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## **US COKING SECTOR ENVIRONMENTAL PERSPECTIVES: CHALLENGES AND OPPORTUNITIES IN THE 21<sup>ST</sup> CENTURY**

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### **INTRODUCTION**

During the next decade, the US coking sector will be facing tremendous environmental challenges and opportunities. The median age of existing US byproduct coke plants that produce more than 80% of domestic coke is in excess of 40 years. These older byproduct coke plants are costly to maintain and facing increasingly stringent existing environmental regulations. Future US green house gas (GHG) regulation is also a significant financial uncertainty to the coking sector. With this challenging background, many within industry might expect the continued decline of the US coking sector. In fact, a close review of the evidence suggests that the US coking sector is well positioned for future growth and success.

### **BACKGROUND**

Coke is a heating agent and an essential raw material input for blast furnace and foundry cupola operations. Blast furnaces and the tremendous capital invested in them will continue to support a substantial portion of US steel output for decades into the future. Cupola furnaces also continue to account for more than 53% of the total metal poured at US iron and steel foundries.

Production of coke uses either a recovery (i.e., byproduct) or non-recovery (i.e., heat recovery) manufacturing process. In the US, integrated steel manufacturers have traditionally owned and operated byproduct coke plants to serve steel production requirements. As a result, older captive byproduct coke plants at integrated steel plants comprise an estimated 70% of the total domestic US coke production capacity. Of the remaining US production capacity, byproduct merchant plants comprise approximately 15%.

In the byproduct coking process, direct and indirect high-temperature heating of coal is conducted in a positive pressure oxygen deficient environmental to transform coal to coke by driving off the volatile matter (VM) to concentrate the carbon. The VM in the coke oven gas (COG) is then processed by a chemical plant to recover usable gas and salable byproducts such as benzene, sulfur, ammonia, naphtha, tar, and pitch. The usable COG is typically used as fuel for integrated steel furnaces.

In contrast, the non-recovery coking process uses direct and indirect high-temperature heating in a negative pressure oxygen deficient atmosphere to transform coal to coke by driving off the volatile matter (VM) to concentrate the carbon. The VM is then fully combusted in a secondary waste gas tunnel to produce large quantities of excess heat that can be used to co-generate steam for industrial use and/or the generation of electricity.

## **ENVIRONMENTAL CHALLENGES**

US coking industry sector environmental regulations have changed significantly over the past decade and are expected to become increasingly stringent in the future. These tightening USEPA and State-specific air pollution and other environmental regulations will make it increasingly more difficult for older US byproduct coke plants to cost-effectively maintain environmental compliance and continue operating competitively with non-recovery coke plants.

### **Tightening Existing Regulations**

Byproduct and non-recovery coke ovens are regulated by USEPA under Clean Air Act (CAA) National Emission Standards for Hazardous Air Pollutant (NESHAP) regulations. In 1993, USEPA's initial coke battery NESHAP regulations effectively determined that byproduct coke ovens were such a large source of HAPs that the byproduct coking process was eliminated for use by new plants in favor of non-recovery coking.

USEPA allowed existing coke batteries the flexibility to follow either a MACT compliance track or alternative Lowest Achievable Emission Rate (LAER) compliance track. The MACT track required existing coke batteries to meet specific environmental improvements by no later than January 1, 2003. Under the LAER track, existing batteries were provided additional time that included extensions up to January 1, 2010.

Based on information from USEPA, only five existing coke batteries at four plants elected to follow a compliance track with MACT regulations. These MACT-track byproduct coke plants represent less than 10% of present U.S. capacity. Therefore, the remaining pre-1993 coke plants in operation today must meet the stringent LAER regulations regardless of cost. LAER-regulated byproduct coke plants represent approximately 76% of all existing domestic US coke production. Uncertainty with the compliance cost of meeting the 2010 LAER requirements is so great that it was specifically noted in the 2006 Annual Report for the US Steel Corporation.

Since 2000, USEPA has also issued additional NESHAP regulations on coke oven charging, pushing and battery stacks. These additional regulations have also significantly greater adverse impact on byproduct verses non-recovery coke plants.

