Clean Heat and Power Market Assessment for the Mining Industry in Arkansas

Prepared by the North Carolina Solar Center at North Carolina State University and Mississippi State University

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Executive Summary

In the beginning of 2008, the Southeast CHP Regional Application Center commenced work pertaining to Clean Heat and Power (CHP) and the Industries of the Future as designated by the United States Department of Energy (DOE). This report describes the mining industry and its potential for fostering CHP development.

Clean heat and power (CHP) is an effective way to increase energy efficiency and reduce polluting emissions. CHP applications may reduce consumer costs and provide reliable heat and power to a facility. Favorable scenarios for CHP applications exist near well matched thermal and electrical loads or in industries with access to an abundant fuel source. If a facility uses substantial amounts of both heat and electricity, there is a possibility of implementing CHP.

In the state of Arkansas, over 300 mining and refining companies produce approximately $940 million dollars in mined product annually.

Nationwide, the mining industry consumes over 291 trillion btus of energy/yr. The fact that the mining industry is regarded as an energy-intensive industry has prompted a market assessment of CHP in the Arkansas mining industry.

While the mining industry initially seems to be a poor fit for CHP because of its high reliance on diesel fuel and lack of need for recycled heat, there still exists potential for CHP systems that will utilize opportunity fuels to produce electricity for nearby facilities as well as the specific refining facilities themselves. This assessment attempts to evaluate opportunities for CHP in unexplored areas that may serve to lower costs and/or increase energy efficiency for the mining industry in the state of Arkansas.

What is Clean Heat and Power?

Conventional electricity production, as it exists today in the United States, is only about 33% efficient[1]. The waste of approximately two-thirds of internal energy from a fuel is generally accounted for by thermal losses resulting from the thermodynamic cycle used in standard electricity production and losses in the transmission and distribution system. Clean heat and power (CHP) systems capture and utilize these heat losses by applying thermal energy to existing needs.

CHP is an integrated energy system located at or near a facility to provide at least a portion of the electrical or mechanical load while recycling the waste heat from the power application to provide heating, process steam, cooling, and/or dehumidification or the production of electrical power[1].

Common thermal loads for CHP applications can be cooling, heating, humidity control systems, steam production, and hot water production. CHP can also utilize opportunity fuels such as landfill gas, biomass, and digester gas[2,3].

By capturing waste heat, CHP systems, if effectively integrated, can reach up to or greater than 80% efficiency[4]. An illustrative example of CHP system efficiency can be seen in Figure 1: CHP Efficiency. Additionally CHP includes the added benefit of power availability and reliability. CHP also alleviates grid overcrowding and costs associated with distribution[5]. If a utility outage occurs, a CHP system can maintain operation and lessen the effect of the outage on a facility[6]. Certain facilities have a requirement for constant, uninterruptable steam and power. An example of such a facility is the Bristol-Myers Squibb facility in Wallingford, Connecticut. The requirement for a closely monitored working environment led Bristol-Myers to install a CHP system which provides 4.8 Megawatts (MW) of generating capacity[7].

One report estimates that power interruptions cost industries $80 billion dollars annually in the United States. The commercial and industrial sectors incur the largest costs associated with power outages. It was also shown that "momentary interruptions," those lasting less than five minutes were more expensive than "sustained interruptions[8]." CHP installations can reduce the effects of power outages in industrial manufacturing settings. When interconnected with the utility grid, during an outage, power can be obtained from the CHP system without costly interruption.

