Chapter 3: Fossil Fuels

Section 3.5: Coal

For additional charts and graphs related to coal-based electricity, please refer to the *Kansas Energy Chart Book*, Chapter 3 (http://kec.kansas.gov/chart_book/).

Subsection 3.51: Coal Gasification—IGCC Coal Power Plants

Topic/Issue Description

Coal is the world's most abundant and widely distributed fossil fuel resource. Some 23% of the world's primary energy needs are met by coal and 39% of the world's electricity is generated from coal. About 70% of world steel production depends on coal feedstock.

The U.S. has the world's largest coal reserves, which analysts believe are sufficient for the next 200 to 250 years.[1] In Kansas, coal is used to generate 74% of the electricity consumed, compared to 52% nationally. For the foreseeable future, coal is forecasted to remain one of the lowest-cost electric power sources in Kansas and the rest of the country.

However, coal-fired power plants are responsible for 60% of U.S. sulfur dioxide emissions, 33% of U.S. mercury emissions, and 25% of U.S. nitrogen oxide emissions. In addition to these pollutants, U.S. coal-fired power plants are also responsible for more than 33% of the nation's greenhouse gas (carbon dioxide) emissions. Worldwide, burning coal produces about 9 billion metric tons of carbon dioxide each year that is released to the atmosphere, about 70% of this being from power generation. Other estimates put carbon dioxide emissions from power generation at one quarter to one third of the world total of over 27 billion metric tons of CO_2 emissions.

The use of coal for electrical generation is growing worldwide. U.S. utility companies have announced their intention of building more than 100 new coal plants over the next 10 to 15 years. Currently, China is building the equivalent of one large coal-fired plant each week.

Given the expected 60-year life span of these plants, this new coal-fired generation could collectively release an enormous amount of carbon dioxide as well as other pollutants into the atmosphere. Development of integrated gasification combined cycle (IGCC) coal power plants in association with carbon dioxide capture and storage—not just in Kansas, but worldwide—is a vital component of any strategy to reduce emissions of greenhouse gases and other pollutants into the atmosphere.

[1] Steve Quinn, October 15, 2006, "U.S. coal plant boom poses big environmental, economic questions" (Associated Press story).

In IGCC systems, coal is not combusted directly (as it is in conventional coal-fired plants). Instead, the coal reacts with oxygen and steam to form a so-called syngas (primarily hydrogen) and solid slag (containing much of the traditional pollutants). After additional cleaning, the syngas is burned in a gas turbine to generate electricity and to produce steam to power a steam turbine.

IGCC plants have been tested as a means of using coal and steam to produce hydrogen and carbon monoxide, which are then burned in a gas turbine with secondary steam turbine (i.e., combined cycle) to produce electricity. If the gasifier is fed with oxygen rather than air, the flue gas contains highly concentrated CO_2 that can readily be captured, at about half the cost of capture from conventional plants. Ten oxygen-fired gasifiers are operational in the U.S., including one in Coffeyville, Kansas.[2]

Captured carbon dioxide (CO_2) gas is being used, on a commercial basis, for enhanced oil recovery in West Texas, where today over 1,800 miles of pipelines connect oilfields to a number of carbon dioxide sources in the region. In North Dakota, at the Great Plains Synfuels Plant, roughly 5,000 metric tons per day of CO_2 is piped 320 kilometers into Canada for enhanced oil recovery. Overall in the U.S., 32 million metric tons of CO_2 is used annually for enhanced oil recovery, about 10% of this from anthropogenic sources.

Another way to sequester CO_2 involves injection into deep, unmineable coal seams where it is adsorbed to displace methane (natural gas). This is another potential value-added use or disposal strategy. Currently, the economics of enhanced coal bed methane extraction are not as favorable as enhanced oil recovery, but the potential is considered to be large.

The scale of envisaged future CO_2 disposal far exceeds current use; however, current practices demonstrate the practicality and safety of sequestration on a small scale. Research on geologic sequestration, particularly in deep saline aquifers and depleted oil and gas fields, is ongoing. In both, the CO_2 is expected to remain as a supercritical gas for thousands of years, with some trapping by dissolution and mineral precipitation. Large-scale storage of CO_2 from power generation will require an extensive pipeline network similar in scale to the existing natural gas pipeline network.

The advantages of IGCC coal power plants that have carbon capture and storage capabilities justify the policy to support this form of generation, once the feasibility of the technologies has been demonstrated (see discussion of FutureGen below).

[2] Coffeyville Resources in Coffeyville, Kansas, uses partial oxidation gasification technology to produce approximately 413,200 short tons of ammonia, two-thirds of which is further upgraded to 663,300 short tons of Urea Ammonium Nitrate Solution (UAN) per year. The Coffeyville gasifier converts low-priced petroleum coke into a hydrogen rich synthesis gas (similar to high-BTU coal). The syngas is then converted into anhydrous ammonia; the ammonia is further upgraded into UAN in a fully integrated plant licensed from Weatherly.

Existing Policies and Programs

1. FutureGen is a project of the U.S. Department of Energy to build a "near zero-emissions" coal-fired power plant that intends to produce hydrogen and electricity while using carbon capture and storage. FutureGen will be a 275-megawatt power plant expected to take ten years to build and whose cost will be shared: $620 million by the Department of Energy and $250 million by a large industrial consortium. It will be operated as a research facility. When operational, the prototype will be the cleanest fossil fuel fired power plant in the world and will establish the technical and economic feasibility of producing electricity and hydrogen from coal, while capturing and sequestering the carbon dioxide generated in the process at an operating rate of one million metric tons per year. The DOE originally predicted it would demonstrate the IGCC and carbon capture and storage technology and have commercial designs available by 2012, but it is likely this was an overly optimistic prediction.

2. The Kyoto Protocol is an agreement made under the United Nations Framework Convention on Climate Change. Countries that ratify this protocol commit to reduce their emissions of carbon dioxide and five other greenhouse gases, or engage in emissions trading if they maintain or increase emissions of these gases. As of August, 2006, 165 countries and other governmental entities have ratified the agreement. The United States and Australia, though signatories, have not ratified the agreement.

3. Kansas House Substitute for Senate Bill 303 (passed in the 2006 Legislative session) provides (1) Kansas tax credits for expansion of existing IGCC plants; (2) property tax exemption for any new or expanded IGCC plant; and (3) KDFA revenue bonds for financing of new or expanded IGCC plants.