A pristine future for coal

Clean Coal Technologies, US, explains why coal must become cleaner and more sustainable in the coming years.

Global coal consumption increased by 60% from 5.3 billion t in 2001 to nearly 8.5 billion t in 2012.[1] Nearly 100% of the growth took place in Asia, primarily in India and China. The trend is likely to persist and flies in the face of the idea that coal is being pushed off the grid.

As world coal consumption has expanded dramatically, the entire world has become aware of the environmental consequences of burning raw coal, absent measures to clean the emissions. Air quality in China and India has declined to dangerous levels and has brought to the fore an inescapable dilemma, namely, the hard choice between clean air and economic growth. Currently, the latter appears to be winning. The politics of growth in pan-Asia indicate that air quality will not be adequately addressed without affordable enabling technologies.

Technically and economically viable processes are needed to dehydrate coal and to render the burning of it clean. Sustainable coal is not an option but an urgent necessity in a world that depends on cheap energy to support economic growth. Coal remains the most abundant and cheapest source of non-renewable energy on the planet and, as such, remains the fuel source of choice in low per capita income countries.

As an environmental company dedicated to problems associated with the use of coal, Clean Coal Technologies Inc. (CCTI) has introduced a suite of innovative pre-combustion coal treatment processes that could liberate the power industry from the heavy burden of air quality compliance. Coal should be treated before it is consumed: i.e., it should not be burned as it comes out of the ground.

CCTI technology has three distinct primary applications: dehydration of low-rank coal (LRC); the cleaning of coal for direct use as fuel with extraction of chemical byproducts for commercial sale; and the use of processed coal as a feedstock for gasification and liquefaction and coal-to-liquid (CTL) projects. Each of these three patented or patent-pending processes removes undesired moisture from coal, while two of them are also designed to remove volatile matter (VM). The CCTI process is able to reduce the coal to zero or near-zero volatiles, i.e., to carbon and hydrogen, a solution that requires the addition of hydrogen to ensure the combustion of such coal in conventional boilers with only minor adaptation. The Pristine end products can be tailored to suit boiler design and, depending on the amount of VM that is removed, costly emissions scrubbing may also be eliminated.

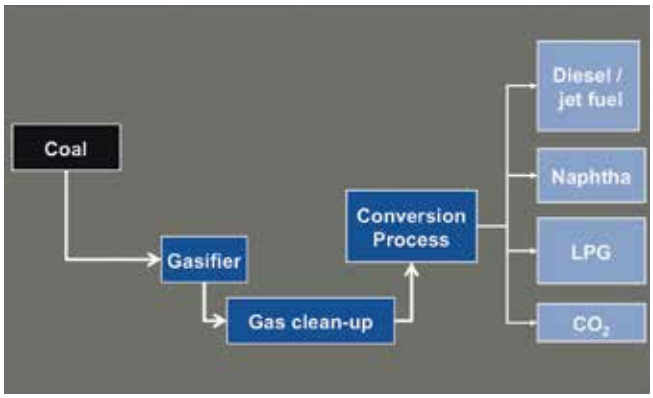

Figure 1. Conventional CTL process.

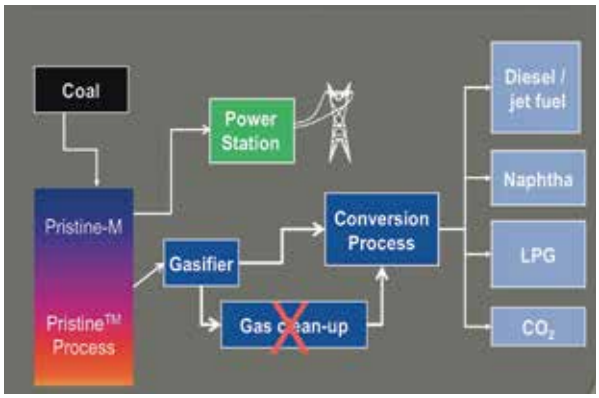

Figure 2. CTL process with Pristine-SA.

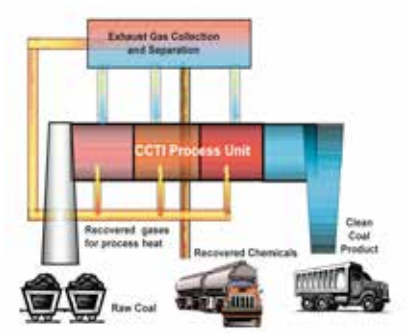

Figure 3. Pristine process removes unwanted volatiles as hydrocarbon liquids.