### **NAAQS Non-Attainment**

Old existing US byproduct batteries are also facing increasingly expensive operation and maintenance costs associated with more stringent NAAQS regulations that seek to maintain and improve air quality in the geographical regions where the older coke plants are located. In June 2004, USEPA revised the National Ambient Air Quality Standard (NAAQS) for ozone to a lower 8-hour limit. US EPA also implemented new NAAQS PM 2.5 requirements in 2004. These new NAAQS have resulted in a large number of formerly NAAQS compliant areas in the US to be newly designated as “non-attainment” areas.

As of 2006, 100% of the existing captive byproduct and 80% of the merchant byproduct coke production in the US was located in non-attainment areas. The oldest byproduct plants in these non-attainment areas are clearly at risk of closure due to increasingly stringent US EPA and State-specific air pollution regulations. For example, the 2006 Annual Report for the US Steel Corporation specifically states that the US EPA is developing regulations to address ozone non-attainment areas and the impact of which “could result in significant costs” to US Steel.

### **Mercury and GHG Regulation**

Byproduct coke ovens produce COG used by steel furnaces. Based on existing information, mercury contained in the coal charged to the coke ovens is traveling with the COG to the steel furnaces. As a result, mercury emissions from steel furnaces are expected to be regulated in the future. The difficulty will be obtaining cost-effective mercury controls.

In contrast, mercury emissions from non-recovery coke plants are expected to be controlled effectively (80 to 90%) by established powered activated carbon (PAC) injection technology. PAC injection has already been demonstrated to be effective in removing the mercury species emitted by non-recovery coke plants when used in conjunction with flue gas desulfurization (FGD) systems currently used as BACT for SO<sub>2</sub> removal at non-recovery coke plants.

Finally, one of the most critical environmental risks emerging for older byproduct coke plants is an ongoing problem with uncontrolled loss of methane from the byproduct recovery operations. Methane gas leaks from piping, valves, process vessels, and tanks are extremely difficult if not impossible to eliminate. LMG estimates that older byproduct plants emit on average approximately 16 tons of CO<sub>2</sub> per ton of coal coked compared to the approximately 1 ton of CO<sub>2</sub> per ton of coal to be emitted by a non-recovery coke plant. The huge difference between non-recovery coke plants and existing US byproduct coke plants is the significant fugitive methane (CH<sub>4</sub>) emissions at the byproduct plants. Methane has a CO<sub>2</sub> equivalent weighting of 21.

## **COKING OPPORTUNITIES IN THE 21<sup>ST</sup> CENTURY**

The North American blast furnace and foundry coke market is currently estimated to be short approximately 3 to 4 million tons of coke. North American demand for coke has steadily increased from 2005 thru 2008, while domestic production has remained flat, if not decreasing due to older coke plants temporarily or permanently shutting down. Wholesale electricity prices to industrial, commercial, and residential users are also projected to increase by more than 50% in the next 20 years. Retail price increases are expected to be even greater.

The shortfall in existing domestic US coke production, aging of existing byproduct plants, and large expected increases in electricity prices provides a tremendous opportunity for new non-recovery coke plants within the US. These new non-recovery coke plants could also generate tremendous overall environmental improvements for the US.

### **Turing Green to Gold**

According to USEPA, non-recovery coke ovens produce significantly less air pollutant emissions per ton of coal charged than byproduct coke ovens. For example, during the byproduct coking cycle, uncontrolled organic compound emissions from the coking process occur due to the positive pressure environmental through poorly sealed doors, charge lids, off take caps, collecting main, and cracks that develop in oven brickwork. In addition, fugitive methane and other VOC emissions from chemical processing operations can be significant.

Even though non-recovery coke ovens emit less air pollutants per ton of coal charged, the non-recovery coking is significantly less costly than byproduct coking. This cost saving results primarily from lower labor input requirements per ton of coke produced and significantly lower air pollution control costs. Most importantly, non-recovery coke ovens produce waste heat that is used to generate steam that can produce large amounts of increasingly valuable electricity.

