

ConvertCoal, Inc.

CCI COAL-CHAR FUEL ADVANTAGES

The CCI clean coal fuel provides important advantages to the power plant or project located adjacent. An important advantage for both the PC-generating plant and IGCC configuration is the increased fuel efficiency resulting from the removal of humidity and pyrolysis water from the coal, amounting to 5 – 6% gain in heat-rate and decrease in CO₂-emissions. Important reductions in capital and operating costs also result from the reductions of sulfur and mercury.

SUMMARY	
CCI COAL-CHAR-FUEL ADVANTAGES FOR PC-POWER PLANT	
PARAMETER	IMPROVEMENT AND CAUSE
Emissions	Reductions due to decrease in SO ₂ , NO _x , Hg
Heat-rate improvement	Decrease due to fuel heating value upgrade
GHG reduction	Reduction in CO ₂ due to heat-rate decrease
Captive power	Decreases due to less combustion air flow, feed-coal weight, etc.
Water supply	Increase resulting from coal moisture recapture
Stack plume	Decreased stack gas plume due to reduced water content
Feed-coal flexibility	Expanded flexibility to use lower rank coals as fuel
Other advantages	Prospective synergism from CCI and PC-generation

SUMMARY OF POWER GENERATION BENEFITS FROM CCI CLEAN COAL FUEL

Low rank coals have been a source of fuel for electric power plants for years. More recently the plants have had the requirement to add or upgrade environmental clean up systems to meet current and future emissions regulations. The development of “clean coal” technologies has drawn keen interest for helping to achieve lower plant emissions. The Convert Coal, Inc. (CCI) process was developed to respond to this market demand. The CCI process removes sulfur and mercury from low-sulfur low-rank coals to produce high quality clean coal fuel. The coal-char fuel is suitable for use in existing coal-fired power plants as a higher quality fuel with reduced emissions, higher plant efficiency and lower auxiliary power requirements. The byproduct process water becomes a supplemental source of power plant make-up water.

COAL-CHAR FUEL - The CCI processing of low rank coals produces a product that has reduced moisture content, lowers the sulfur content, reduces the fuel bound nitrogen and mercury content. The resulting product represents a boiler fuel that has a higher heating value, and produces fewer emissions from the power plant. Typically, the heating value of low rank coals is on the order of 6000-8000 Btu/lb and after treatment into coal-char fuel the heating value is increased to approximately 9000-11000 Btu/lb. By reducing the moisture content of the fuel the energy required for vaporizing water is eliminated resulting in an improvement in plant efficiency by approximately 5%. Additional benefits result by reducing the fuel handling requirements and thus there is less maintenance and replacement of equipment. An additional benefit for existing coal plants is that alternate fuel sources with a lower heating value can now be made available following treatment with CCI processing.

EMISSIONS - The CCI process reduces the fuel bound nitrogen content of the coal in the amount of 60% or more. A corresponding reduction of the NO_x that is formed from the fuel would lead to a lower requirement for NO_x reduction chemicals such as ammonia and extended life of catalyst for any emissions control systems currently in place. Since 66% or more of the sulfur is also removed from the feed coal, there will be a reduction in the formation of SO₂ emissions. Therefore, savings result in operations of scrubbers that will require less chemicals and reduced equipment duty. The EPA 2010 CAIR requirements for SO₂ emissions can also be met with the CCI process without equipment upgrades for a number of low rank coals. CO₂ emissions would be reduced proportionally with the increased plant efficiency providing a benefit related to concerns over global warming issues. The CCI process also reduces mercury by 85 - 95%. This exceeds current requirements for mercury reduction and may provide sufficient margin to eliminate the need for mercury control system upgrades. Due to the drying of the coal in the CCI process visible moisture plumes from the plant would also be reduced.

EFFICIENCY - The increased heat content of CCI clean coal fuel will have the effect of lowering the quantity of fuel that is fed to the boiler and increasing the boiler efficiency. With a roughly, 40% to 45% increase in heating value the power required to operate coal stackers, conveyers, pulverizers, and blowers will all be reduced by approximately one-third. Reduced auxiliary loads contribute to lower plant heat rates as well as wear and tear on equipment. The water loss results directly in a boiler efficiency gain of 5 - 6%

OTHER CCI PLANT ADVANTAGES - The water recovered in the CCI process can be used to offset some of the water requirements in the power plant, e.g., for cooling tower make-up or boiler feed-water make-up. The amount of water available from the CCI process varies depending on the coal composition, and for a feed coal with 30-w% water will be approximately 1-gpm per MW.

COST NEUTRALITY - While the PC generating plant will have the advantage of operating on CCI clean coal fuel product, the power generating cost can become economically neutral to the choice of fuel. This occurs when the cost of the CCI clean coal fuel can be based on equivalent Btu costs reflecting savings due to improved boiler efficiency and operations of the PC generating plant.

SPECIFIC PC-POWER PLANT BENEFITS FROM CCI COAL-CHAR-FUEL

The operation of a CCI coal conversion project adjacent to a PC-Power-Generation plant will provide several benefits to the PC-PG plant. Some of these are obvious, some perhaps less so. The benefits include emissions reductions, energy savings and additional water supply. The increased value of the coal-char-fuel [CCF] compared to the feed-coal results from the recognition of these benefits.