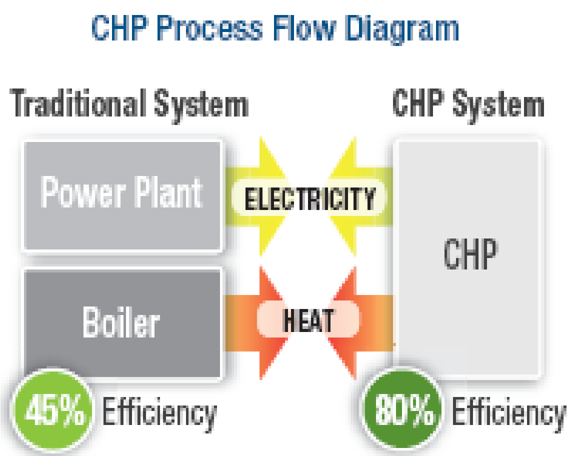


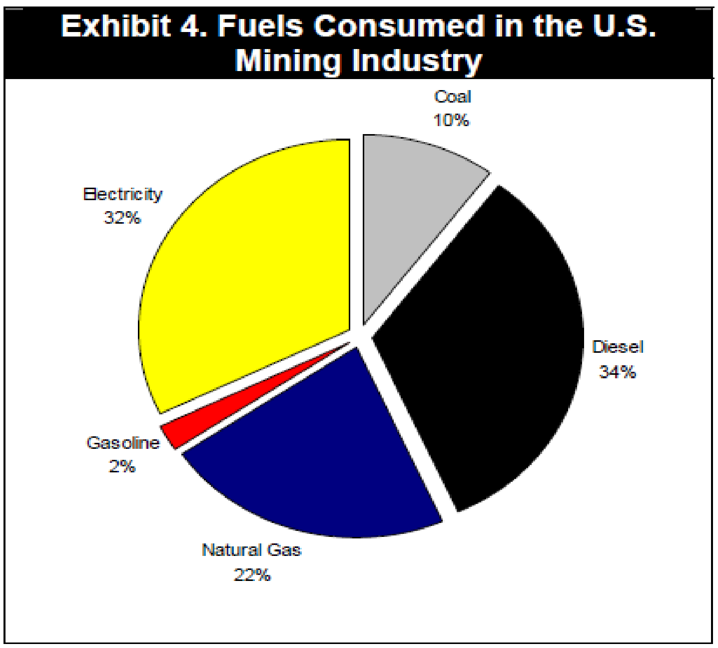
Figure 1: CHP Efficiency

A CHP system also includes the benefits of reduced emissions due to increased system efficiency. If the potential for CHP in the United States was met, approximately 130GW, the carbon equivalent emissions would shrink by 70 million metric tons[6].

Common thermal loads for CHP applications can be cooling, heating, humidity control systems, steam production, and hot water production. CHP can also utilize a variety of opportunity fuels such as landfill gas (LFG), tire-derived fuel (TDF), wood and wood waste, biomass, and digester gas[9,10].

Mining Industry Divisions

The mining industry can be broken down into three separate segments which include mineral extraction, materials handling and transportation. The mining industry consumes energy from many different sources, approximately one-third of which is purchased electricity.[11]



(Energy and Environmental Profile of the U.S. Mining Industry: Mining Overview. Dec. 2002.)

Extraction

There are different extraction techniques applied for surface and underground mining. Surface mining accounts for the majority of all mining in the United States with underground or shaft mining accounting for the rest. Underground mining consumes much more energy than traditional surface mining as there is a greater need for ventilation and water pumping.

Exhibit 6. Underground and Surface Mining in the United States			
	Million Tons Of Material Mined	% Produced in Surface Mines	% Produced in Underground Mines
Coal	1,309	65%	35%
Metals	1,613	92%	8%
Industrial Minerals	3,556	96%	4%

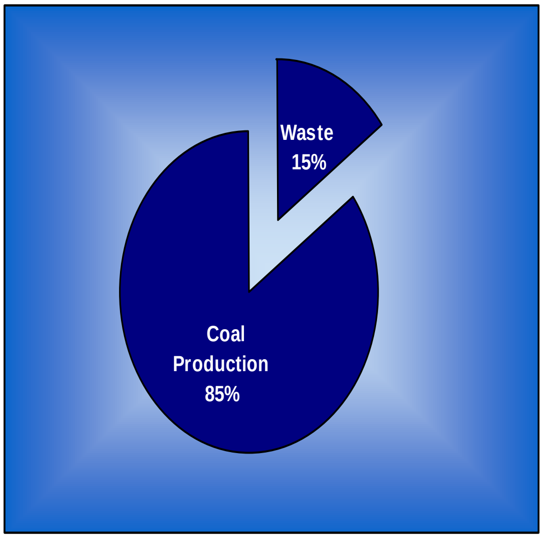
(Energy and Environmental Profile of the U.S. Mining Industry: Mining Overview. Dec. 2002.)

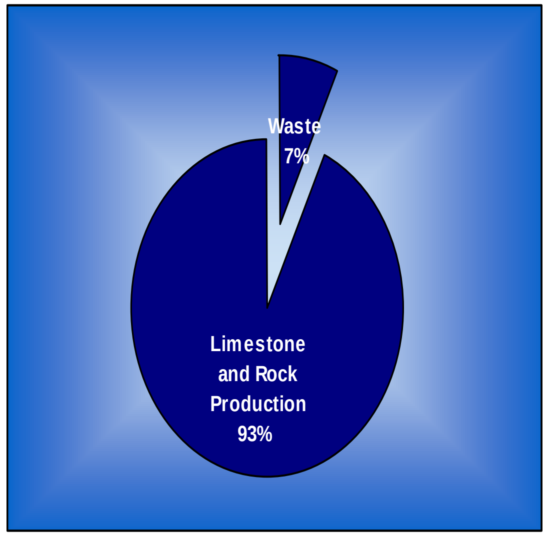
Extraction begins with drilling a hole into the area to be mined for exploration, blasting or tunneling purposes. Drills are powered by electricity, diesel power and/or indirectly from compressed air. Explosives are then used to aid in the extraction or removal of the ore. The energy consumed by the explosives is completely derived from the chemical agents used in the blasting process and not from resources such as electricity or diesel fuel; however, making this process more efficient will have a direct effect on the energy consumption of the downstream processes. Digging equipment is then used to remove valuable materials from the site. Digging equipment consists of items such as hydraulic and cable shovels, as well as continuous and longwall mining machines.

