figure 7**) Reviews of the current technology needed to extract gas from shale reserves will make the product more costly than conventional gas (IEA). This being the case, converting coal to syngas may have an excellent opportunity to meet the greatly increased new demand for natural gas.

Figure 5



Natural gas prices are at near record lows. It would be a very costly mistake to believe that these low cost will remain if the future depends on increasing the use of natural gas.

Figure 6

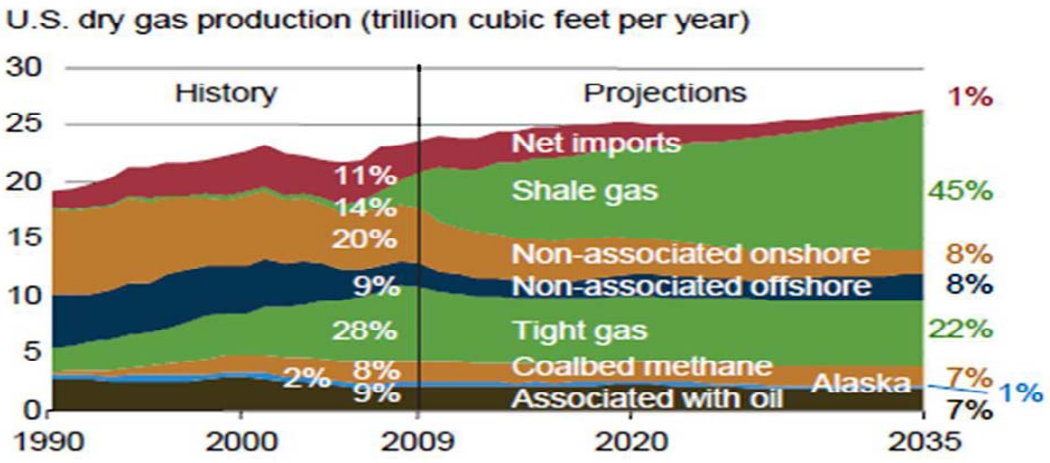
Natural gas is the answer!
(Wanna Bet)

- Gas Turbine capacity in Indiana 6,003 Mw
- Gas Turbine generation 3.1% (3.7 Billion KWH) need to generate 14.4 Billion KWH.
- Natural gas can replace the 2,280 MW of Coal capacity lost, with 1800 MW of turbines used as baseload, But:
- 1) Natural Gas is 2X the cost of coal
- 2) We have reduced our ability to meet peak demand by 30%
- Cost of electricity goes up by 7 % across the board (this is in addition to the cost increase from adding scrubbers).
- We need to bring **in 25% MORE NG** than is consumed in the entire state today
  - There currently exist no source of NG that can produce that much additional supply plus what the other states that are doing the same will need.
- Blackouts during Summer and Winter peaks are no longer a possibility, they are an absolute certainty, not IF, it is how often and for how long.

- 20% + 14%+7%=**41%** increase in rates possible in next next 8 years

Figure 7

US Sources Of NATURAL GAS



3.5 Times as much gas from shale in next 20 years.
33% reduction "Standard" sources

Posted on Sun, Jan. 22, 2012 08:03 PM
Surplus of natural gas causes producers to scale back
By STEVE EVERLY
The Kansas City Star
By STEVE EVERLY - The Kansas City Star
Updated: 2012-01-23T05:13:14Z
Natural gas companies have had it with low prices and are making plans to rein in production and tighten supplies. Companies have produced so much gas, mainly through the recovery methods known as "fracking," that there's a big surplus. Domestic gas production went up 7.4 percent last year. On top of that, this winter's moderate temperatures have cut demand, and wholesale natural gas prices have collapsed. The price of 1,000 cubic feet of gas, which averaged just more than $4 last year, plunged to $2.25 on Friday, its lowest since 2009. But what looks great for consumers can't be sustained by producers, and the plunge in price is sure to reinforce moves to scale back on gas production. Those efforts eventually should bring prices back up.

This will be the third winter for relatively stable gas bills, thanks to the ample supplies, and the Energy Information Administration now expects the average gas household to pay $730 for heat this winter, down from $778 in its previous forecast in October and about $90 less than last winter. The recent price collapse probably won't have much further effect on this winter's heating bills, because gas utilities had already bought most of their fuel for the winter. But the current glut will take time to work off and should keep prices from rising much while utilities buy fuel for next winter. The energy agency believes average natural gas prices this year could be lower than they were in 2011 before rising in 2013.

Efforts are afoot to keep such a big surplus from building up again. Production this year is expected to rise a more modest 2.2 percent and in 2013 by 1 percent. Much of that increase will be absorbed by utilities using more natural gas to generate electricity, allowing prices to go back up. "The market is sending a signal with the price that production can't continue to grow as it has," said Tancred Lidderdale, an analyst for the federal agency. The shift is apparent in plans by Chesapeake Energy, which has been in the vanguard of producing more natural gas through fracking – hydraulic fracturing technology that allows recovery of gas locked in underground rock formations. Chesapeake claims to have produced more than half the recent increases in U.S. gas supplies.

In plans sketched out to 2016, Chesapeake wants to increase its production by an additional 50 percent — but with drilling aimed more at crude oil and so-called natural gas liquids such as propane, which fetch higher prices. Natural gas production will stay flat as Chesapeake waits for supplies to catch up with demand and prices to increase. "The company that brought you the gas oversupply is now dedicated to increasing its liquid production," Aubrey McClendon, its chief executive officer, said in a recent teleconference with analysts.

Less than a decade ago, the U.S. natural gas industry was in decline, and billions of dollars were being poured into expensive facilities to import the fuel to meet demand. But plans call for those ports to be retrofitted to export gas because fracking has transformed the business. The technology, though dogged by questions about

its environmental and seismic effects, has left the country with more natural gas than it can use and questions about what to do with up to 100 years of reserves. This winter's collapse in natural gas prices has been a bonus for those able to take advantage of them. Kansas City, which has a fleet of natural gas cars and trucks, is now paying less than half the equivalent units of gasoline or diesel, said Sam Swearngin, the city's fleet administrator.

