The Lure of Ultra-Supercritical

EXPLORING THE FUTURE OF COAL-BURNING

BY WILLIAM L. SIGMON

COAL. IT'S THE FUEL PEOPLE LOVE to hate.

Coal generates more than half of the electricity in the United States. It's used in baseload generation supplying some of the nation's least-expensive electricity. It's the most plentiful fuel source in the United States, enough to last more than 200 years at today's level of use. It's one of America's strategic energy advantages.

But burning coal emits carbon dioxide, a greenhouse gas, into the atmosphere at a time when climate change is a significant issue.

Rational people admit that coal must remain an important part of the nation's fuel mix to avoid potentially devastating economic consequences. The same rational people express concern about climate change.

It creates a difficult equation. Use less coal, but keep electricity affordable by not reducing the amount of electricity produced with coal. And reduce greenhouse gas emissions.

With the United States needing new baseload generation to replace higher-emitting plants nearing retirement and to supply the continued growth in the nation's demand for electricity, it's an equation that requires an immediate solution.

It requires new technologies.

NewsFlash

SOUTH AFRICAN SHIFT

South Africa is turning from coal generation to nuclear and renewable power, according to a report by the *Associated Press*.

Coal has generated about 90 percent of South African electricity.

Marthinus van Schalkwyk, the environment minister, said, "We are saying to business and society at large that we have to move away from dirty coal as a dominant energy source."

The cost of generating electricity from coal in South Africa is lower than most other areas of the world.

American Electric Power and others are advancing technologies to capture and store carbon dioxide emitted from existing and new coal-fired plants, but widespread implementation of these technologies is up to a decade away.

Advanced coal-fueled generating technologies provide a more immediate solution for use in new baseload generation today. AEP is a vocal advocate of two such technologies.

One – integrated-gasification combined-cycle, or IGCC – receives the most attention. Its precombustion chemical process, converting coal into a synthetic gas while removing impurities, is a radical change from coal-fired generation in use today. In AEP's view, IGCC is the best solution for new generation using the higher-BTU coals mined in the eastern United States.

But ultra-supercritical pulverized coal technology represents an equally important advancement, especially for areas relying on lower-BTU coals from the Powder River Basin. AEP has received regulatory approval to build a 600-megawatt ultra-supercritical plant in Arkansas and, as of this writing, is waiting for the necessary environmental permit to begin construction.

This will be the first ultra-supercritical power plant in the United States.

> "An ultra-supercritical coal-fired plant consumes less coal than existing plants..."

An ultra-supercritical coal-fired plant consumes less coal than existing plants to create the same amount of electricity, addressing the "less coal" half of the equation. By using less coal, the plant emits less carbon dioxide per kilowatt generated. That helps address the greenhouse gas half of the equation until carbon capture and storage systems are commercially available.

Ultra-supercritical receives less attention than IGCC because, on the surface, it isn't radically different from today's generation. The plant pulverizes coal to fuel burners that turn water to steam that drives a turbine to create electricity.

But below the surface, significant advancements make ultra-supercritical much more efficient than previous pulverized-coal technologies.

The earliest coal-fired generation, characterized as sub-critical, burned coal to bring water to a boil and used the steam to create electricity. AEP changed that in 1957 when the world's first supercritical unit – Philo Unit 6 in Ohio – began operation. Philo produced higher pressure and higher temperatures,

An artist's rendering of AEP's 600-megawatt, ultra-supercritical, coal-fueled Turk Plant planned for construction in Hempstead County, Ark.
ILLUSTRATION COURTESY OF AMERICAN ELECTRIC POWER

turning water to steam without boiling.

The improved thermodynamics of supercritical temperature, 1,000 degrees Fahrenheit, and pressure of 3,600 pounds per square inch increases efficiency.

Today, AEP's more than 17,000 megawatts of supercritical generation is North America's largest fleet of high-efficiency coal units. Many companies announcing new coal-fired generation today are using supercritical technology introduced by AEP a half century ago.

Philo was designed to operate at ultra-supercritical levels, at which even higher temperatures and pressures increase thermodynamic efficiency and reduce both coal use and emissions. Though Philo worked successfully at ultra-supercritical levels, operating at those levels could not be sustained because metals available at that time could not tolerate the extreme conditions.

Metallurgical advancements – specifically the development of chrome- and nickel-based super alloys for components exposed to high-temperature, high-pressure steam – make ultra-supercritical practical today.

AEP's ultra-supercritical plant in Arkansas, when operational, will use Powder River Basin coal and produce temperatures of 1,115 degrees Fahrenheit and pressures of 3,800 pounds per square inch, increasing the efficiency by 11 percent when compared with a supercritical plant using the same coal. The higher-cost advanced metals make an ultra-supercritical plant up to 5 percent more expensive to build than a same-sized supercritical plant, but the reduction in coal use and improved emissions profile make ultra-supercritical a better long-term value for customers, our company and the environment.

The United States has a critical need for new baseload generation. Coal must meet much of that need. But we must adopt advanced technologies to capture the positives of coal – lower electricity costs, plentiful domestic fuel source – while addressing the environmental negatives.

William L. Sigmon is American Electric Power senior vice president of engineering, projects and field services.