Supercritical Pulverized Bituminous Coal Plant

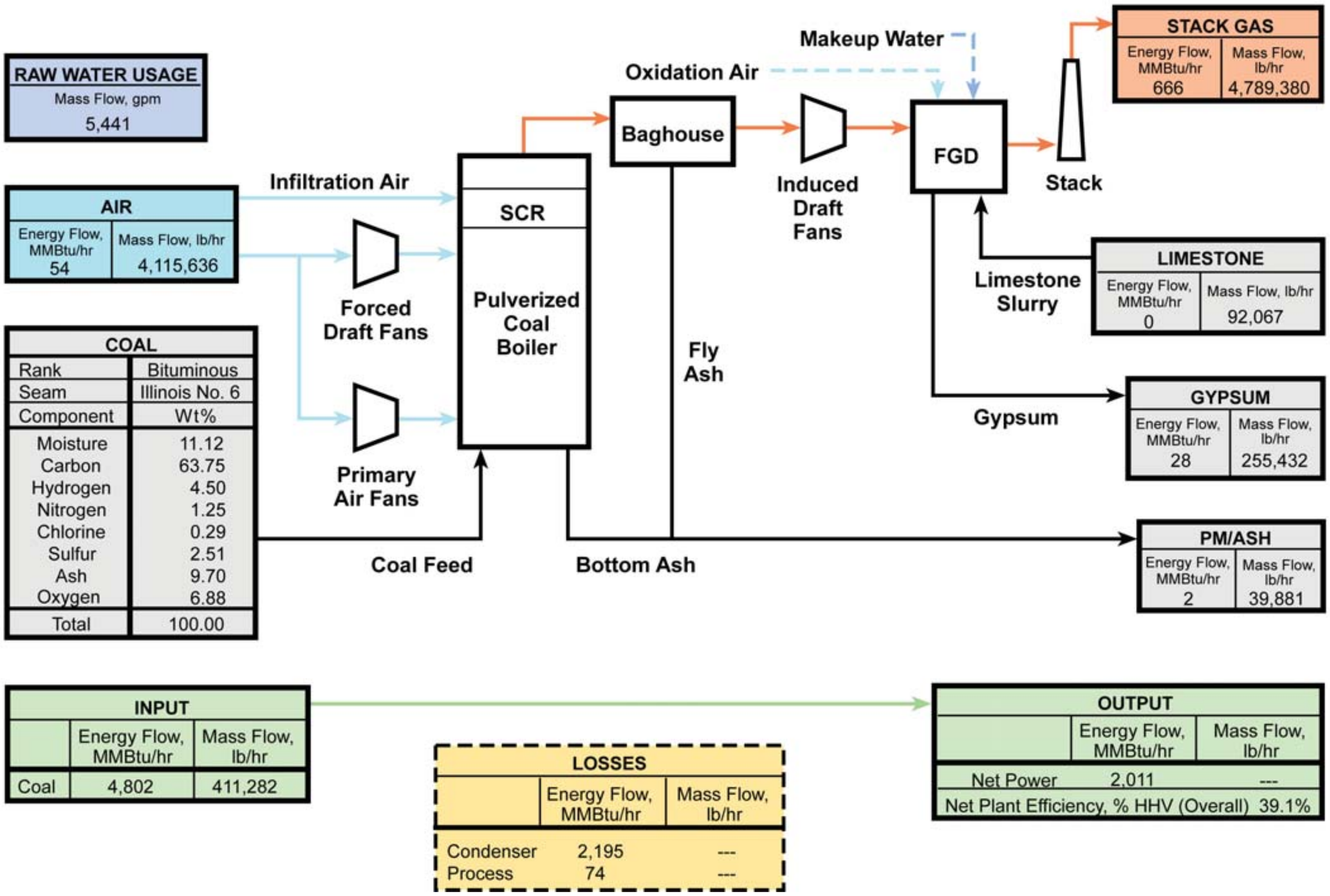
Plant Overview

This analysis is based on a 550 MWe (net power output) supercritical bituminous pulverized coal (PC) plant located at a greenfield site in the midwestern United States. This plant is designed to meet Best Available Control Technology (BACT) emission limits. The plant is a single-train design. The combination process, heat and mass balance diagram for the supercritical PC plant case is shown in Figure 1. The primary fuel is an Illinois No. 6 bituminous coal with a higher heating value (HHV) of 11,666 Btu/lb. The capacity factor (CF) for the plant is 85 percent without sparing of major train components. A summary of plant performance data for the supercritical PC plant is presented in Table 1.

Table 1. Plant Performance Summary

Plant Type	PC Supercritical
Carbon capture	No
Net power output (kWe)	550,150
Net plant HHV efficiency (%)	39.1
Primary fuel (type)	Illinois No. 6 coal
Levelized cost-of-electricity (mills/kWh) @ 85% capacity factor	63.3
Total plant cost ($ x 1,000)	$866,391

Figure 1. Process Flow Diagram
Supercritical Pulverized Coal Unit



Note: Diagram is provided for general reference of major flows only. For complete flow information, please refer to the final report.