James Williams, an analyst for WTRG Economics, said he doesn't expect a return to the days when prices could occasionally spike above $10 per 1,000 cubic feet of gas. The average 2011 wholesale price for natural gas was $4.12, and by the end of this year or next we could see some spikes around $6, especially if there is a normal winter. **)**. *"**I expect prices to be higher**," he said.*
Note: 1000 cubic feet is 1,103,753 Btus, $6 per 1000 cubic feet is equal to $5.44/ million Btu's.

The U.S. currently enjoys the lowest natural gas prices of any industrialized country. But the retrofitting of ports would allow exporting as early as 2015, which could bring domestic prices more in line with world markets — higher and more volatile. But that in turn could damage efforts to increase U.S. demand, which have been gaining traction. The fuel's lower cost compared with gasoline and diesel, for example, has caused interest to soar in using more of the fuel in transportation. General Motors, for example, sells two vehicles that use natural gas and recently announced an agreement with a company to develop improved natural gas engines. ***are accounting for most of the increase in demand so far****. Ray Kowalik, president of the energy group at the engineering firm Burns & McDonnell, said natural gas prices* ***around $4.50 make them competitive with coal when building a new power plant. "There is no question that natural gas usage is on the way up," he said, and gas-fired plants are what utilities are building now.***

Coal to gas may be a needed option since the EPA has hinted that it may restrict the drilling for shale gas to areas where you do not have to drill through existing water tables, which would eliminate most of the area east of the Mississippi River from development. This, plus a recent media report suggesting that hydro-fracking in Pennsylvania and Ohio caused the earthquakes in Eastern Ohio (Christian Science Monitor, January 3, 2012) may make shale gas less of an option than anticipated by USDOE**.** The US Geological Survey is looking into this issue but has made no such claim to date. Remember correlation, not causality, is all that is needed for this EPA to start making rules. This claim could halt almost all of the new shale gas production. But if we are to use shale for oil or gas, we need to get it right the first time.

Coal to gas technology is such that modular sized plants can be placed at the power plant location to gasify the coal that was once delivered to fire the coal boilers. This use of existing infrastructure will reduce the cost of this conversion technology. The retention of energy capital as a result of this operation will be great. This will also enable the coal conversion operations to place excess gas into the natural gas pipeline network for delivery to users located in other places. Coal by pipeline will be a means of using Indiana coal in a very clean manner. Indiana's proximity to the nation gas pipeline network allows for the placement of syngas into the existing pipeline.

Indiana Gasification Inc. has submitted documentation to obtain an Air Permit for the proposed plant. The permit is currently set for public discussion in 2012. To put this in perspective the application for an air permit to convert coal to syngas is over 800 pages in length. There are no shortcuts in this process. But when completed this one plant can supply nearly 7% of the gas needed in the State of Indiana, and 28% of the immediate increase in natural gas needed to meet the new demand. All while using Home Grown Resources.

Coal conversion technology also has a significant opportunity unique to the Midwest. The process of gasifying coal requires a cleanup and enhancing of the raw syngas to make it pipeline quality. The gasification process also allows for the syngas to be converted to ammonia rather than natural gas. Ammonia is a very valuable commodity, currently trading at over $100/ton. Ammonia is used primarily in the production of fertilizers. Indiana imports most of the ammonia it uses for agricultural and industrial purposes. Coal gasification technology could convert large amounts of coal to ammonia at less cost than it takes to convert the coal to pipeline quality gas. This means that the profit margin be greater by not producing pipeline quality gas. Then if the ammonia market becomes saturated the same processing plant can switch to making pipeline gas. The ammonia that is currently being imported into the USA from offshore is produced from natural gas. Using Indiana coal to make ammonia would offset the need to import natural gas for fertilizer production and leave it available for direct power or home heating use.

5) Coal to Diesel/Jet fuel

Due to the particular characteristics of coal the conversion of coal to liquids yields a feedstock suited to the development of kerogen which can be further refined to diesel fuel and/or jet fuels. Currently there are 2 projects investigating the conversion of coal to liquid through a direct catalytic conversion technology.

US Dept. of Defense (DoD) has a mandate to purchase up to 10 million gallons of alternate fuel jet fuel. This project is housed primarily at the Wright Patterson Air Force Base in Dayton Ohio. The existing infrastructure makes the delivery of the fuel easy through train and eventually pipeline. Both of these projects also have had discussions with existing petroleum refineries to take the feedstock for refinement into needed products. While the market clearly exist, it is nearly impossible to build a coal to jet fuel facility based on it. DoD has legislative limits on long term contracting, and to use future sales as leverage for financing cannot be done on short term contracts.

6) Coal to Gasoline

There exists a technology to directly convert coal to methanol using a catalyst rather than gasification. This technology produces a feedstock that can then be converted to gasoline. Currently a company is considering a location in Sullivan County to develop this process. A plant capable of producing 10,000 barrels of petroleum a day is insignificant compared to the total amount of liquid fuels used in Indiana and the nation, but the local impact of adding 2 million tons of Indiana coal production will be a major plus to southwest Indiana's economy. This plant would offset of the need to import 10,000 barrels of petroleum a day, which is equal to adding $1 million dollars a day to the state's economy.

7) Wind/Coal Hybrid System

CCTR has expanded upon a 2009 SUFG study that details how coal in a gasification system, tied to existing gas turbines, allows for the now limited wind capacity of the state to be better utilized. 100 Mw of wind power blended with 50Mw of gas turbines would yield 60 Mw of constant power. Even if coal is used to produce the gas the CO2 emissions are 61% less than a similar sized pure pulverized coal plant. Supplementing the wind power to balance output would allow for more wind power to go onto the grid system. Locations of the proposed site are also discussed. Currently the best suited site would be using the Newport Munitions Depot and Cayuga Power Plant. Newport has the infrastructure in place to build the coal to gas plant. Cayuga has the gas turbine capacity and is the largest substation in the wind power region. Coordinating the system from this location would require a great deal of work but the outcome could be wind power being better utilized. (***Indiana Coal Report, CCTR 2009***)

Biomass/Coal Co-firing

There is continuing interest in the use of biomass for power generation. This is principally because, if the biomass is grown in a regenerative way, its combustion will not produce any net CO emissions. However, there are some disadvantages when using biomass for power generation which relate to its supply and composition, which can be reduced if the biomass is co-fired with coal. Typical biomass fuels for power generation include wood-based fuels such as wood chips, sawdust bark, tree trimmings, paper and cardboard; agricultural wastes such as straw, corn stover; sludge and municipal solid waste and energy crops specially grown for use as biofuels such as switch grass, eucalyptus, willow and poplar trees. (*Co-firing high ratios of biomass with coal by Rohan Fernando, IEA Clean Coal Centre, October 2011*)

Number 7 on the **Coal Technology Projects in Indiana** list below is one of blending biomass and coal in a pellet form to be used by utilities. The question would be will the pellet qualify for the Renewable Energy Voluntary Standards (Indiana Senate 251, 2011). This would not only reduce the emissions associated with direct coal firing but also help to reduce the need to landfill certain biomass waste and MSW.

