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Clean Coal Technology

Publication No. 2009-05-E
22 July 2009
Revised 10 July 2012

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(In Brief)

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Publication No. 2009-05-E
Ottawa, Canada, Library of Parliament (2012)

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CLEAN COAL TECHNOLOGY

1 ABSTRACT

This paper provides a brief outline of clean coal technology, including the combustion and gasification methods, as well as enabling technologies such as carbon capture and sequestration.

2 BACKGROUND

The term “clean coal” is used to describe technologies that reduce the environmental footprint of coal power plants, generally through combustion or gasification processes. Additional enabling technologies such as carbon capture and sequestration, oxy-fuel combustion, combined heat and power, and upstream coal cleaning also fall under the “clean coal” umbrella. These enabling technologies, however, have applications beyond coal-fired power generation.[1]

A combination of different clean coal technologies is generally required to achieve any significant progress in cleaning up coal power generation. In addition, the efficiency and economics of coal plants and of carbon-capture techniques depend on the coal content (ash, water, carbon, etc.), which differs according to the type of coal.[2]

2.1 COMBUSTION TECHNOLOGY[3]

Most existing coal plants generate power by burning coal directly to produce steam which in turn rotates turbines that operate an electrical generator (see Appendix, Figure 1). In face of growing environmental concerns and emerging greenhouse gas regulations, improvements to the combustion technique have focused primarily on cycle efficiency and emission reduction.

There are two main types of coal combustion plants:

1. ***Pulverized coal (PC) combustion plants*:** classified in three categories according to their steam cycles: subcritical (most common and least efficient), supercritical, and ultra-supercritical (least common and most efficient). Their efficiency is directly proportional to both their temperature and pressure. Supercritical steam cycle PC plants are the favoured choice in Asia and Europe.

2. ***Fluidized bed combustion (FBC) plants*:** operate at 800–900°C using low-grade coals, biomass, and other waste fuels. Small FBC units, below 300 MW, have been successful in areas where suitable fuels exist.

2.2 GASIFICATION TECHNOLOGY

At elevated temperatures and pressures, coal gasification is a reaction between coal, steam and air (or pure oxygen) to produce raw synthesis gas (syngas – a combination of hydrogen, carbon monoxide, and impurities). In an integrated gasification combined cycle (IGCC) plant (see Appendix, Figure 2), pulverized coal and oxygen are transformed into syngas by the gasifier. The syngas passes through a heat exchanger where heat is recovered, then through a gas-cleaning unit before being expanded and burned to produce power. Additional power is produced by passing the turbine exhaust through a heat recovery steam generator (HRSG) to recover waste heat. The gas turbine produces approximately 65% of the power, while the steam turbine produces the remaining 35%.[4]

Commercial-sized IGCC plants are already available in Europe and the United States. However, there are still challenges concerning: their cost, reliability and fuel flexibility; the demonstration of the carbon monoxide / hydrogen shift reaction; and the development of hydrogen-fired turbines and fuel cell technology on a large scale.[5]

2.3 ENABLING TECHNOLOGIES

Enabling clean coal technologies can considerably reduce the carbon footprint of a given coal plant. For example, carbon capture and sequestration (CCS) could theoretically eliminate carbon dioxide emissions through post-combustion capture (most suitable for combustion plants) or pre-combustion capture (most suitable for gasification plants).

Other enabling technologies include:[6]