Technical Description

The analysis for the supercritical PC plant is based on a commercially available supercritical dry-bottom, wall-fired boiler equipped with low-nitrogen oxides burners (LNBs) with over-fire air (OFA) and selective catalytic reduction (SCR). The unit is a balanced-draft, natural-circulation design equipped with a superheater, reheater, economizer, and air preheater. Hot flue gas exiting the boiler is treated by an SCR unit for nitrogen oxides (NOx) removal, a baghouse for particulate matter (PM) removal, and a wet limestone forced oxidation scrubber for sulfur dioxide (SO_2) control and co-removal of mercury (Hg). This plant utilizes a conventional steam turbine for power generation. The Rankine cycle is based on a single reheat system with steam conditions of 24.1 MPa/ 593°C/593°C (3,500 psig/1,100°F/1,100°F).

Achieving a nominal 550 MWe net output with this plant configuration results in a HHV thermal input requirement of 1,406,161 KWt (4,799 MMBtu/hr basis). This thermal input is achieved by burning coal at a rate of 411,282 lb/hr, which yields an HHV net plant heat rate of 8,721 Btu/kWh (net plant HHV efficiency of 39.1 percent). The gross power output of 580 MWe is produced from the steam turbine generator. With an auxiliary power requirement of 30 MWe, the net plant output is 550 MWe.

Environmental Performance

This study assumes the use of BACT to meet the emission requirements of the 2006 New Source Performance Standards.

The supercritical PC plant has an emission control strategy consisting of LNBs with OFA and SCR for NOx control, a pulse jet fabric filter for PM control, and a wet-limestone, forced-oxidation scrubber for SO_2 control. After NOx emissions are initially controlled through the use of LNBs and OFA, an SCR unit is used to further reduce the NOx concentration by 86 percent. Particulate emissions are controlled using a pulse jet fabric filter, which operates at an efficiency of 99.8 percent. The wet-limestone, forced-oxidation scrubber for SO_2 control achieves 98 percent removal efficiency. The byproduct, calcium sulfate, is dewatered and stored onsite. The wallboard-grade material can potentially be marketed and sold but, since it is highly dependent on local market conditions, no byproduct credit is taken. The combination of SCR, a fabric filter and wet scrubber also provides co-benefit Hg capture at an assumed 90 percent of the inlet value.

A summary of the resulting air emissions is presented in Table 2.

Table 2. Air Emissions Summary @ 85% Capacity Factor

Pollutant	PC Supercritical Without CCS
CO_2	
• tons/year	3,632,123
• lb/MMBtu	203
• cost of CO_2 avoided ($/ton)	N/A
SO_2	
• tons/year	1,514
• lb/MMBtu	0.085
NOx	
• tons/year	1,250
• lb/MMBtu	0.070
PM (filterable)	
• tons/year	232
• lb/MMBtu	0.013
Hg	
• tons/year	0.020
• lb/TBtu	1.14

Cost Estimation

Plant size, primary/secondary fuel type, construction time, total plant cost (TPC) basis year, plant CF, plant heat rate, fuel cost, plant book life, and plant in-service date are used to develop capital cost, production cost, and levelized cost-of-electricity (LCOE) estimates. Costs for the plant are based on adjusted vendor-furnished and actual cost data from recent design/build projects. Values for financial assumptions and a cost summary are shown in Table 3.

Project contingencies were added to each case to cover project uncertainty and the cost of any additional equipment that could result from detailed design. The project contingencies represent costs that are expected to occur. Project contingency was 10.7 percent for the supercritical PC case TPC. No process contingency is included in this case because all elements of the technology are commercially proven.

This study assumes that each new plant would be dispatched any time it is available and would be capable of generating maximum capacity when online. Therefore, CF is assumed to equal availability and is 85 percent for PC cases.

The 550 MWe supercritical PC plant is projected to have a TPC of $1,574/kWe, resulting in a 20-year LCOE of 63.3 mills/kWh.

Table 3. Major Financial Assumptions and Resulting Cost Summary[1]

Major Assumptions					
Case:	**1x550 MWe net Supercritical PC**				
Plant Size:	550.2	(MWe, net)	Heat Rate:	8,721	(Btu/kWh)
Primary/Secondary Fuel (type):	Illinois #6 Coal		Fuel Cost:	1.80	($/MMBtu)
Construction Duration:	3	(years)	Plant Life:	30	(years)
Total Plant Cost[2] Year:	2007	(January)	Plant in Service:	2010	(January)
Capacity Factor:	85	(%)	Capital Charge Factor:	16.4	(%)
Resulting Capital Investment (Levelized 2007 dollars)					**Mills/kWh**
Total Plant Cost					34.7
Resulting Operating Costs (Levelized 2007 dollars)[3]					**Mills/kWh**
Fixed Operating Cost					3.9
Variable Operating Cost					5.7
Resulting Fuel Cost (Levelized 2007 dollars) @ $1.80 / MMBtu					**Mills/kWh**
					19.0
Total Levelized Busbar Cost of Power (2007 dollars)					**Mills/kWh**
					63.3

[1]Costs shown can vary ± 30%.

[2]Total plant cost includes all equipment (complete with initial chemical and catalyst loadings), materials, labor (direct and indirect), engineering and construction management, and contingencies (process and project). Owner's costs are not included.

[3]No credit taken for by-product sales.

Contacts

Julianne M. Klara
Senior Analyst
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236
412-386-6089
julianne.klara@netl.doe.gov

John G. Wimer
Systems Analysis Team Lead
National Energy Technology Laboratory
3610 Collins Ferry Road
P. O. Box 880
Morgantown, WV 26507
304-285-4124
john.wimer@netl.doe.gov

Reference: Cost and Performance Baseline for Fossil Energy Plants, Vol. 1, DOE/NETL-2007/1281, May 2007.
B_PC_SUP_051507