8) Transportation issues

CCTR's sponsored study: A Prescriptive Analysis of the Indiana Coal Transportation Infrastructure ~ *Thomas F. Brady and Chad M. Pfitzer, Purdue University*, May 2007, reports where and how the Indiana rail system can be modified for more flexibility in coal movement. Key to its analysis is the

north south movement of coal. The report looks at current means of moving coal and the prospect of new means of doing so. The follow-up report, due out March 2012, will directly discuss how to modify the existing system to allow for Indiana coal to reach the Burns Harbor facility and thus be available for export to Europe. The report will also be handy in assessing the ability to move large quantities of coal into the potential Michigan market.

What is not discussed in this report but is under review is the enhancement of the CSX east west rout that parallels US 50 in southern Indiana. This route could also be used to Indiana coal to the east coast for export to the fast growing Europe market via the Virginia and Carolina ports. The study needs to be expanded to consider the movement of coal beyond Burns Harbor on to Michigan. Michigan represents a market that can develop very quickly and is easiest for Indiana to meet.

9) Shale Resources for Natural Gas and Oil

Indiana's shale resources are vast (**Figure 8**). Large enough to supply the entire nation with all of its energy needs for a full year. But that is a deceptive analysis. The resources, while vast, will be difficult to exploit. Indiana's New Albany shale has been analyzed and assessed by the Indiana Geological Survey many times in the past. In 1984, under the US Synthetic Fuels Corp. Indiana had secured funding for developing the resource. The project involved mining the shale where it outcrops in south central Indiana, retorting it to extract oil and gas, then replacing the remaining commodity back into the mine. Under this method the mass removed is only reduced by about 1%, therefore the materials returned to the ground nearly equal what is taken out. Soon after the announcement the Synthetic Fuel Corp. was disbanded, and this and all other pending projects were cancelled.

It appears as if mining of the shale may still be the best means of extracting its energy. The mining method requires much less water than the hydro-fracking process being done at Marcellus shale locations. Recent media reports suggest that hydro-fracking of shale may be the cause of the earthquakes in eastern Ohio. The US Geological Survey is conducting studies into the issue, but to date no clear causality between the two events has been made, just observation and speculation. Even so this is enough for the EPA to make a ruling to halt or slow the practice. In so much that shale is predicted to be a major source of natural gas in the very near future and the fact that natural gas will be needed in much greater amounts, this may lead to revisiting the method of extraction that was proposed for Indiana.