1. **EMISSIONS REDUCTION** - The reduction in pollutants resulting from the use of CCF includes sulfur oxides, nitrogen oxides and mercury. This can be translated directly into incremental savings in the operation of each of the individual emission control units. Alternately, the strategy may be to eliminate certain emissions control units because the low concentration of pollutants in CCF may make them unnecessary. The reduction of carbon dioxide is addressed separately below.
 - a. **SO₂ REDUCTION** - The CCI process removes 66 - 75% of the sulfur present in the feed coal. Depending on the selection of the feed-coal CCF therefore may be a compliance fuel in accordance with CAIR 2010. In any case, the chemicals used for SO₂ removal can be decreased in proportion to the CCI-process sulfur removal.
 - b. **NO_x REDUCTION** - Since approximately 75% of the fuel-contained nitrogen converts to NO_x in the combustion, the removal of 50 - 75% of the fuel bound nitrogen by the CCI process can be translated directly to proportional savings in NO_x-reduction chemicals [e.g., ammonia, urea or hydrogen].
 - c. **MERCURY REDUCTION** - Current regulations require 21% removal of Hg, prospectively increasing in future years. PC-plant mitigation strategies include dry-scrubbing and wet-scrubbing. The reduction of Hg by CCI processing will exceed 50 - 95% depending on the distribution of various Hg-compounds in the coal. Additional mercury emissions mitigation therefore will be unnecessary for PC boilers using CCF.

2. **HEATRATE DECREASE DUE TO BOILER EFFICIENCY IMPROVEMENT** - The difference in water content between feed-coal and CCF, say for example 30-w%, results in a boiler efficiency increase and corresponding heatrate decrease of 4 – 5%. This is due to the savings in energy required for evaporation of the water present in the feed-coal. A numeric example for illustration: The objective heat savings is expressed as the enthalpy difference between liquid water at 60-F in the feed-coal and water vapor at 300-F in the stack-gas. Assume a feed-coal at 60-F, 16.8-mmBtu/t and 30-w% water, and CCF at 60-F with 22.4-mmBtu/t and 0-w% water. The enthalpy difference for water at 60-F and steam at 300-F is $dH = 1179.7 - 28.1 = 1151.6$ Btu/lb. Based on a ton of feed-coal the enthalpy difference dQ therefore is: $dQ = 2000\text{-lb/t} \times 0.30 \times 1151.6 \text{ Btu/lb} / 16.8\text{-mmBtu/t} = 4.1\%$
3. **CAPTIVE POWER REDUCTION** - The captive power consumption will be reduced incrementally due to the reduction on weight of feed-coal, increase in coal heating value and reduction on emission mitigation intensity. For example, the increase in HHV and corresponding reduction in weight of feed-coal will be approximately 42.8% for CCI due to removal of 30-w% water plus an additional 4.1% due to boiler efficiency increase. Determination of the objective power savings will require site-specific evaluation.
4. **CARBON DIOXIDE EMISSION REDUCTION** - The reduction in PC-plant heat-rate resulting from the removal of water from the feed-coal translates directly into a corresponding reduction in CO2 emission per kWh produced. In addition, so do any other reduction in the internal energy consumption in the PC-plant, e.g., reductions in power loads for the coal transportation, pulverizers, gas wet-scrubbers, and recycle water pumps.
5. **WATER SUPPLY** - The water recovered in the CCI process will be cleaned and can be made available for the PC-plant as supply for cooling tower feed water of boiler-feed-water. The amount available for a 500-MW PC-plant [10,000-t/d coal, 30% moisture and 3% pyrolysis water] will be 3300-t/d of near 500-GPM.
6. **STACK PLUME REDUCTION** - The reduction in water in CCF reduces the water in the stack-gas proportionally and therefore also will reduce the water condensation plume off the stack. This may allow an incremental decrease of the stack gas temperature and corresponding plant efficiency gain.
7. **FEED-COAL FLEXIBILITY** - Conceptually, the CCI plant upgrades LRC to higher fuel-density CCF, and therefore can extend the range of feed-coal suitable for the PC-plant. For example, if a given PC-plant is designed for coal with 8500 – 9800-Btu/lb-coal, then the range of fuel may be expanded down to 6000-Btu/lb because the CCF will prospectively have 8500-Btu/lb. This enhanced fuel flexibility may eventually reflect in the cost of coal for the plant.
8. **OTHER PROSPECTIVE GAINS** - There may be other prospective advantages for the PC-plant that can be investigated. For example, the CCI plant will require approximately 15-MW to operate, and therefore is a new prospective client for base-loaded capacity. Also, fuel gas produced by the CCI plant may be considered as fuel supply for the PC-plant. Also, it may be attractive for the PC-plant and the CCI plant to interchange other energy streams that the other can utilize to advantage, e.g., medium and low-pressure steam will be needed by the CCI process, and recovered CCI waste heat may be available for BFW preheat at the PC-plant.