FINAL TECHNICAL REPORT
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Project Title: **DEMONSTRATION OF A COAL INDUSTRIAL PARK FOR ILLINOIS COAL INDUSTRY ENHANCEMENT**

ICCI Project Number: 00US-1
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ABSTRACT

A concept of a Coal Industrial Park (CIP) has been developed. This concept integrates mining, processing, and combustion by-products management operations to improve coal company profitability and minimize negative environmental impacts. An integral part of this concept is an on-site or near mine-site, small size (25-35 MW) fluidized bed combustion (FBC) power plant, which utilizes a low value/waste coal stream from the processing plant. The power generated is sold to the mine as well as to the outside markets. The by-products of combustion are co-managed with mining and processing wastes to achieve "Near-Zero Solid Waste Discharge" and minimize negative environmental impacts. Some of the byproducts may also be used to fabricate products for use in mines as well as for construction industries. The CIP attempts to achieve a "GREEN ENERGY" concept.

A techno-economic feasibility analysis for the proposed CIP concept utilizing a mine-mouth 25 MW (28 MW gross) Circulating Fluidized Bed Combustor (CFBC) has been conducted. The results of the feasibility study, presented in this report, involve evaluation of technical factors such as combustion properties, feed, cooling water and transmission capacity availability, technical evaluation of coal processing, tailings management and CCBs-based product development concepts, quantification of savings from the innovative waste management strategies and an overall CIP concept economic feasibility analysis.

Feasibility findings indicate that the project is economically viable. Conservative estimates of profitability indicate potential to provide a return on investment in the range of 20-25%. This level of investment return is superior to most power projects, even of larger sizes, as a result of waste fuel utilization and the synergies involved in the CIP concept. Results of the feasibility study indicate that the proposed concept for 28-30 MW mine mouth power plant can be implemented at most mines with a life of about 20 years and availability of about 300 gpm of water.

The remainder of this report contains proprietary information and is not available for distribution except to the sponsor of this project.

EXECUTIVE SUMMARY

This report contains information pertaining to the findings of a feasibility study evaluating a "Demonstration of a Coal Industrial Park for Illinois Coal Industry Enhancement". The project envisions a Coal Industrial Park (CIP) which integrates upstream and downstream activities such as, mining, processing, fine coal processing, processing waste management, mine-mouth power generation, mitigation of negative environmental impacts, coal combustion byproducts (CCBs) management and production of beneficial use products from CCBs for sale and underground placement to improve the profitability of Illinois coal mines. This project involves conducting a feasibility study for establishment of such a facility at Turris coal mine in Elkhart, Illinois.

Over the last 10-11 months, a Friends of Coal Industry Consortium[1] (The Consortium) has developed concepts and performed technical and economic feasibility studies of the CIP concept. The studies have demonstrated validity of the developed concepts to 1) enhance high sulfur coal industry throughout the State of Illinois; and 2) overcome most of the environmental concerns associated with coal mining and processing operations, and to some extent management of coal combustion byproducts from power plants. The CIP attempts to achieve Near-Zero Solid-Waste Discharge. In that sense the CIP comes close to achieving a "GREEN ENERGY" concept. More specifically, the CIP concept achieves the following:

1) Ensures an expanded use of high sulfur Illinois coal in the very near term (10 years), creating more jobs with low capital investment.
2) Utilizes about 95% of the mined-coal energy as compared to about 80% to 85% currently utilized.
3) Minimizes negative environmental impacts associated with mining, and management of mining and processing waste, and coal combustion byproducts (CCBs).
4) Generates and markets competitive low-cost power from the use of coal waste.
5) Reduces the cost of power used at the mine site.
6) Reduces the cost of coal received by the power plant and lowers the cost of sulfur emissions controls.
7) Fabricates and markets products from byproducts of mining, processing, and combustion of coal for mining and construction industries.