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Figure 8

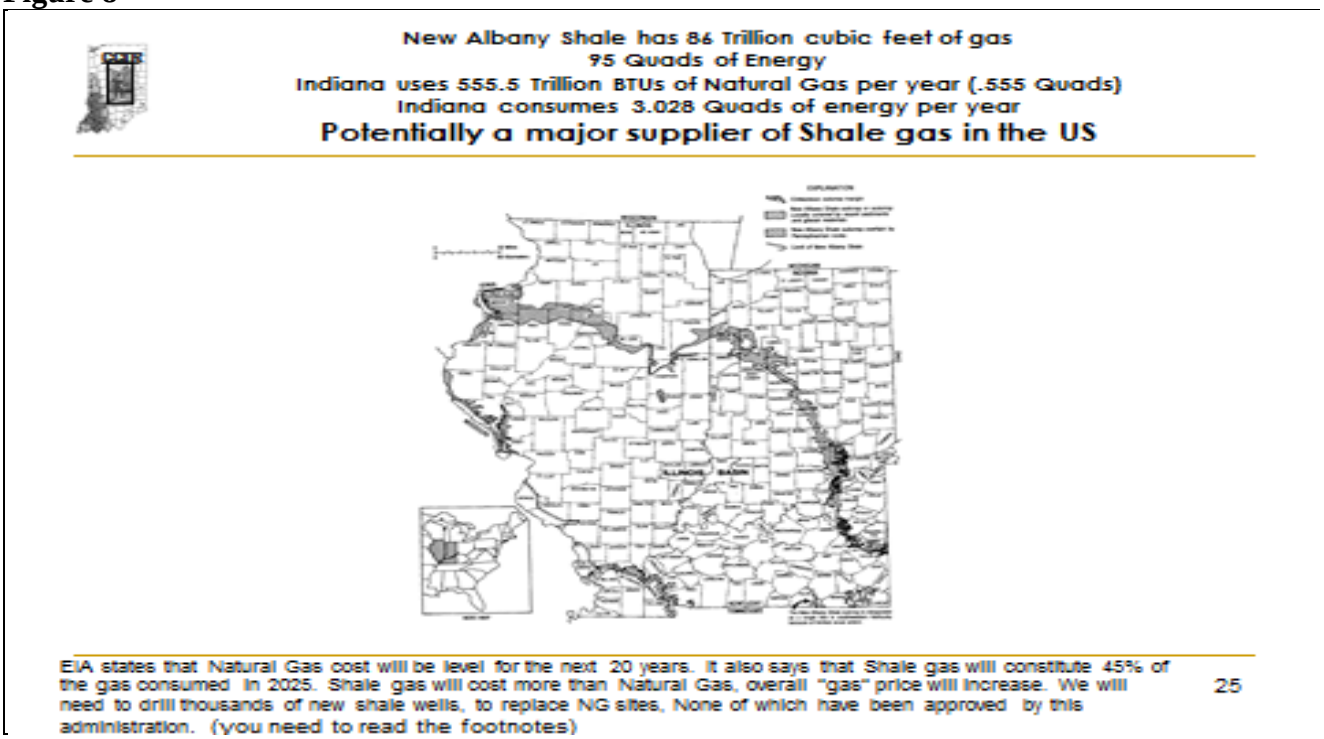
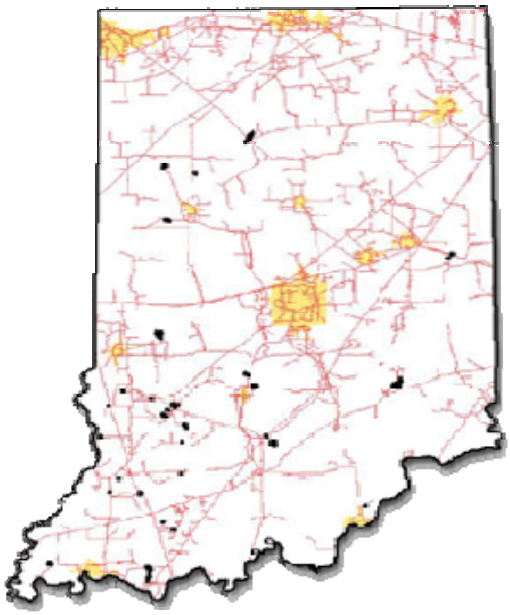
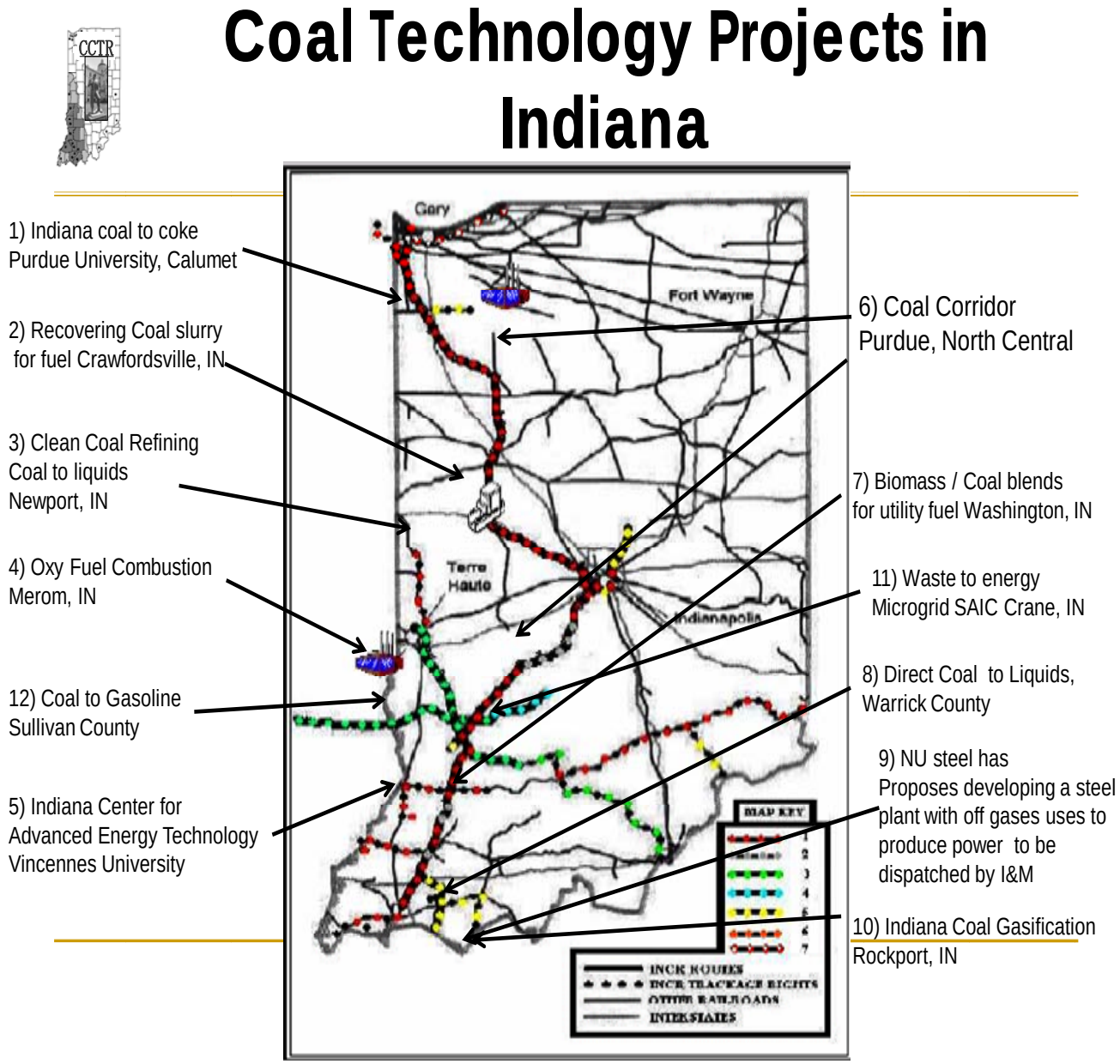


Figure 8A Gas and Oil Pipelines in Indiana, and major underground gas storage sites



Indiana Geologic Survey Copyright 2011

10) Coal Technology Projects in Indiana



1. Indiana Coal to Coke, Purdue Calumet, starting 3rd cycle of CCTR funding of the project, which is now in the small scale test mode and gathering Steel Industry support. If all goes well should have a full scale coking unit in 2-3 years. Potential of 6 million tons of Indiana coal a year.

2. FuelStreaming has purchased the Crawfordsville municipal power plant and will be upgrading the boilers to include a gasifier to burn a briquette created from the coal slurry and gob waste from an abandoned mine in southern Indiana, this has the potential of 1 million tons of recovered fuel a year. This group has the possibility of becoming fully

operational in 2 years. CCTR is working with the group to help with the technology to recover the coal slurry and convert it to a useful fuel

3. Clean Coal Refining will be taking 1500 acres from the Newport Munitions Depot to build a coal to liquids plant producing 22,000 barrels a day and consume 1.5 million tons of Indiana coal. The feasibility study is currently underway and due out in early 2012. This process will be able to use coal, MSW or petcoke as a feedstock. If funded the plant could be fully operational in 48 months. The process would benefit from a connection between Newport and the BP Refinery at Whiting. BP's petcoke can be cleanly converted to raw diesel fuel which BP could then take back as a feedstock.