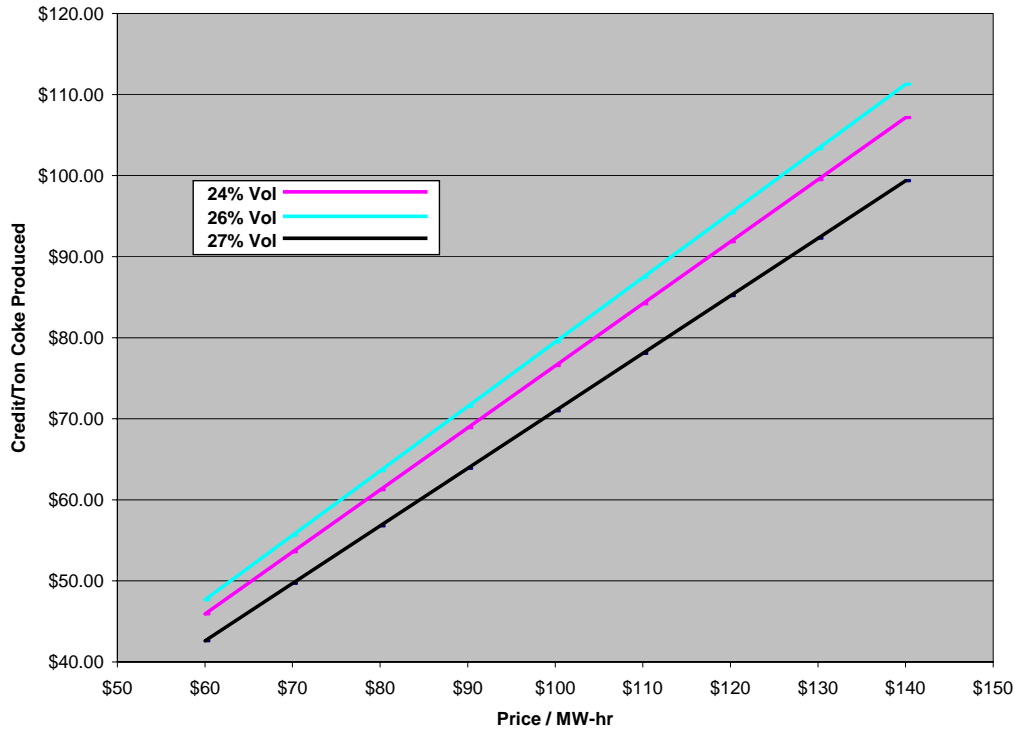
As shown in Exhibit 1, the electricity component of a non-recovery coke plant is estimated to produce from \$60 to \$80 dollars of value per ton of coke produced. Furthermore, all indicators point to increasing electricity prices in the near future. In contrast, byproduct plant COG used by steel furnaces is becoming increasingly regulated. The byproduct coke plant products such as tar, ammonia sulfate, and sulphur are also declining in prices.

### **GHG Advantages**

Based on significantly lower GHG emissions per ton of coal charged, GHG regulation does not represent a financial risk to non-recovery coke plants. In fact, US regulation of industrial GHG emissions would represent a competitive advantage and potential financial opportunity for non-recovery coke plants.

## Exhibit 1

### \$/Ton Energy Credit to Coke Production



The GHG advantage for non-recovery coke plants would also provide the US with a tremendous environmental benefit. If at least 50% of US coke was produced by non-recovery coke plants, LMG estimates that the annual reduction in direct GHG emissions from the US coking sector would be at least 150 million tons. When you add in the production of electricity the annual reduction in GHG emission increases to an estimated 175 million tons, if you assume the electricity would have been produced by coal-fired power plants.

## CONCLUSIONS

The US coking sector faces tremendous environmental challenges and opportunities in the 21<sup>st</sup> Century. Replacement of existing aging byproduct coke plants with non-recovery coke plants will allow the sector to significantly lower air pollutant emissions and produce increasing valuable electricity. This potential electrical generation represents a tremendous opportunity for the US to obtain further environmental benefits from changes in the coking sector.

## KEYWORDS

Coke, Coking, Non-recovery, Byproduct, GHG, Energy, Electricity