The Consortium studies have indicated that the internal rate of return (IRR) on investment for a 25 MW (net)[2] mine-mouth power plant (minimum size required to achieve "Near-Zero Solid Waste Discharge") at the cooperating mine, integrated with mining and processing operations would range from 20-25%. This is significantly higher than a similar plant operating without synergies provided by CIP (~10%). The IRR numbers for CIP above are also higher than a typical large-size (500-1,000 MW) merchant power plant (15-18%). For a 100 MW mine-mouth power plant utilizing CIP concepts, the expected IRR value is about 23-27%.

The Consortium studies for the 25 MW (net) mine-mouth CIP plant have undergone an independent evaluation by Montgomery-Watson-Harza Consulting (MWHC). MWHC is a premier consulting company based in Chicago. MWHC has confirmed IRR numbers of 20-25% for the 25 MW (net) power plant and CIP potential to benefit the high sulfur coal industry of Illinois. A copy of the confidential report is available with the PI and can be furnished upon request to DCCA/ICCI.

Most cooperative utilities interested in the CIP project, have suggested that the size of the mine mouth power plant be increased to near 100 MW to make it a more attractive investment from a business point

[1] Consortium members include Turris Coal Company/AEI Resources Inc., Sedgman, Foster Wheeler Energy International, Babcock and Wilcox, Cooperative Electric Utilities, Department of Mining and Mineral Resources Engineering, Southern Illinois University at Carbondale

[2] A 25 MW net power plant implies approximately 28-30 MW gross capacity power plant.

of view through economies of scale. However, the maximum size of the CIP power plant may be limited by economic availability of water and transmission capacity, over and above what is committed to the Low Emission Boiler System (LEBS) power plant planned at Turris mine.

The CIP has the potential to enhance high sulfur coal industry throughout the State of Illinois. In addition to Turris Coal Company Elkhart mine, the developed concepts have the potential for implementation at RAG Wabash mine, Monterey #1 mine, American Coal Galatia mine, Freeman Crown III mine, Old Ben Zeigler 11 mine, and White County Pattiki mine. All new mines currently in planning stages should also seriously consider the concept. The CIP concept can be used at most mines in Illinois, with a life of about 20 years and availability of about 300 gallons per minute of water, to enhance coal production and employment. The concept should also have a stabilizing influence on the electricity prices throughout the State of Illinois.

Following this study, the Consortium, plans to demonstrate and commercialize these concepts at Turris Mine near Elkhart, Illinois.

Phase I studies (the ongoing project, 2000-2001) focused on concepts development and feasibility studies. More specifically, studies included:

- CIP concepts development and their technical and economic feasibility.
- Bench scale studies of the proposed processing circuit for fine coal processing waste (FCPW).
- Bench scale and preliminary studies of direct vegetation on neutralized mixes of gob, tailings and CCBs.
- Bench scale FBC combustion studies using the developed feed.
- Feasibility of using limestone waste in the proposed FBC unit.
- An independent review by MWHC (previously Harza) of the studies completed by the Consortium.
- Applicability of CIP concepts to other mines in Illinois.

The results of these studies to date for a 25 MW (net) power plant are summarized below.

I. General

- For a typical mine in Illinois, the economic impact of coal processing waste disposal and loss of about 7-10% BTUs in Fine Coal Processing Waste (FCPW) is about $2.50/clean ton.
- A small-size mine-mouth power plant (25-35 MW) will utilize most of the lost BTUs in FCPW and provide sufficient CCBs to neutralize tailings and fabricate CCBs-based products for mine use.
- Ash for neutralization of coarse coal processing waste (CCPW) or gob must be procured from external sources.
- A CIP facility for achieving "Near–Zero Solid Waste Discharge" at Turris mine will require a 25 MW (net) mine mouth FBC power plant, a retrofitted advanced fine coal cleaning and dewatering circuit in the processing plant, a plant using annually about 15,000 tons of CCBs for fabricating products, and managing at least 190,000 tons of FBC byproducts for CCPW neutralization.
- The facility described in (4) above will require about 55 million dollars in capital. The Internal Rate of Return on investment (IRR) and Net Present Value (NPV) for the facility

should be about 20-25% and 20-30 million dollars. The payback period for the investment should be about 4 years.