4. OXY-Fuel Combustion technology is a technology studied at Purdue Lafayette by CCTR. This technology will use pure Oxygen instead of air in the coal combustion process. This will greatly reduce emissions could enable older smaller scale power units to keep producing power under the EPA rules. At issue is whether the EPA will allow an older plant to be retrofitted without adding scrubbers.

5. Indiana Center for Advanced Energy Technology (ICAET) will be based at Vincennes University and focus and apply the technologies developed by CCTR and others to retrofitting on existing power units. ICAET will work with the coal industry to develop and train the new wave of coal miner that will be needed especially as we move to more underground mining. The center is also working on a new technology that will use coal ash from power plants to build pillar systems in long wall deep mines in order to increase the coverable coal from 45% of the resource to up to 90% per mine. CCTR is working with ICAET to secure Federal funding.

6. Indiana Coal Corridor is an extension of the CCTR study on rail systems in Indiana mentioned above. CCTR is working with coal companies, power plants and rail system to find the least cost and best means of moving Indiana coal north to Schahfer power plant (potential 4 million tons per year) and on to Burns Harbor where it is estimated that Europe will need millions tons of coal a year and on to Michigan which currently imports 30 Million tons of coal, none from Indiana. This track will also connect to the proposed Illianna Express rail plan when and if Illinois ever gets around to building it (it was originally proposed in 1925). Our goal is to identify needs and begin construction if necessary in 12 months.

7. Biomass /Coal blends as power plant fuel will use the waste biomass, in this case primarily wood waste from the furniture industry to make a fuel for power plants. The advantage will be the use of the now wasted wood residue and to allow more use of older plant in that the new fuel will have a significant emission reduction. The company already has orders of 1.2 million tons of coal to be delivered over the next year. The group plans to ship the fuel to

Europe via Mt Vernon and out of New Orleans. The company sees a big potential for the fuel if it could be shipped out of Burns Harbor rather than New Orleans, thereby reducing the length of travel by 1800 miles.

8. Nu Steel is proposing a coal to liquids plant for Warrick County. The plant will use Indiana coal and produce 10,000 Barrels of crude a day from 4 million tons of coal a year. Nu Steel is currently reviewing the air permit requirement for the proposed plant

9. Rockport Power Plant is in need of extensive retrofitting for their power plants to meet new EPA standards. CCTR introduced to I&M the possibility of using a steel making operation which would produce 1200 MW of power for sell to I&M for distribution. The use of this method would be a less expensive way of producing the amount of power I&M needs without the emissions. This technology would use 6 million tons of coal and be built in a 48 month if I&M decides to proceed.

10. Indiana Gasification Inc. coal to gas plant has set up public meeting to discuss to hear the proposed Air Permit from IDEM in 2012.

11. SAIC and Crane Naval Surface Warfare facility has developed a microgrid a system to be used at front line military positions to convert bio waste to energy. This is designed to reduce the need to import diesel fuel for the production of power. This system a great potential to combine landfill municipal waste to syngas for the purpose of enhancing the power production of municipal power plants. Injection syngas will increase the plants efficient and reduce the emissions from these small plants allowing them to stay open and continue their use Indiana coal.

12. A Texas/Pennsylvania company has approached an Indiana coal mining interest to consider locating a coal to gasoline facility in Sullivan County. It is an option to look into the reuse of the abandoned Breed Power plant area west of Sullivan Indiana. CCTR is working closely with this group as it moves through the process. Decisions will be made some time in 2013.

11) Recommendations / Conclusion

A) The Indiana State Legislature in 2011 passed Senate 251 which helps in the pursuit of Homegrown Energy.

The section summarized below may be a key component to the cause. The State allows a utility to more quickly recover the cost of federally mandated environmental equipment. The question is how aggressive this mandated recovery can be. If Indiana is to benefit from this round of devastating, and environmentally worthless rule making, then the utilities need to be able to move quickly to get in line to build these new scrubbers. The first ones built will become the baseload units for the region.

DIGEST OF SB 251 ***(Updated April 26, 2011 4:03 pm - DI 84)***

Clean energy defines a "compliance project" as a project undertaken by an energy utility to comply with certain specified federally mandated requirements. S521 requires an energy utility that seeks to recover federally mandated costs incurred in connection with a compliance project to apply to the utility regulatory commission (IURC) for a certificate of public convenience and necessity for the compliance project.

S521 sets forth certain factors that the IURC must consider in determining whether to grant a certificate. Specifies that if the IURC approves a proposed compliance project and the projected federally mandated costs associated with the project, the following apply:
(1) 80% of the approved costs shall be recovered by the energy utility through a periodic retail rate adjustment mechanism.
(2) 20% of the approved costs shall be deferred and recovered by the energy utility as part of the next general rate case filed by the energy utility with the IURC.
(3) Actual costs exceeding the projected federally mandated costs of the approved compliance project by more than 25% shall require specific justification and approval before being authorized in the energy utility's next general rate case.

B) Indiana needs to establish the Clean Coal Development Fund

The law establishing the CCTR provided for the funding of coal research through voluntary contributions, no state funding was provided or has ever been received. This method has been sufficient for the operation of the group but is not capable of providing the funding necessary to push the technologies from the paper studies to steel in the ground. Indiana has funded advanced technology development groups in the past. 21st Century Fund is a good example of state funds used to take technology from the drawing board to actual buildings. Coal technology has the benefit of being a faster development and creating a real center of excellence in the State. The number of jobs created by one coal conversion plant would exceed the total number of jobs created by all 21st Century Fund projects funded in the last 3 years.

The 21st Century Fund, in its 2010-2011 annual report to the State Legislature, states that it invested on average $723,000 per award which resulted in a 4-1 leverage. The report states that 11,000 jobs have been created by the efforts of the fund, generating $427 million in state GDP. This comes out to $39,000 of GDP per job. A coal conversion plant itself does not employ a large number of people. But, the coal needed for the plant is a great job creator. A single coal conversion plant can use 2 million tons of coal, adds on average 160 high paying jobs and over 400 support jobs and adding $130,000 per job to the local economy. A single $1 million feasibility study can result in a $4billion facility being located in a community. The payback is almost immediate.

