Integrated Pollutant Removal from Fossil-Fueled Power Plants

The path to energy security for the United States includes responsible coal combustion. Half of our nation's electricity is produced from coal, and the country has abundant coal resources—enough to last through the 23rd century. Power system research has provided modern approaches that manage environmental concerns such as sulfur and nitrogen oxides (contributors to acid rain) and mercury (a human health hazard). Carbon dioxide (CO_2), another significant by-product of coal combustion, has been increasing in the atmosphere since the dawn of industrialization. Studies over the past 10 years have linked these anthropogenic increases in CO_2 to climate change. The emerging need to manage CO_2 requires a new approach; and NETL has developed a method that, in one process, controls all the traditional pollutants and CO_2.

Oxy-fuel combustion of hydrocarbon fuel (coal, natural-gas, biomass) generates denitrified combustion gas comprising dominantly CO_2 and H_2O. The combustion gas is compressed and dried, separating non-CO_2 components from the CO_2 to produce a sequestration ready supercritical mixture, in a gas clean-up/heat recovery operation known as Integrated Pollutant Removal (IPR®™). To the extent they occur in the flue gas, mercury, sulfur and other "pollutant" compounds are removed with water as it leaves the mixture (aided as needed by reagents), or are captured with the CO_2. Nitrogen, argon and oxygen are also removed as needed, integrating IPR processes with Air Separation Unit (ASU) processes in some configurations. Heat recovery during IPR preserves thermal efficiency (see graph on back of this page). Water recovery, employing water produced in combustion and captured via IPR's heat recovery processes, is being studied with an eye toward optimizing applications for this water and accompanying treatments.

IPR technology may be combined with oxy-combustion technology on retrofits to existing plants or incorporated into novel designs for new oxy-combustion plants. In either case, these technologies are intended to enable fossil fuel utilization with ultra-low emissions. Transition from air-fired, fossil-fuel combustion to oxy-combustion requires careful examination of each required and potential change. NETL GateCycle© modeling evaluated a number of factors for their impact on thermal efficiency in a sub-critical single reheat pulverized coal power plant. The modeling showed that the greatest improvements in heat rates could be achieved through lower-energy oxygen production, elimination of flue gas desulfurization (FGD) during recycle, and recovering useful heat during exhaust gas processing.

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U.S. DEPARTMENT OF ENERGY

Researchers are examining oxy-fuel combustion with IPR gas cleanup on a systems level. Various oxy-fuel and gas cleanup concepts are being applied to existing plant and new plant designs. Advanced techniques such as computational fluid dynamics and thermodynamic cycle modeling are being used to evaluate and compare the relative effects of the various concepts. Applicability of IPR in the context of advanced and innovative power systems is also being assessed. In the context of Direct Power Extraction (a system utilizing magneto-hydrodynamics or MHD) researchers are examining the synergy of CO_2 capture in IPR with the task of recovering ionization seed-material. Workers are evaluating various configurations of seed-recovery processes integrated with the basic IPR process through modeling.

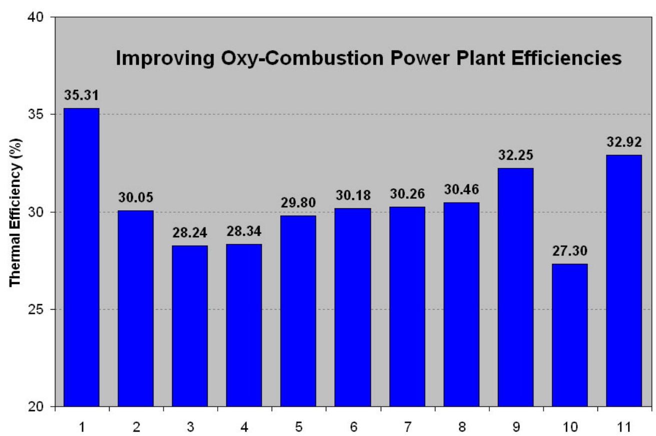
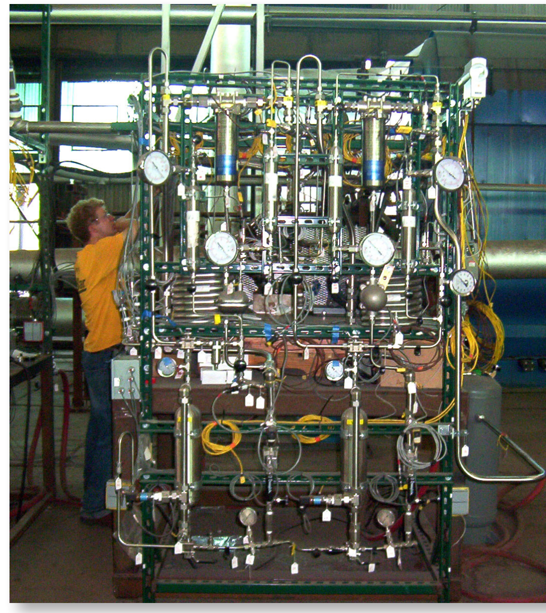


Figure from Ochs et al. Oxy-fuel Combustion and Integrated Pollutant Removal as Retrofit Technologies for Removing CO_2 from Coal Fired Power Plants. Proceedings of PowerGen International 2007.

Key to x-axis: Operational conditions or changes. Items (1) and (2) are baseline plants; items (3) through (11) are changes to the baseline oxy-combustion plant.

(1) Baseline air-combustion coal-fired power plant
(2) Baseline oxy-combustion coal-fired power plant with CO_2 capture and heat recovery
(3) Flue gas is desulfurized during recycling
(4) No heat is recovered during carbon capture
(5) Oxygen provided to combustion is reduced in purity from 99% to 95.5%
(6) Unburned carbon is reduced from 1.0% to 0.5%
(7) Amount of flue gas recycled to the boiler is reduced (increases oxygen concentration, but requires heat transfer surface modifications as part of retrofit)
(8) Reduction of excess oxygen in exhaust gas
(9) Advanced technologies require less energy for oxygen production
(10) Oxy-combustion plant with all detrimental contributions
(11) Oxy-combustion plant with all beneficial contributions



Integrated Pollutant Removal™ recovers heat from oxy-combustion flue gas, while producing streams of flue-gas water and super-critical CO_2 mixture.