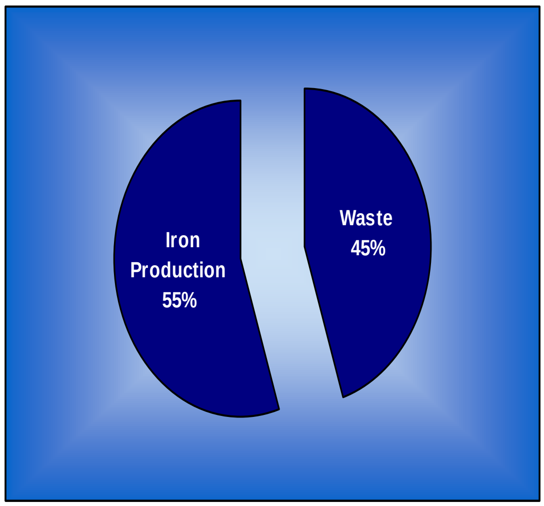
Ventilation is the process of replacing the stale or contaminated air in underground mines with fresh air. This serves not only to provide breathable air but also to cool work areas in the deeper sections of the mine. A system of fans is used for these purposes. Finally, dewatering is the process of removing water from the mine work area. Typical pumping systems use the largest portion of the energy consumed in the extraction process.

Materials Handling

Materials handling refers to "ore and waste that are generated in the mining and beneficiation process."[12] Materials handling processes and equipment primarily utilize diesel fuel equipment, in the transportation of materials, such as bulldozers, front-end loaders and dump trucks. Certain electrical equipment, such as conveyor belt systems and pipelines comprise 20% of the materials handling costs for coal.[13] In the charts below, the relationship between waste materials handled and mined ore are depicted in iron, coal and crushed rock mining operations.







(Energy and Environmental Profile of the U.S. Mining Industry: Mining Overview. Dec. 2002.)

Processing and Separations

The processing and separation segment of the mining process is very energy intensive. Crushing and grinding are the initial steps of the process that reduce the size of the mined material into fine particles. The efficiency of these processes depends on the upstream processes in the extraction process. Next, the undesirable particles are separated from the valuable particles through a physical process such as a centrifuge or magnetic separator.

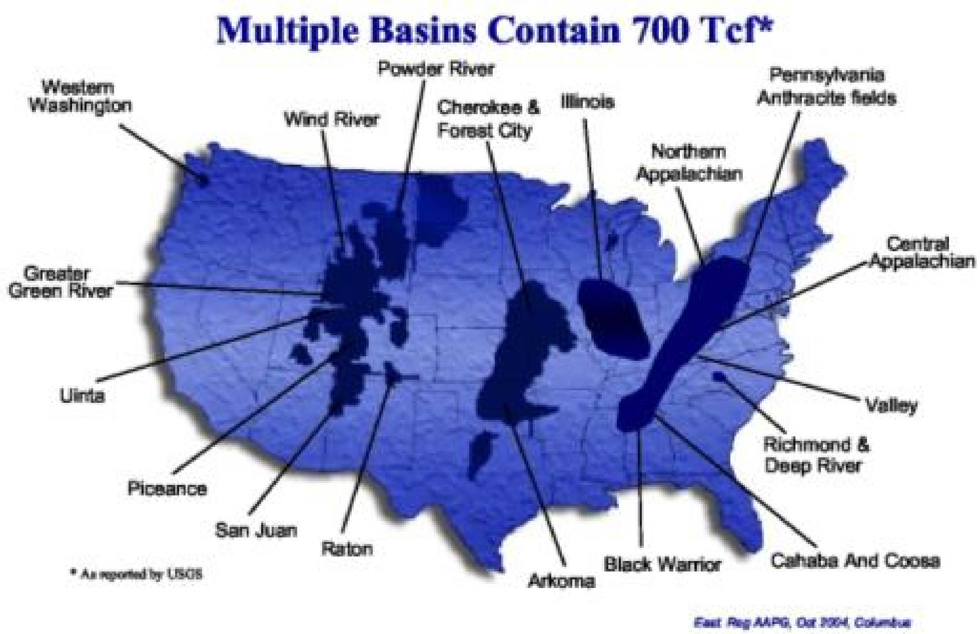
Depending on the type of ore (i.e. coal, iron, copper, limestone, granite, etc.), there are several different steps to complete the transformation from ore to a pure and valuable form. Roasting, smelting and refining are examples of the final processes which are still considered elements of the mining industry. These final processes consume, in relation to earlier processes, much less energy.