- The CIP facility above should provide significant socio-economic benefits. The following estimates are provided by MWHC.
  - 750 – 1250 construction jobs – 3 years
  - 80 – 100 production jobs – Life of plant (Higher paying technical jobs)
  - 500 – 600 spin–off jobs – Life of plant.
- The CIP facility should generate about $2.2 million annually in cash flows after taxes over and above what is currently generated by the mine, without additional mining.
- The facility ensures use of high sulfur coal and more mining jobs.
- The facility will commercialize four (4) technologies developed as part of research and development studies from ICCI / DCCA and the U. S. Department of Energy.

II. Advanced Processing Circuit for Fine Coal Processing Waste

- About 120 tph of FCPW (≈300,000 tons/year), with heating value of 6,000 BTU/lb on moisture-free basis, is generated at Turris mine.
- A column flotation cell is proposed for processing the FCPW. It is expected that about 90,000 tons per year of clean coal, with heating value of 11,000 BTU/lb, and 2.75% sulfur will be generated. This product will feed the 25 MW (net) mine-mouth power plant.
- The processing cost of FCPW is expected to be $3/clean ton.
- A filter press, manufactured in Spain and marketed in the U. S. by PrepTech Inc., for dewatering fine coal is proposed as part of the processing circuit. The filter cake will have total moisture content of about 30%. The estimated cost of dewatering is $0.50/clean ton.
- Coal processing and dewatering circuit, by itself, is a good investment to produce feed for the mine-mouth power plant. The expected IRR is 80-100%.
- Pumping tests have established feasibility of 55% solids slurry pumping. Based on these tests and the application, a hydraulically driven piston pump was recommended by the manufacturer.

III. Power Plant

Bench-scale combustion tests have been completed successfully. Some key findings of the tests are:

- Sustained combustion of the fine coal slurry fuel was achieved at least up to as high as 50% moisture content.
- Combustion efficiencies of about 95% were achieved.
- Very low loss on ignition (LOI) was recorded for the bed-ash making it amenable for beneficial uses.
- Fly-ash LOI, CO emission and some volatile organic compound emissions were high. It is believed that this issue will be resolved in larger size boiler with a hotter cyclone and higher residence time.
- NO_x emissions were very low with fuel nitrogen conversion of only 4-5%.
- SO_2 capture of 90% was achieved at Ca/S ratio of 2.16%. This relates to a limestone utilization of 40% which is better than what is typically achieved with FBCs.
- Mercury emissions were low at about 0.27 $\mu g/m^3$. Significantly lower levels can be anticipated in a full scale unit depending on the operating temperature of the baghouse.
- The proposed FBC plant will utilize about 15 tph of processed FCPW with heating value of about 11,000 BTU/lb.

- The boiler heat rate is assumed to be about 13,392 BTU/lb for 25 MW (net) generation.
- The power plant will use about 36,750 tons/year of limestone.
- The plant will generate about 55,000 tons of CCB's.
- The plant will require about 250-300 gallons/minute of water.

Discussions with Cornbelt Energy (LEBS project developers) and Farnsworth Group (Hydrogeologic consultants) have indicated a high probability of finding the requisite water to support a larger size CIP system. Further exploration will however be required to establish water availability.