The problem is that these projects are very expensive. For example the application for an IDEM Air Permit for a gasification project to be located in southern Indiana exceeds 800 pages. There is a real

benefit to having a fund administered by the State to aid in the Pre FEED and feasibility studies for these projects.

C) Right-of Way & Eminent Domain

A resource available to the State will go a long way to speeding up the permit process and reducing the cost of development is the use of existing right-of-ways for power lines and pipe lines. This is also true of rail line rehabilitation. Dual use of right-of-way cuts greatly in to the time needed to create paths for connecting energy facilities to their appropriate marketplace. An example could be the use of the I69 Right-of-Way for a CO_2 pipeline. By placing the CO_2 pipe down the middle of the I69 Right-of–Way the State will to be ready to build the line once one is needed. I69 and the other interstates and State highways access all parts of the state. This reduces the disruption of current land use and makes planning and mapping more convenient.

D) Infrastructure Improvement

Barge / Rail / Pipeline / Transmission lines

The deterioration of the nation's infrastructure has been discussed in the media and at town halls across the country. Key to the development the energy network is the ability to move massive amounts of coal, gas, and petroleum. As an unintended consequence to the idea is that damage it would do to the state and nations highway system. To improve efficiency and protect the existing road system Indiana must reassert itself as the Cross Roads of America again. Only this time the Cross Roads will be improved Barge / Rail / Pipeline / and Electric Transmission lines.

Barge:

1 barge = 15 Rail Car= 80 Trucks (INDOT)

The more we can move coal and aggregate by barge, the more trucks we can get off of the roads in Indiana and the Midwest. As stated above there is a great deal of coal market potential from power plants that are closed to rail lines and those rail lines can interconnect with the barge system for accessing certain plants along the Ohio River and Michigan plants located along the Great Lakes. A full assessment is needed of the 3 main Ohio River ports (Mt. Vernon, Jeffersonville, and MAT) to see where coal could most easily be uploaded or off loaded. There is a study being conducted to see how Burns Harbor can be used not only to access European Markets but the site could also be used barge coal to the Wisconsin and Michigan coal fired plants located along the shores of Lake Michigan Superior and Huron from a rail terminal at Burns Harbor.

Rail:

The study cited above identifies certain improvements that may aid in the increased use of rail to deliver coal. A single power plant does not have the energy demand significant enough to warrant modification of a rail system. But, improved access to Michigan and Burns Harbor may afford the state the ability to increase exports. Beyond the North/South issues there is a great deal of opportunity in the assessment of the east bound CSX rail line that parallels US 50. This gives access to the east

coast and the ports thereof. INDOT's recent rail plan is a good place to detail the future needs and benefits of advanced rail work.

Pipeline:

Pipelines are a very efficient means of moving commodities. The existing network will allow the movement of coal in the form of synthetic gas or petroleum products to the market. Key to this will be the dual use of existing Right-of-Ways.

Indiana is truly the Crossroads of America when it comes to the existing pipeline infrastructure. Most of the natural gas pipelines originating in the Gulf region and terminating in Northeast USA cross Indiana. This has both a positive and a negative connotation. Negative in that since most of the gas consumption terminates in the Northeast USA, Indiana is therefore the recipient of rather than the originator of price for the commodity. This means that Indiana is subject to the price negotiated at both ends of the piper rather than the needs of those located in the middle.

Positive in that recently Enterprise Pipeline decided to reverse the direction of the flow of an existing gas pipeline to facilitate shale oil originating in Pennsylvania and ending in Missouri. This is extremely important to Indiana since the pipeline crosses southern Indiana at the point where a shale to gas and oil retorting plant was once proposed to be located. This is instant access to the market for this commodity. The pipelines are here, we need to use them better.

Every barrel of oil moved by a pipe is a barrel of oil not moved by truck on the roads. One way to reduce the cost of the rehabilitating of the nations existing infrastructure would be to move commodities to the most efficient mover: rail rather than truck, barge rather than rail, pipe rather than barge. Maximizing the efficiency of movement of materials only reduces the cost of the goods.

Transmission Line:

Moving coal by wire means you must first convert the coal to electricity. It also means being able to put the power on a grid that can move the power to where it is demanded. The same is true for wind power. Indiana and the Midwest need to expand and improve the transmission grid that allows for the easy flow of power from producers to consumers. This means that power line improvements must be discussed and paid for on a regional not a state basis. This is contrary to local law that states that persons in the service district must pay for the improvements to the service in that district. This means that if an east / west power line cross the state, the locals must pay for it even if the locals have no access to it. Transmission lines are like the highway system. It serves all and a payment system needs to be regional if not national in nature.

Boiler By-Pass

EPA is putting ever tighter restrictions on the use of coal fired boilers with and without scrubbers systems. One area that may avail itself to Indiana is the idea of by-passing the coal fired boiler all

together. Using gasifiers or pyrolysis methods one can convert the coal or biomass into a gas and fire it directly into the turbine system. Likewise you can convert the coal or biomass to gas and produce steam to go directly into the steam turbines. In the second case the biomass coal conversion system can be nearby but not necessarily on site of the power plant.

If the problem is the coal fired boiler then eliminate the problem but don't negate the fact that there is still millions of dollars worth of power production equipment on site beside the boiler. This of course brings in a major logistical issue of when where and how to convert the coal and or biomass but it would be less costly than scrapping the whole unit for something new.

This also brings into question the whole idea of Brownfield use. There is very little possibility to reuse a coal fired power plant site for anything other than industry unless millions are spent for land clean-up. The best use for a brown site is to use it as a brown site, keep the industrial aspect going under new regulations. This will negate the nearly impossible task of trying to locate another power plant on a new site.

CONCLUSION:

Indiana's economic recovery is still based on manufacturing, and manufacturing is based on low cost readily available energy. Indiana can use its natural resources as an economic development tool by first reducing the flow of money out of state and oversea to energy suppliers and retain more of the energy capital we expend. We can grow the economy of the state while supporting the vital manufacturing sector in its recovery.