Mining Industry Fuel Sources

Coal bed Methane

Coal bed methane is a form of natural gas which is generated by either microbial activity or a thermogenic process in which heat and pressure transform organic matter inside a coal vein. Coal bed methane, or CBM, represents an underdeveloped fuel source. Because of its large internal surface area, coal tends to house between six and seven times more gas than a typical natural gas reservoir.[14] Coal bed methane is considered to be a high quality fuel due to the ease in which it is collected and the minimal amount of refining necessary for use. Coal deposits are usually saturated with water, in which case the methane becomes trapped by the water pressure. By pumping out this water, the pressure can be reduced which allows the gas to be pumped out separately.[15]

The United States is estimated to house resources of 700 trillion cubic feet (Tcf), a significant portion of which is located in the Arkansas River Valley area across the states of Arkansas, Kansas, Oklahoma, and Missouri.[16] This is in comparison to its conventional natural gas reserves of 187 trillion cubic feet (Tcf).[14]



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Typically, coal bed methane is not used for CHP as coalmines have little or no demand for thermal energy. The methane, when collected, is usually pumped into natural gas pipelines as a money making venture for mining companies. In some instances, the methane has been utilized on-site, but strictly to power turbines for the production of electricity. In isolated instances, waste heat is captured and re-circulated; however, the low thermal demand often contributes to making CHP cost-prohibitive.

If, however, there was a nearby facility that was willing to accept the thermal load, then a CHP project could be implemented on-site or at the facility with the methane being pipelined to the facility.[10] Coal bed methane is currently underutilized in the state and has the greatest potential as a fuel source for CHP applications in the Arkansas mining industry.

Acid Mine Drainage (AMD)

Acid mine drainage or AMD refers to outflow of acidic water from mines where ore mining activities have caused the water to come into contact with oxidized rock that contains sulfides such as coal, zinc, copper, iron, or lead. AMD can cause significant damage to not only community health, but local plant and animal life as well. Recently, scientists in Pennsylvania have been successful in developing fuel cells that can generate electricity from this wastewater. These microbial fuels cells are capable of generating electricity from the bacterial oxidation of organic matter such as acetate or glucose and inorganic matter such as the sulfides found in acid mine drainage. The AMD fuels are currently capable of producing up to 290 mW/m^2 and further refinement will undoubtedly improve that figure. AMD fuels cells are only capable of producing electricity from this wastewater and with the low level of thermal demand at the mine site, CHP is likely not applicable.[17]

CHP in the Arkansas Mining Industry

For the purposes of this report, materials will be separated into three categories; Metals, Industrial Materials (non-metals) and Coal. To further simplify these categories, iron will be used as an example in the metals category and limestone in the non-metals category as these are primary materials mined in the state of Arkansas.

Metals – Iron

Iron ore is found in every state in the United States, however, only a few states contain relatively large deposits in recoverable areas that make mining the ore economical. In Arkansas, most iron and coal mines are surface or “open-pit” mines that do not require the digging of deep shafts.

If the iron ore is located close to the surface, then the soil and overlying rock can simply be stripped away to provide access to the ore. The iron is then drilled and blasted so it can be loaded by electrical shovels, hydraulic excavators, or front-end loaders on to dump trucks.

After iron is extracted and loaded, it is then transported to a facility for beneficiation. Beneficiation is defined by Webster's as "the treatment of raw material to improve physical or chemical properties" in preparation for use. There are four main beneficiation methods used to prepare iron ores including; crushing and screening, grinding, concentration, agglomeration. Choosing which method or combination of methods would be determined by the iron content present in the ore. Ores containing more than 60 percent iron likely require only crushing and blending, while ore with low content may require screening and concentrating.

Crushing and screening takes place initially in the primary crusher which will reduce the ore to pieces with a diameter of roughly 6 inches. The primary crusher will usually be located at the mine itself, while the secondary and tertiary crushers may be located either at the mine or in a processing mill. The final product following the crushing process will be approximately one-half to three-eighths of an inch in diameter.[12]

Following the crushing process, the material is ground down to a fine powder like substance to help facilitate the separation of the iron from sand and rock. This separation process is referred to as concentration. The concentration process can range from very quick and simple to lengthy and complicated depending on the exact nature of the ore. Simple concentration consists of magnetic separation which will separate iron ore from less magnetic substances. If simple magnetic separation is not sufficient, chemical reagents or a combination of both methods may be used.

The final stage of the beneficiation process is agglomeration. This process is necessary to allow adequate gas flow through the material that will be sent to blast furnaces for iron-making. There are three main processes used for agglomeration; sintering, pelletizing, and briquetting. Sintering is a process that involves mixing iron–containing materials such as ore fines and flue dust with fuel. The mixture is then heated to approximately 1100°C (slightly below the melting point of iron) to create a thick, corrugated material known as sinter to be used in iron-making.[12]

Pelletizing is simply the formation of pellets from concentrated powder, then hardening by heating. Excess material is rerouted back through the process so there is little to no waste in the finished process. Similarly, briquetting involves heating the ore and pressing it into briquettes while the material is hot.