CCTI's processes have been developed and engineered by Leidos Inc. – formerly Science Applications International Corporation (SAIC) – an engineering company with whom CCTI has a 15-year umbrella contract.

New technology is vital to the transformation of the landscape of coal-based energy generation and environmental sustainability, as the world looks toward a new age of clean coal power generation. In large measure, CCTI's proposition is an economic one, which could have immediate implications for the coal industry – both upstream and downstream.

Technology priorities: the backdrop

As greater amounts of coal are consumed, the share of LRC in the commercial mix has grown rapidly. LRCs with high moisture are an enemy of the environment and burden the power industry with higher costs. The environmental problem is that the consumption of high moisture coal results in significantly greater tonnage of coal consumed for each kilowatt of power generated. In other words, before the first kilowatt of power is sold, the power company will have consumed a portion of coal just driving off the inherent moisture. In areas where air quality rules do not exist or are not enforced, the excessive consumption of LRCs is a problem that demands an urgent solution. In addition, the shipping of LRCs signifies paying for the transportation of water.

Looking beyond mere dehydration and elimination of unwanted volatiles, one can envision a world where coal is not consumed directly but, instead, is converted into clean gas or liquid fuels, or into non-fuel products. As shown in figures 1 and 2, CCTI's Pristine-SA process can be used as a front end to existing coal-to gas (CTL) and coal-to-liquids (CTG) processes. By eliminating moisture and VM from coal, a uniform feedstock can be made available through the Pristine™ process that could greatly reduce the cost and complexity of gasification.

When one considers China's essential problem – namely, that it has a rich endowment of LRC and a dearth of liquid fuels – it makes sense that such a country should employ technologies to convert coal into clean gas or liquid fuels with technologies such as Fischer-Tropp, in combination with CCTI's Pristine process.

The following is a summary of some of the benefits of pre-combustion technology:

- A pre-combustion, solution such as CCTI's, is preferable to post-combustion solutions, such as emissions scrubbers. The latter can be expensive and produce flue gas desulfurisation (FGD) waste containing the scrubbed compounds. FGD waste is disposed of in toxic waste sites, where it may pose continuing environmental risk. Treated coal may eliminate the need for emissions scrubbers and does not produce FGD waste.
- Reduction of toxic emissions and greenhouse gases comes about with the removal of VM that is not required for coal combustion in conventional boilers.
- CCTI makes no specific claim about CO_2 emissions. Removal of moisture and VM, by definition, reduces CO_2 emissions by requiring less coal to produce each kilowatt of electric power. The compounds that are removed from the coal each have a carbon footprint
- VM captured in the Pristine process is removed as hydrocarbon liquids and inorganic products that may be blended with crude oil, refined onsite, or used as feedstock for various products. For example, sulfur is a basic feedstock for fertiliser.
- The harvesting of hydrocarbon liquids from abundant, cheap coal may be cost effective, as compared with acquiring the compounds from expensive crude oil.
- Non-condensable gases may be captured and used for process heat in the Pristine processes.

- Energy independence: to the extent that moisture and VM is removed from coal, coal's sustainability can be greatly improved, thereby enabling the US and other coal-rich countries to use the resource to achieve energy self-sufficiency.
- Lower electricity rates: removal of moisture significantly impacts coal transport costs, particularly when dealing with high moisture coals. Elimination of emissions scrubbers by burning a clean or cleaner fuel can save substantial sums on environmental compliance. Individually or together, these should have a material impact on the ability of power producers to sustain lower rates.
- CCTI's process has been tested to be highly effective with biomass. Treated biomass can be co-fired with upgraded coal. In some parts of the world (e.g., South Korea), regulations are being considered to require co-firing of biomass with coal. Some of the largest power producers in the UK are already doing so.
- Pristine-SA treatment results in a product that, beyond being the ideal for co-firing solutions, is the basic ingredient for various products: for example, activated carbon (water filtration); carbon electrodes (aluminium); petcoke substitute; cosmetics; plastics; agriculture, etc. Coal is a cheap source of various chemicals that are less abundant in other fossil fuels.
- Exports: US western coals are known for their low sulfur content but also high moisture. The CCTI Pristine-M process is suited to upgrading these coals for export to Asian markets from the West Coast.
- Pre-combustion treatment of coal puts environmental compliance within the financial reach of smaller power companies that have been unable meet Environmental Protection Agency (EPA) emissions standards. To the extent that the companies are viable contributors to the grid, CCTI's Pristine/Pristine-SA processes could save such companies from closure.