Indiana can become the supplier of power to the region if we are faster at developing the resources we have. This is a viable option, but we need to act.

Abbreviations:

CCTR: Center for Coal Technology Research, Indiana Office of Lt. Governor, Purdue University, selected material from over 80 reports and presentations produced by CCTR.

EIA: US DOE Energy Information Agency

EXP: Expanding the Utilization of Indiana Coals, 2008, some data revised by CCTR, 2011

HHE: Hoosier Homegrown Energy, Indiana's Strategic Energy Plan, 2006, with updated data added by CCTR in 2011

IMF: International Monetary Fund

INDOT: Indiana Department of Transportation

MISO: Midwest Independent System Operators

SUFG: State Utility Forecasting Group, Purdue University

Appendix A

Oil & Gas - A Brief Overview of the History of the Petroleum Industry in Indiana

Trenton Field

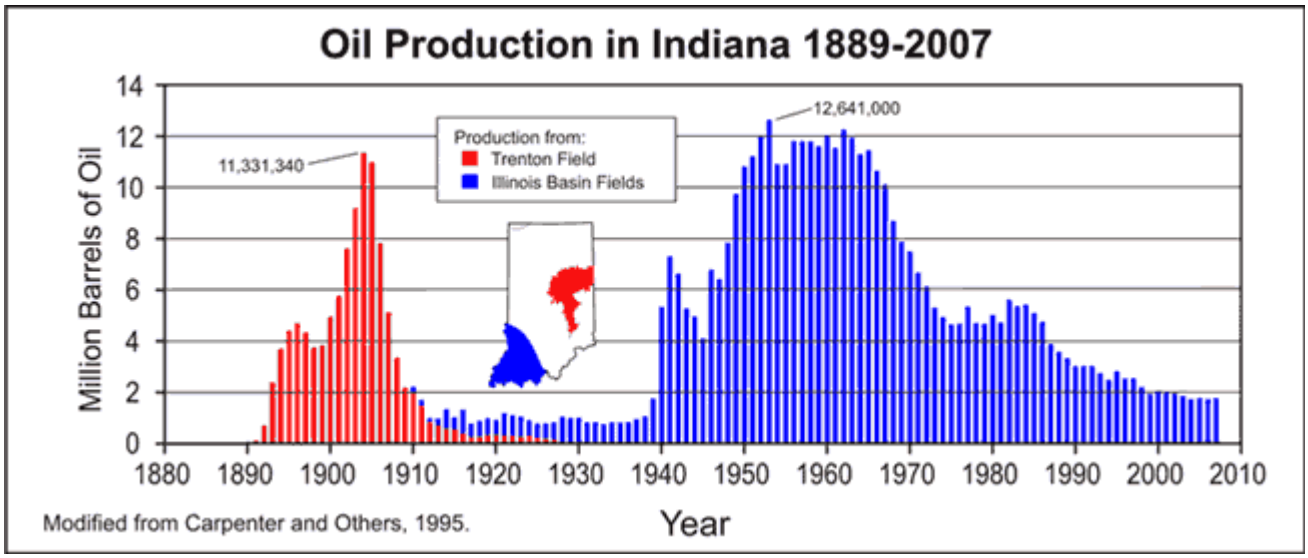
The history of oil and gas development in the state of Indiana officially began in the mid-1800s with the early settlers' practice of drilling for salt water. Salt was a necessity for the preservation of foodstuffs and critical to the early state's agricultural industry; shallow wells were sunk in many parts of the state to obtain salt water that could be evaporated to produce salt. Drilling was probably accomplished by using a "spring pole" method. Early settlers also became aware of gas springs and oil seeps along the Ohio River in Harrison and Crawford Counties.

Following the news of the success of Colonel Edmond Drake's oil well in Titusville, Pennsylvania in 1859, oil exploration moved westward into Ohio and Indiana. Between 1862 and 1869, wells were drilled in Pulaski County and Vigo County and gas and oil were discovered but not further developed. Gas was discovered in what would become the Trenton Field near Eaton in Delaware County in 1876. Beginning in 1886 and continuing into the first decade of the 20th century, gas and then oil were discovered and developed in east central Indiana. A wild untethered boom ensued that ultimately resulted in thousands of wells being drilled; this was America's first giant oil field (greater than 100 million barrels of oil). The gas was used to attract and then fuel numerous industries in the region. In fact, the existence of Muncie, Anderson, Marion, and Kokomo as manufacturing centers can be directly attributed to the development of the Trenton Field. In addition to these industrial complexes, the oil boom led to the development of refining and petrochemical industries in the Calumet region. The boom quickly ended in the beginning of the 20th century because wasted resources and unregulated drilling practices caused a precipitous drop in production. Unfortunately much of the resource was wasted or lost through the burning of gas at the surface and the contamination of oil by fresh water within the subsurface reservoir.

Southwestern Indiana

As gas and oil production quickly declined in northern Indiana, new discoveries were being made in the southwestern part of the state known as the Illinois Basin. Production from fields in Vigo and Pike Counties was rapidly followed by new discoveries in Sullivan and Gibson Counties. Unlike the single field of northern Indiana that produced from a single reservoir, these new discoveries produced from many smaller fields and a variety of different reservoirs at different depths. Also, unlike the Trenton Field, the Illinois Basin fields produced mostly oil, not gas. Soon all the counties located in the

southwestern part of the state were contributing to oil production. Production peaked in 1956 at over 12 million barrels for the year. Since that time both the number of holes drilled and the production for the state has declined.