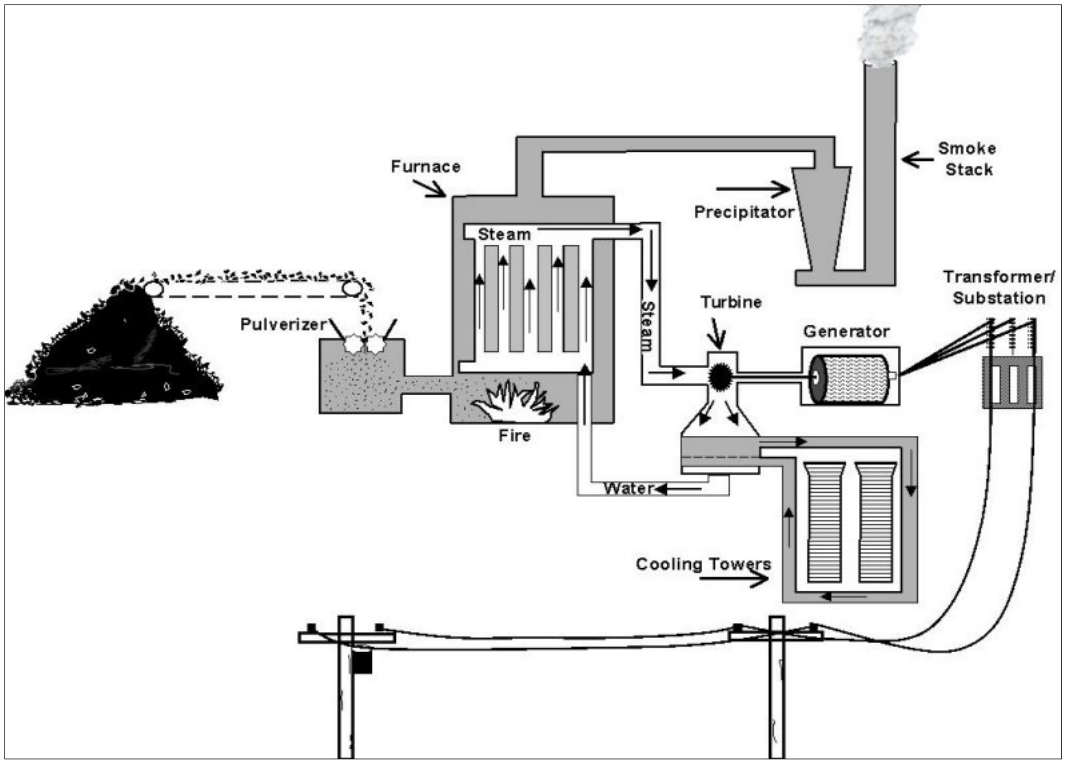
- ***Oxy-fuel combustion*:** provides an alternative to CCS whereby a carbon-dioxide-rich flue gas stream is produced and can be compressed and transported;
- ***Combined heat and power*:** recovers low-grade heat for use in process steam applications (e.g., district heating), and can raise a coal plant's efficiency to over 80%; and
- ***Upstream coal cleaning*:** performs stepwise improvements to the coal content to produce 99.8% pure coal or "ultra-clean coal."

NOTES

1. Natural Resources Canada [NRCan], CanmetENERGY, *Clean Coal Technology Roadmap*, Ottawa, 2005.
2. Kevin Bullis, "Picking a Winner in Clean-Coal Technology," *Technology Review*, March 2007.
3. NRCan (2005).
4. Ibid.
5. Ibid.
6. Ibid.

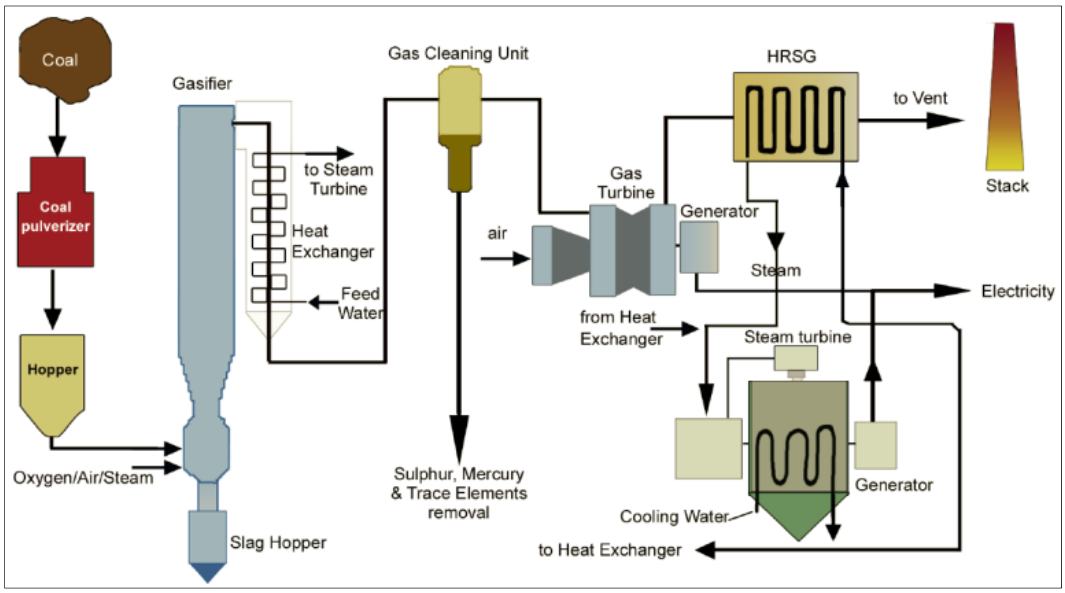
APPENDIX

Figure 1 – Conventional Coal Combustion Plant



Source: University of Kentucky.

Figure 2 – A Typical Integrated Gasification Combined Cycle Plant



Source: Natural Resources Canada, CanmetENERGY.