IV. Transmission Capacity

- LEBS plans to transmit about 90 MW of power.
- CIP will require additional transmission capacity of 25 MW.
- Illinois Power (IP) studies indicate about 160 MW of existing transmission capacity. However, the capacity can be increased incorporating some transmission upgrades if there is a need for additional transmission capacity.
- Corn Belt/IP studies suggest minor modifications in equipment to transmit CIP power. (Note: Upgrade costs have been included in the financial model)

V. Tailings Management

- Integrated coal processing waste and FBC by-products management concept has a significant potential to minimize future environmental problems associated with the current disposal practice and reduce reclamation costs.
- Approximately 10% FBC fly ash by weight of tailings, and 15-20% FBC fly ash by weight of gob will result in long-term neutralized and stabilized waste.
- Direct vegetation on neutralized mixes of tailings and gob using FBC fly ash is possible. The amount of fly ash required for this purpose is 5-7% by weight of tailings, and about 10-12% by weight of gob.
- Two innovative spatially efficient disposal concepts have been developed. These have been discussed with mining company professionals and appear to hold promise.
- A potential exists to reduce reclamation cover requirements for neutralized mixes delineated above. However, regulatory agencies will require considerable field data over a long period of time to allow this practice. (Note: This data will be collected in the proposed Phase II studies)

VI. Power Plant Enhancement Concepts

Utilization of byproduct limestone as a sorbent appears to be feasible. Reactivity tests on 5 samples from 2 sources in the vicinity of the proposed CIP location have provided excellent results. Preliminary discussions with quarry operators indicate that a potential to achieve a limestone cost savings of about 40% is achievable.

The concept of co-firing Coal bed methane in the CIP boiler has been developed. Coal bed methane from active and old mine workings will be utilized. The idea has received encouraging response from boiler designers. The features of this concept are:

- When applied to a 100-MW power plant, additional power generation of 4.5 MW power is possible at a very small capital investment.
- FBC cycle efficiency can improve by 5%.

- 7,600 tons/year methane not discharged in atmosphere.
- From greenhouse perspective, equivalent savings of 55,000 tons of CO_2 discharge.
- CIP project revenue will increase by $1.1 million.
- CIP project ROI increase from 24.3% to 28.3%.
- It is to be noted however that this concept may not be as attractive for the particular case of Turris mine.

Bed ash reactivation and recycle can provide significant technical and economic advantages.

Potential exists to reduce costs through reduction in limestone consumption, higher combustion efficiency and lower disposal costs. Savings of up to $550,000/year can be achieved for a 100-MW power plant.

In addition, CO_2 emissions would be reduced by about 10,000 tons/year.

Back-end humidification concept will allow improved sorbent utilization and deep-cleaning of SO_2 in a conventional FBC boiler.

Again, a potential exists to reduce costs through reduction in limestone consumption, higher combustion efficiency and lower disposal costs. Savings of up to $350,000/year can be achieved for a 100-MW power plant.

In addition, CO_2 emissions would be reduced by about 3,000 tons/year.

Concepts for waste heat recovery have been developed. These concepts involve heat recovery from the flue gas and bed ash drain. Possible uses of this heat include apace heating, greenhouses and more importantly mechanical-thermal dewatering of the fine coal slurry fuel. This latter concept is being investigated by the PI in a related project. Cost savings of about $100,000/year are anticipated.

VII. Recommendation to the State of Illinois

- CIP concept is technically and economically viable and has the potential to enhance the high-sulfur industry in Illinois.
- Based on the technical input from professionals, CFBC provides the best approach for burning waste fines whose quality may be variable. Gasification of waste fines or PC-fired boilers are not recommended.
- Co-firing mine-mouth power plant with low concentration methane should be seriously considered as a part of CIP implementation on a site-by-site basis. In addition, the concept of removing methane gas immediately behind a longwall face to enhance power plant efficiency should also be considered.
- Although a 30-40 MW mine-mouth power plant is adequate to utilize all waste fines and achieve near-zero solid waste discharge at a typical Illinois mine, it is recommended that the concept should be implemented with a FBC power plant of about 100 MW to minimize risk and achieve some economies of scale. This approach also permits the mine to increase their coal production and sales by about 150,000 tpy.
- The CIP implementation should be seriously considered at the following existing mines in addition to Turris Coal Elkhart Mine.
  American Coal Galatia Mine
  White County Pattiki Mine
  Brushy Creek Mine
  In addition, all new mines currently being considered in the State of Illinois should be evaluated for CIP implementation.

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