Current Activity and Future Prospects

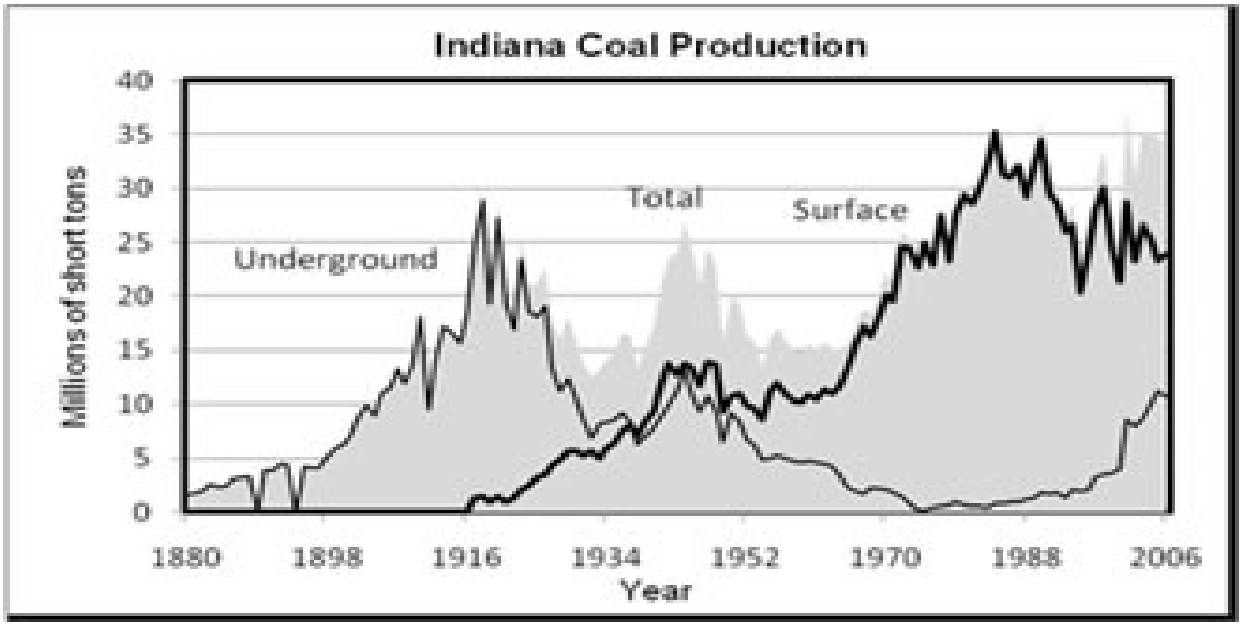
Since the early 1960s, the amount of oil produced in Indiana has declined. Close examination of this decline reveals that changes in the price of oil are directly related to the number of wells drilled and consequently, the volume of oil produced. For instance, the reversal of the steep decline in the 1960s and 70s can be attributed to increased drilling in response to the energy crisis of 1973 and Iranian crisis of 1979. After 1986 a steep declined resumed, resulting from a dramatic lowering in the price of crude oil. In this same time frame, the number of holes drilled within the state declined from more than 1,200 per year in the early 1980s to around 200 per year by 1997. While most new holes are drilled as development wells in existing fields, a low level of "wildcat" exploration still takes place within the state. With oil prices approaching $100 per barrel in 2007, exploration for new reserves has resulted in an increase in the number of holes drilled.

The current hot play is the New Albany Shale gas play which is utilizing state of the art completion technologies to access and produce natural gas from this unconventional reservoir. Renewed interest in the New Albany began in the mid-1990s and related drilling has accounted for nearly 500 wells since that time. Initially focused in Harrison County, where New Albany gas production was discovered in the late 1800s, successful exploration has more recently expanded to several other counties in southwest Indiana. Although wells with initial production test rates (IPs) typically range from 20-400 MCFPD (thousand cubic feet gas per day), some wells northern Daviess and in southern Sullivan Counties are rumored to have tested more than 1 MMCF (1 million cubic feet of gas per day). Many of the New Albany wells are being drilled with one or more horizontal boreholes that extend outward from the surface drill-site over a distance of one-half mile to nearly a mile. In Harrison County, the New Albany occurs at depths ranging from 500-1200 ft.; in some of the newly-drilled areas the New Albany is encountered at greater depths, around 2,000 ft. in Daviess County, for example. Additionally there is significant interest and development work ongoing in the coal measures of the southwestern part of the state. Here shallow drilling is tapping unconventional gas known as “coal bed methane” or CBM.

There is a fair potential for the discovery of significant new reserves in the state. Much of the state has been thoroughly drilled; however, this drilling reached only the first few thousand feet of depth. A considerable portion of the subsurface remains unexplored, and many thousands of feet of potential reservoir exist, especially in the southern portion of the state. Although the deep subsurface geology of this region is thought to be similar to northern areas of the state, details of thermal maturity, migration pathways, and trapping mechanisms are unknown. In addition to untested geology, the application of new technologies to explore for and produce oil and gas could hold the key to unlocking some of Indiana's resource potential. These new technologies, some of which are being used in the development of the New Albany Shale as an unconventional gas source, include the application of advanced seismic acquisition and processing techniques, new drilling technologies including horizontal drilling, and complex completion techniques such as CO2 stimulation.

Contact the Publication Sales Office of the Indiana Geological Survey (IGSinfo@indiana.edu, 812-855-7636) and the geological surveys of surrounding states for information about publications. Numerous national and international trade journals and technical publications describe contemporary aspects of the industry as well as the economic and technical factors that affect it. Some of these include: Oil and Gas Journal (Pennwell Pub.); World Oil (Gulf Pub.); Petroleum Independent (Independent Petroleum Association of America); Proceedings of the Society of Petroleum Engineers; and the Bulletin of the American Association of Petroleum Geologists.

Coal in Indiana



Indiana coal production averages nearly 35 million short tons per year (1 short ton = 2,000 pounds). In recent years there has been a resurgence of underground mining as the easily strippable reserves are depleted.

The Indiana Coal Industry

Bituminous coal has become one of Indiana's most valuable natural resources since its discovery along the banks of the Wabash River in 1736. Organized development of Indiana's coal resources began in the 1830s and by 1918, production exceeded 30 million short tons. Coal production declined

following World War I, but underground (deep) mining remained the primary mining method in Indiana until the 1940s. Following World War II, the advent of large-scale excavation equipment made surface mining more cost efficient and by 1965, surface mining accounted for more than 80 percent of the state's annual production. Surface mining continues to be the primary method of coal removal in Indiana, with nearly 70 percent of the current production coming from surface mines.

Indiana Coal Reserves

Indiana has approximately 57 billion tons of unmined coal, of which nearly 17 billion tons is recoverable using current technology. Of the mineable reserves, about 88 percent is recoverable by underground mining and only 12 percent is recoverable using surface mining methods. Based on current production rates, Indiana's 17 billion tons of available coal could last more than 500 years.

Indiana Geological Survey

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