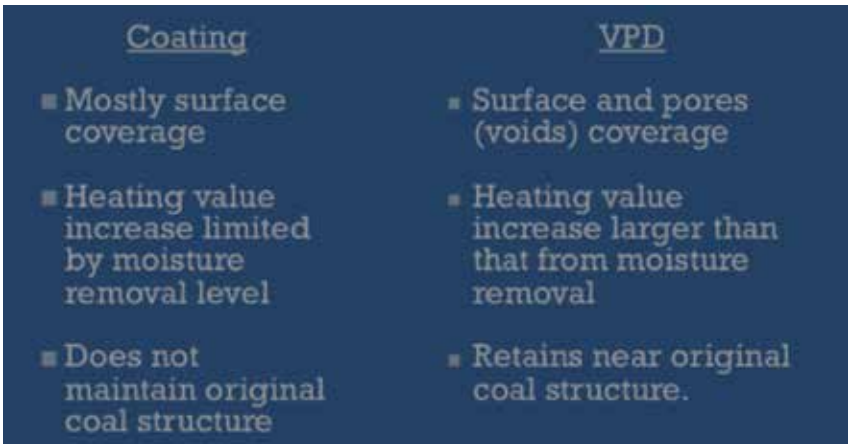

Figure 4. Coating vs vapour phase deposition (VPD).

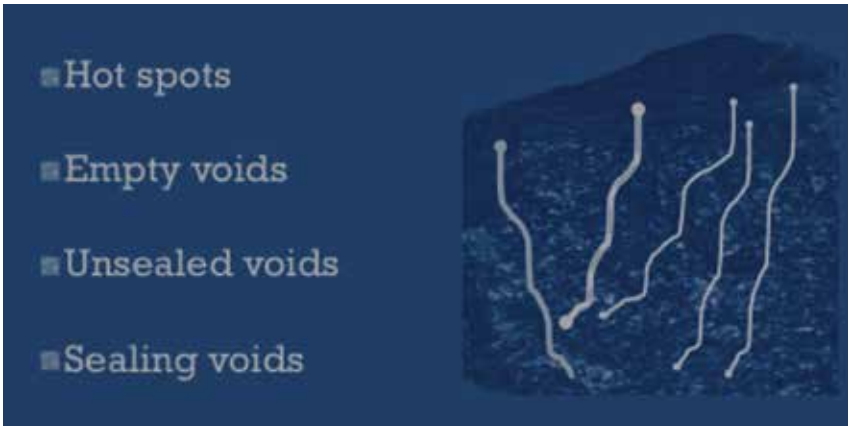

Figure 5. Reasons for product instability.

Technology overview

CCTI's patented Pristine process treats coal to improve its quality by staged heating in a controlled environment. The flow process runs coal continuously through the plant and byproducts are captured and can be sold on the secondary chemical market as a value-add. This process effectively removes moisture, volatiles, while increasing the heating value without adversely affecting the structural integrity of the coal.

Coal typically requires about 15 – 18% volatile matter to sustain combustion of its carbon components. In CCTI's newest concept, it is able to reduce the coal to zero or near-zero volatiles, i.e., to carbon and hydrogen, and have conceived a solution for the combustion of such coal in conventional boilers with only minor adaptation. Low-grade coal to be transformed via a multi-stage process into higher grade, clean burning coal on an industrial scale. The process operates at atmospheric pressure.

Pristine coal process

CCTI's coal treating process (Pristine) extracts the VM and volatile pollutants from LRC by heating coal as it transitions through several heat chambers, causing the VM to turn into gaseous form and escape from the coal, leaving behind a cleaner-burning fuel source (Figure 3). These heat chambers are infused with inert gases, primarily CO_2 or nitrogen (N), preventing the coal from combusting. Commercially, the infusing and heating of the heat chambers with inert gases will be accomplished with spent flue gas. Nitrogen separators are ideal.

By identifying the optimum combination of atmospheres, levels of inert gases, transport speed and temperatures, it is possible to quickly extract and capture VM, while maintaining the structural and chemical