Non-Metals- Limestone

Limestone is typically used to produce lime, which is a key ingredient in many industrial and chemical applications. Lime is used in products such as paper, steel, sugar, plastics, and paint products. It is a critical component in steel manufacturing, which is also limestone's single largest use. Lime's second largest use is the treatment of potable water, air, and solid waste. Lime is also used to treat stack gases from industrial facilities because it absorbs and neutralizes sulfur oxides from these gases which helps prevent acid rain.

Lime is essential to many other industries as well. It is used to treat chemicals which, in turn, are used in almost every product manufactured in the United States.

The three most common processes in lime production are stone preparation, calcinations and hydration. Stone preparation includes crushing and screening similar to those used in iron preparation. The calcinations process involves the heating of the limestone in a rotary or vertical shaft kiln to temperatures exceeding 1800 degrees. This converts the calcium carbonate into calcium oxide to produce quicklime, which is used in the production of mortar, plaster, and glass production. Depending on its intended used the quicklime may be crushed or pulverized, or hydrated with water. The end product is either a fine dry powder or, when hydrated, a milky liquid. [18]

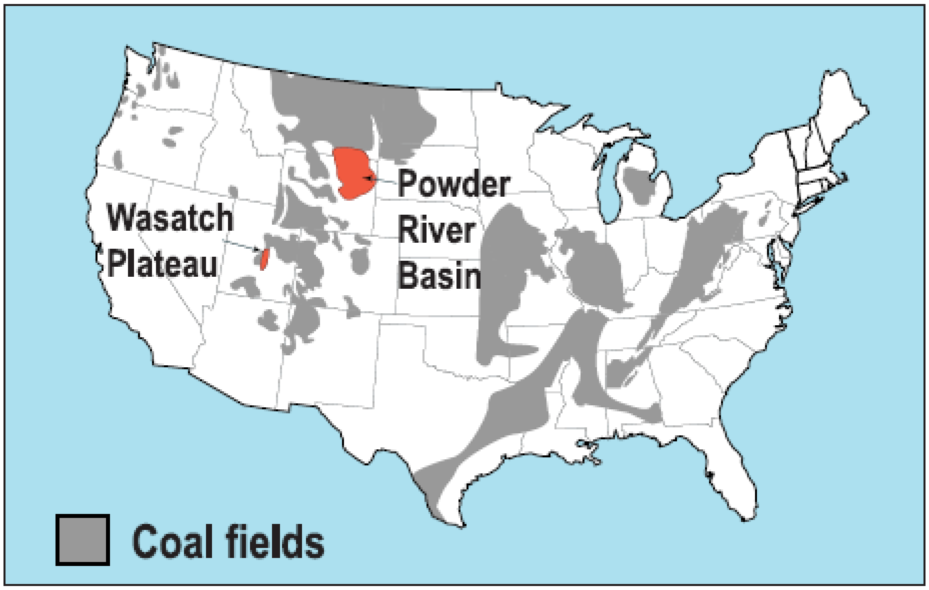
Coal

Once a coal vein has been accessed, there are three types of mining systems that can be used; room-and-pillar mining, longwall mining and shortwall mining. Room-and-pillar systems account for more than half the coal mining that takes place in the US.

The room-and-pillar system involves carving a series of rooms 20 to 30 feet wide while leaving pillars of coal 20 to 90 feet wide to support mine roof. This can be done with blasting (in a conventional mining operation), or cutting and drilling (in a continuous mining operation). When the mining activities reach the end of the coal vein, miners then work backwards, removing as much coal from the pillars a possible until the roof caves, at which point, that section is abandoned. In this scenario, generally 50 to 60% of the coal is recovered, although higher percentages are possible in favorable conditions.[13]

In longwall mining, a shearer, which can best be described as a rotating cutting machine, moves across a wide panel of coal approximately 800 feet wide and 7,000 feet across. The coal is “sheared” from the mine wall and lands on a conveyor belt which sends the coal out of the mine. Longwall mining typically recovers an average of 80% of the mineable coal. Longwall mining is only feasible if the thickness of the coal bed is consistent and if the mine roof and floor are strong enough for hydraulic supports to be used. Over the past 20 years, this method has increased in popularity significantly and now over 45% of all US coal production comes from longwall mining.

Shortwall mining is another mining technique and is by far the least widely used, accounting for less than 1 percent of coal production. Shortwall mining is very similar to longwall mining, except, as the name implies, a panel can be as short as 150 feet wide and 2,500 feet long. In addition, instead of a conveyor belt, mine cars are used which makes this method less productive than the longwall method.[13]



US Geological Survey. Coal bed Methane: Potentials and Concerns. Oct. 2000.

