Environmental Case Study
Coal Gasification

Coal is by far the most abundant fossil fuel in the United States, accounting for approximately half the electricity generated each year. Concerns about acid rain, “greenhouse” gases, toxic hydrocarbons, and heavy metals released by coal combustion have raised questions, however, about continued use of coal as an energy source. Some recent advances in coal technology may change this picture dramatically. One of the most promising new technologies is the integrated gasification combined-cycle (IGCC) system developed at Stanford University. A demonstration model of this system was built by Southern California Edison Company near Barstow in the Mojave Desert in the 1980s.

Utilities initially were interested in the coal gasification process because it produces a clean-burning fuel that can be used directly in gas turbines, eliminating the need for costly and unreliable scrubbers. Sulfur and particulates are removed from the synthetic gas before it is burned, reducing emissions to less than one-tenth of existing federal air quality limits. The burning temperature of the gas is lower than in direct coal combustion so that formation of nitrogen oxides is minimized. In addition, the waste heat from gas turbines can be captured to generate steam to run a conventional steam turbine, making this integrated system not only one of the cleanest but also one of the most efficient means available to generate electric power.

Billions of dollars were spent on research and development of this technology in the 1980s, but low oil and gas prices prevented commercialization of coal gasification. Rapidly rising oil and gas prices in 2005 re-awakened interest in alternative coal technologies. The 2006 U.S. Energy Bill allocated $2 billion for a clean coal plant in Minnesota.

The system starts with a gasifier in which pulverized coal is mixed with water and partially burned at low temperatures (1,370ºC) to release hydrogen and carbon monoxide. The remaining ash solidifies to a nontoxic glasslike slag that can be disposed of in a landfill. Captured heat is used to generate steam that drives electric generator turbines. The cool synthetic gas (syngas) passes through scrubbers that convert hydrogen sulfide gas (H₂S) to elemental (solid) sulfur. Clean syngas is burned in a gas turbine to generate more electricity, and still more heat is captured to make high-pressure steam to run turbo generators. The overall efficiency of this integrated system can approach 40 percent.

Another advantage of this technology is its flexibility. An IGCC can be built in small modular units to match the load requirements of a utility system. A conventional boiler is very inefficient when run at low power loads and may suffer high maintenance costs and structural damage if it is started and stopped frequently. An IGCC can be run at one-third power by turning off two of its three gas turbines and running the remaining one at full power, thus maintaining high efficiency. Furthermore, since there is usually excess oxygen in the exhaust stream from the turbine, extra gas can be burned to boost steam generation and increase power a few percent to match load requirements more precisely. The modular units can be added to a plant one at a time in a phased construction plan that is more attractive to utilities during uncertain times than investing in a single billion dollar conventional boiler that may take five to seven years to build and not meet standards or be needed in the future.

There are also disadvantages in this new technology, however. There is no economical way to capture and dispose of the enormous amounts of CO₂ it will produce; thus, it will continue to contribute to the greenhouse effect. This process also consumes large amounts of water and may exacerbate water shortages in arid regions. Finally, without controls on mining, coal extraction will continue to pollute and scar the landscape.