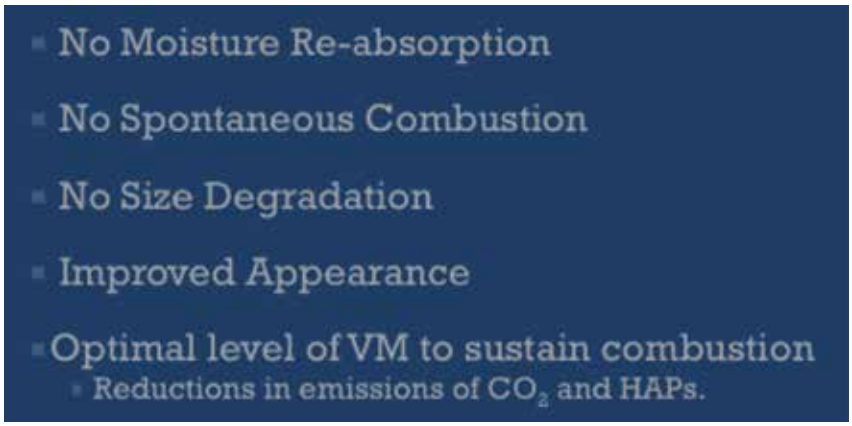

Figure 6. Pristine-M product highlights.

integrity of the coal. With the right technology, it is possible to capture the volatile gases that escape the coal, and to use some of these gases to fuel the process (process heat), while others are captured as byproducts and provide ancillary revenue streams. Depending on the characteristics of the coal being cleaned, flow-processing time is in the range of 10 – 18 min.

CCTI's process derivatives are broadly characterised by the following three elements that vary according to the source coal characteristics:

- The first stream is predominantly water (distilled) that is extracted from the coal.
- The second stream is the condensed light hydrocarbons. This represents a valuable component of the liquid products from the CCTI process. It is anticipated that this product will resemble a crude oil (potentially, a "sweetener" to blend with crude oil, if the sulfur content of the feed coal is low).
- The third stream is the heavy tar-like liquid, whose marketability is primarily focused on the asphalt and coal tar industry.

Coal-to-gas and coal-to-liquid processes

CCTI's Pristine-SA process can be used as a front-end to CTG and CTL processes. Moisture and VM content can be reduced to minimum and optimum levels. Pristine-SA provides a consistent quality of coal as feed to the gasifiers and, as unwanted contaminants are been removed through the CCTI process, hot or warm gas cleanup may be eliminated.

Beyond the potential to save on the complexity and cost of gasification, another benefit of the process is that it opens the door to a far greater variety of feed coal for gasification. At present, gasification relies on higher quality bituminous varieties of coal. The process can also work with lower-cost coals that are abundant and tend to be found in deposits that can be surfaced mined.

Coal dehydration

The Pristine-M process was developed to address the pressing need for an economical way to upgrade those coals with high moisture contents (30 – 60%), but where the reduction of VM is not requested. The process looks to further develop a concept known as vapour phase deposition (VPD).

CCTI's process addresses three fundamental challenges that have proved elusive to the majority of participants in the industrial coal-drying segment. These are the challenge of a product coal that will not re-absorb moisture; the challenge to produce a product of low friability that can be safely transported with minimal risk of spontaneous combustion; and the challenge of a process that is inexpensive and economically viable. CCTI does not pulverise the feed coal. The raw coal suffers almost no degradation and, consequently, briquetting or pelletising is not a part of the process.

During the stabilisation/VPD phase, the VM is absorbed into the pores of coal, from which the moisture has been driven off (Figures 4 and 5). To achieve the desired result, stabilisation parameters are established based on the chemical profile of the feed coal. When there are significant variations in the feed coal (structural, chemical, or inherent moisture), the CCTI drying plant is designed to handle the different coals. In the system, it is possible to run coals of different characteristics through the process simultaneously, using separate modules able to address the differences appropriately.

By using the Pristine-M process, the coal is rendered impermeable, structural integrity is maintained and the heat value of the coal may be enhanced beyond what would occur from the removal of moisture alone (Figure 6). Tests indicate the same Hardgrove Grindability Index (HGI) of the product coal as of the feed coal. The Pristine coal does not have a tendency to break in transport and also has a shelf life long enough to sustain long ocean or surface transportation and long periods in coal yards exposed to the elements.

Biomass applications

Bioenergy is growing in significance in terms of its potential for becoming a clean renewable fuel for the future. Biomass represents a huge untapped potential. CCTI has developed a technology for the efficient deployment of biomass technologies. The process, developed over the past decade, provides an opportunity to gasify biomass to produce biogas, as well as process the biomass into a clean-burning solid fuel with a high energy density. Extensive tests have been conducted on biomass, such as wood chips, lumber waste, and coconut shells with CCTI's technology, but the process may be extended to other forms of biomass such as cornhusks, stover, and sugar-cane bagasse. WC

Reference

1. US Energy Information Administration. http://www.eia.gov/cfapps/ipdb-project/iedindex3.cfm?tid=1&pid=1&aid=2&cid=regions&syid=2000&eyid=2012&unit=TST