Arkansas Mining Industry Potential

According to the Bill Prior at the Arkansas Geological Commission, approximately 1.5 billion tons of coal is currently present in the 1,700 square-mile area of Western Arkansas.[14] Additionally, there is as much as 9 billion tons of lignite or "brown coal" located in the southern and eastern part of the state.[19]

The development of Arkansas's coal-bed methane (CBM) industry began in 2001 and has, thus far, produced approximately 10 billion cubic feet of CBM.[14] CBM rich coal beds are currently distributed amongst 25 developed fuel beds, the largest of which is the Lower Hartstone coal bed. Thirty-eight coal-bed methane wells have been drilled in this area and have produced 4.2 billion cubic feet of coal-bed methane.[14]

At a price of $6.40 per thousand cubic feet (mcf)[20], Arkansas has produced $64 million worth of coal-bed methane since 2001. The Arkoma Basin, which includes parts of Oklahoma and Arkansas, and the Gulf Coast Coal Basin, which stretches primarily across five southeastern states, including Arkansas, are estimated to contain 1.8 and 3.4 trillion cubic feet (Tcf)[21] of CBM resources respectively. If just 50% of that amount contained in those regions was recovered, it would have a value of approximately $16.6 billion, of which a significant portion would come from the state of Arkansas.

In addition to the enormous financial benefits that may be enjoyed from the direct sale of CBM, there are other more indirect benefits that must also be considered. Degasification systems increase methane recovery while at the same time preventing gas from seeping into mine working areas, which improves worker safety, and significantly reduce ventilation costs. The increase in recovery also will significantly reduce methane-related mining delays, resulting in increased coal productivity.

The environmental effects associated with recovering potential methane emissions can serve as another benefit. According the EPA, many US mines have methane emissions in excess of ten million cubic feet per day (cf/d) (or nearly 3.7 billion cubic feet per year). In this instance, methane recovery at a mine recovering two billion cubic feet of that total per year would result in emissions reductions in the amount of 890,000 tons of CO_2. Mine methane recovery projects may serve as an inexpensive alternative to utilities and others looking to offset their own greenhouse gas emissions.[20]

CBM, as a fuel source, is largely underutilized in the Arkansas and in the United States as a whole. Using CBM as a fuel source offers the greatest potential for CHP applications in the state.

Barriers to CHP Development

Several barriers prohibit the timely and efficient design, installation, and operation of CHP facilities. These barriers include air quality regulations, interconnection issues, the prohibition of third party sales of electricity, and utility rates. These barriers are not specific to CHP, but apply to most distributed generation projects. CHP does have a number of forestry-specific barriers. These include functional on-site productivity, the prevalence of recovery boilers, and capital intensive nature of installing CHP operations in the industry.

Air Quality Regulations

There are six criteria pollutants that the EPA utilizes as indicators of air quality. These pollutants include ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter, and lead. For a detailed look at these various pollutants, please refer to the EPA's website Green Book at: http://www.epa.gov/oar/oaqps/greenbk/o3co.html

Hazardous Air Pollutants (HAP) adversely affects human health and the environment, resulting in cancer, reproductive defects, birth defects, etc. Currently, there exist 188 pollutants that the EPA defines as HAPs. Nine of these pollutants are related to CHP technologies including benzene, formaldehyde, naphthalene, and toluene. For a comprehensive list of HAPs please visit the EPA's website at http://www.epa.gov/ttn/atw/188polls.html

Limitations arise from the prohibitive unit costs of after treatment technology generally applied to larger installations. Standards for emissions limits from large installations are unsuitable for smaller CHP units, however these limits are erroneously applied to mass produced generation equipment, voiding the cost savings yielded from mass production. The savings from mass production are lost because of the high cost per unit of treatment technology. Improper emissions requirements often lend to the difficulty of a CHP installation and therefore should be carefully reviewed before the consideration of a CHP operation**Error! Bookmark not defined.**.

Interconnection

When a facility installs onsite generation, there are typically three ways in which that system may be configured in relation to the utility grid: isolated operation, isolated operation with utility backup, and parallel operation with utility system[22]. Installation of a system with utility backup or parallel operation may yield interconnection issues which pose a barrier to smooth and timely installation. Additional costs and lengthy installation schedules may result as an effect of interconnection boundaries. These barriers may be classified by two categories: technical barriers and regulatory barriers[23].

Technical barriers arise from the utility's requirement that CHP technology systems be grid compatible[23]. Utilities are generally concerned with issues of safety, power quality, equipment protection, and system control[22]. Typically, technical issues are addressed with thorough engineering analysis and costly equipment; however, this is sometimes unnecessary due to the already present safety devices included in the customer's generation system[23]. Comparable to expensive emissions equipment inappropriate for the small scale of CHP, mass production cost savings are reduced via the required equipment and analysis appropriate for a large scale installation where cost per unit is considerably less.

Regulatory interconnection issues also hinder the successful installation of CHP systems. Many states lack consistent polices, if policies even exist at all[24]. Arkansas has adopted net metering standards of up to 25 kW for residential systems and commercial systems up to 100 kW. Interconnected customers must comply with all local and national standards: the National Electric Code (NEC), Institute of Electrical and Electronic Engineers (IEEE), Underwriters Laboratories (UL), and the National Electrical Safety Code (NESC). Furthermore, utilities may require facilities to meet other safety and performance standards approved by the Arkansas Public Service Commission (PSC).

Arkansas also requires that customers' install an external disconnect switch, although it is possible to have this provision waived if customers meet certain other conditions. Utilities may also require facilities to submit to additional testing before approving interconnection, however, additional insurance requirements are not addressed by the PSC.[25]

Utility Rates

Many CHP applications utilize the local utility as a source of back-up power in the system design. But relying on the utility for back-up power creates a large hurdle for CHP applications in Arkansas.

Arkansas rate structures outline certain charges that pertain to owning and operating private power production equipment. Charges known as “back stand” charges or “standby rates” are charges that the consumer must pay in compensation for the utility’s generating capacity. These rates apply to consumers that generate their own power, but still require electrical service from the utility intermittently. The need for this “standby” power arises for periods of predetermined downtime of the consumer’s generation equipment, additional supplemental energy supply from the utility, and the use of the utility as back-up power during unforeseen system downtime[22]. Sometimes the standby rate can be a large enough expense to negate any financial benefit from a CHP system in effect hindering a peak shaving application[26].

There are 21 electric utilities in the state of Arkansas with residential rates ranging from a low of 5.7 ¢ per kWh for Oklahoma Gas and Electric (OG&E) to a high of 8.21¢ per kWh for Entergy. Commercial rates range from 4.25¢ per kWh to 8.06¢ per kWh for Ashley-Chicott Electric Cooperative.[27]

A CHP owner/operator may invest in multiple generating units as insurance against system outages. Then standby rates and insurance are purchased for only one of the units. Owners/operators may also identify non-critical loads that may be shed in the event of an outage. Load shedding would decrease demand and lessen penalties applied by the utility in the event of an outage[28].

Removal of standby charges and exit fees would be a best case scenario for advocates of CHP. Although this event is unlikely, certain steps may be taken by the utility commission to address prohibitive rate and fee practices. Increased testing and analysis should be placed on standby rates. This analysis may prove that exit rates and standby charges are unnecessary. Other rates are subject to a rigorous evaluation and standby rates and exit fees should be no exception. Public interest should also be considered when deciding standby rates. Environmental and economic issues that affect a community at large may outweigh utility profit and the goal of utility service should include society’s long term interests[29].

Mining Industry Specific Obstacles

Lack of Need for Thermal Load

In the best possible scenario, CHP is utilized efficiently where there is a constant supply of thermal energy and a constant load for that thermal energy. However, the extraction process functions in the mining industry, such as drilling, blasting, digging, ventilation and pumping take place out at the mine itself and require very little thermal load. The mining industry utilizes mainly diesel-powered devices such as gas-powered trucks, drills, shovels, and loaders. These types of operations do not lend themselves well to CHP processes as there is no practical functional way to deliver waste-heat out in the actual mine site. For this reason, there is not much interest or need for CHP processes in the initial stages of what is traditionally referred to as mining, such as digging and blasting.

Exploring Implementation of CHP

CHP technologies offer a potential opportunity to increase productivity and economic efficiency within the Arkansas mining industry. There are numerous government, trade, and support organizations for the implementation of CHP equipment.

The Southeast CHP Application Center was established in August 2004 for the DOE. The Center promotes the development and deployment of integrated systems that provide on-site electrical generation and utilize the heat from the generation equipment to provide cooling and/or heating for the building. It provides the following services for CHP systems in the Southeastern United States

- Application Assistance
- Technology Information
- Educational Support

The DOE through a contract with the Mississippi Development Authority - Energy Division (MDA-ED) funds the Southeast CHP Application Center. It is co-located at the Micro-CHP and Bio-Fuels Center at Mississippi State University and the NC+CHP Application Program at North Carolina State University. Contact information, along with CHP evaluation tools, publications, and other CHP related material may be accessed at the Southeast CHP Application Center website at http://www.chpcenterse.org/home.html.

The Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) offers *Quick Plant Energy Profiler (Quick PEP)* software on its website to help plants determine how energy is currently being used and where opportunity exists to save cost and energy. The Department of Energy also sponsors *Industrial Assessment Centers (IACs)* which provide no-cost energy assessments for small and medium sized manufacturing facilities.

The United States CHP Association (USCHPA) offers links under the resources section of its website including CHP software tools, CHP manufacturing company links, and national case studies for current CHP projects and technologies.

Conclusions

Under the direction of the United States DOE, the Southeast CHP Application Center has set out to develop market assessments for CHP with respect to specific industries within the southeastern states.

The Arkansas mining industry is a large, energy intensive, multi-billion dollar industry which accounts for the employment of a significant portion of Arkansas working population. The high utilization of diesel fuel and the lack of a need for thermal load have hindered the adoption of CHP systems throughout the industry. Although the mining industry initially appears to be a poor fit for CHP installations opportunities, there are several areas for implementation that continue to be ignored by a significant portion of the industry.

Opportunities for CHP installations do exist around mine sites where potential energy sources are often ignored or discarded. As discussed earlier, coal bed methane and acid mine drainage are two potential fuel sources that could make CHP systems economically viable. The largest barrier towards the implantation of CHP in the industry is the high implantation costs associated with purchasing the equipment necessary to take advantage of these available fuel sources. These initial costs make it difficult for some to see the longer-term savings and benefits of CHP applications.

Conventional barriers inhibit the installation of CHP in the Mining industry as well. Restrictive environmental regulations, prohibitive interconnection procedures, and prohibitive standby rates for electricity all present themselves as barriers for CHP installation. The mining industry also faces more specific barriers such as the high utilization of diesel fuel and the lack of on-site heat requirements. Difficulty in obtaining local industry data such as energy usage, production rates, and waste heat utilization manifest a barrier in the creation of a market assessment as well as CHP development in general.

Policy reformation and modification of federal, state, and local legislation, can work to overcome some of these barriers. Regulators, officials, and industry and utility representatives must work together to create sound, consistent policies and regulations that give CHP equal treatment in the world of power generation.

While CHP may provide a cost-saving, energy-efficient option for the mining industry, change is slow to come due to the capital and energy-intensive nature of the industry. However, the availability of fuel sources in the industry at a relatively low cost is something that will not be ignored much longer. Coal bed Methane represents the most abundant fuel source in the industry and is currently being underutilized and in many cases, completely ignored. The possibilities for heat and electricity production from coal bed methane gas reserves offer the largest potential opportunity for CHP in the Arkansas mining industry. In addition, the accessibility and relatively low-cost of this opportunity fuel may serve as an incentive for other unrelated businesses to come to the region.

CHP implementation, as discussed within this report, is a cost-based decision that will more than likely coincide with government incentives, rising fuel costs or industry-wide adoption of facilities located near mining sites that can both refine ore while simultaneously producing electricity.

APPENDIX A

Mining Industry Profile: United States

As identified by the US Department of Energy's Industrial Technologies Program, the Mining Industry is comprised of "blasting, dewatering, drilling, digging, ventilation, materials handling, crushing, grinding, and separations."[30] To simplify this, we can divide the mining industry into three main segments: extraction, materials handling, and processing. The area of extraction consists of drilling, blasting, digging, ventilation, and de-watering which serves to remove material from the mine. The second segment is materials handling which consists of all the activities involved with transporting materials away from the mine. The third segment is processing which consists of taking the valuable material extracted from the mine and converts it into usable material by crushing, grinding and/or refining. The United States mining industry (excluding oil & gas) consumes approximately 1,246 trillion btu/year and spends more than $3 billion/year on that energy.[Error! Bookmark not defined.]

Mining Industry Profile: Arkansas

Arkansas's mining industry is a hefty contributor to the Arkansas economy. According to the National Mining Association, the combined direct and indirect economic gain from Arkansas's mining industry is $3.9 billion dollars.[31]

The state of Arkansas is home 189 mining operations which employ 3,670 people directly and another 9,810 people indirectly. The average annual wage for in the mining industry of Arkansas was $45,000 in 2007, which was 32 percent higher than the average wage in the state. Arkansas ranks 29th in the United States in mineral production and 25th in the production of coal.[31] For this reason, Arkansas's mining industry was chosen for a CHP market analysis. Arkansas ranks first in the US in the production of bromine and silica stone and accounts for more than 1% of all mineral production value. Currently, coal is potentially Arkansas's largest untapped resource. According to the Arkansas Geological Commission, there are more than 10 billion tons of coal and lignite present in the state.

Mining in Arkansas, 2007

	Output ($ million)	Employment	Payroll ($ million)
Total Mining			
Direct	940	3,670	160
Indirect	1,080	9,810	320
In-state	610	5,430	200
Out-of-state*	470	4,380	120
Total	2,020	13,480	480
Coal Mining			
Direct	20	270	10
Indirect	150	2,110	60
In-state	10	560	10
Out-of-state*	140	1,550	50
Total	170	2,380	70
Metal Mining			
Direct	340	680	40
Indirect	370	2,470	90
In-state	240	1,590	70
Out-of-state*	130	880	20
Total	710	3,150	130
Nonmetallic Mineral Mining			
Direct	580	2,720	110
Indirect	550	5,230	170
In-state	360	3,280	120
Out-of-state*	190	1,950	50
Total	1,130	7,950	280

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