NATIONAL ENERGY TECHNOLOGY LABORATORY

Cost and Performance Baseline for Fossil Energy Plants

Volume 3b: Low Rank Coal to Electricity: Combustion Cases

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COST AND PERFORMANCE BASELINE FOR FOSSIL ENERGY PLANTS VOLUME 3b: LOW RANK COAL TO ELECTRICITY: COMBUSTION CASES

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NETL Contact:

James B. Black

Office of Program Planning & Analysis, Performance Division

National Energy Technology Laboratory
www.netl.doe.gov

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NETL Viewpoint

Background

The goal of Fossil Energy Research, Development, and Demonstration (RD&D) is to ensure the availability of ultra-clean (“zero” emissions), abundant, low-cost, domestic electricity and energy (including hydrogen) to fuel economic prosperity and strengthen energy security. A broad portfolio of technologies is being developed within the Clean Coal Program to accomplish this objective. Ever increasing technological enhancements are in various stages of the research “pipeline,” and multiple paths are being pursued to create a portfolio of promising technologies for development, demonstration, and eventual deployment. The technological progress of recent years has created a remarkable new opportunity for coal. Advances in technology are making it possible to generate power from fossil fuels with great improvements in the efficiency of energy use while at the same time significantly reducing the impact on the environment, including the long-term impact of fossil energy use on the Earth’s climate. The objective of the Clean Coal RD&D Program is to build on these advances and bring these building blocks together into a new, revolutionary concept for future coal-based power and energy production.

Objective

To establish baseline performance and cost estimates for today’s fossil energy plants, it is necessary to look at the current state of technology. Such a baseline can be used to benchmark the progress of the Fossil Energy RD&D portfolio. This study provides an accurate, independent assessment of the cost and performance for Pulverized Coal (PC) Combustion and Circulating Fluidized Bed (CFB) Combustion with and without carbon dioxide (CO_2) capture and sequestration using both Powder River Basin (PRB) and North Dakota lignite (NDL) coals.

Approach

The power plant configurations analyzed in this study were modeled using the ASPEN Plus® (Aspen) modeling program. Performance and process limits were based upon published reports, information obtained from vendors and users of the technology, cost and performance data from design/build utility projects, and/or best engineering judgment. Capital and operating costs were estimated by WorleyParsons based on simulation results and through a combination of existing vendor quotes, scaled estimates from previous design/build projects, or a combination of the two. Operation and maintenance (O&M) costs and the cost for transporting, storing, and monitoring (TS&M) carbon dioxide (CO_2) in the cases with carbon capture were also estimated based on reference data and scaled estimates. The cost of electricity (COE) was determined for all plants assuming investor-owned utility (IOU) financing. The initial results of this analysis were subjected to a significant peer review by industry experts, academia and government research and regulatory agencies. Based on the feedback from these experts, the report was updated both in terms of technical content and revised costs.

Fossil Energy RD&D aims at improving the performance and cost of clean coal power systems including the development of new approaches to capture and sequester greenhouse gases (GHGs). Improved efficiencies and reduced costs are required to improve the competitiveness of these systems in today’s market and regulatory environment as well as in a carbon constrained scenario. The results of this analysis provide a starting point from which to measure the progress of RD&D achievements.

Table of Contents

List of Exhibits

<u>PREPARED BY</u>:

Research and Development Solutions, LLC (RDS)

<u>UPDATED BY</u>:

Energy Sector Planning and Analysis (ESPA)

Vincent H. Chou
Booz Allen Hamilton

John L. Haslbeck
formerly Booz Allen Hamilton

Allison Kyle
Booz Allen Hamilton

Norma J. Kuehn
Booz Allen Hamilton

Eric G. Lewis
Booz Allen Hamilton

Lora L. Pinkerton
WorleyParsons

Vasant Shah
Booz Allen Hamilton

Elsy Varghese
WorleyParsons

Mark C. Woods
Booz Allen Hamilton

Marc J. Turner
Booz Allen Hamilton

DOE Contract # DE-FE0004001

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John Wimer, Director of Office of Program Planning & Analysis

Jeffrey Hoffmann

James Black

Michael Matuszewski

Robert James

Robert D. Brasington
formerly of Parsons Corporation

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LIST OF ACRONYMS AND ABBREVIATIONS

AACE	Association for the Advancement of Cost Engineering
acfm	Actual cubic feet per minute
AEO	Annual Energy Outlook
BACT	Best available control technology
BEC	Bare erected cost
BFD	Block flow diagram
BFW	Boiler feed water
BLS	Bureau of Labor Statistics
Btu	British thermal unit
Btu/kWh	British thermal unit per kilowatt hour
Btu/lb	British thermal unit per pound
CAMR	Clean Air Mercury Rule
CCF	Capital Charge Factor
CDR	Carbon Dioxide Recovery
CF	Capacity factor
CFB	Circulating Fluidized Bed
CL	Closed-loop
cm	Centimeter
CO_2	Carbon dioxide
COE	Cost of electricity
CS	Carbon steel
CWP	Circulating water pump
CWS	Circulating water system
CWT	Cold water temperature
DC	Direct current
DCS	Distributed control system
DOE	Department of Energy
EAF	Equivalent availability factor
EIA	Energy Information Administration
EPA	Environmental Protection Agency
EPC	Engineer/Procure/Construct
EPCM	Engineering/Procurement/Construction Management
ft/min	Feet per minute
FD	Forced draft
FGD	Flue gas desulfurization
FOAK	First-of-a-kind
FRP	Fiberglass-reinforced plastic
ft	Foot, feet
ft, w.g.	Feet of water gauge
GADS	Generating Availability Data System
gal	Gallon
GDP	Gross domestic product

GJ	Gigajoule
GJ/hr	Gigajoule per hour
gpm	Gallons per minute
h, hr	Hour
H_2	Hydrogen
HAP	Hazardous air pollutant
Hg	Mercury
HHV	Higher heating value
HP	High pressure
HSS	Heat stable salts
HVAC	Heating, ventilating, and air conditioning
HWT	Hot water temperature
Hz	Hertz
ICR	Information Collection Request
ID	Induced draft
IEA	International Energy Agency
IGCC	Integrated gasification combined cycle
in	Inches
IOU	Investor-owned utility
IP	Intermediate pressure
ISO	International Standards Organization
ITD	Initial temperature difference
kg/GJ	Kilogram per gigajoule
kg/hr	Kilogram per hour
kJ/kg	Kilojoules per kilogram
kPa	Kilopascal absolute
kV	Kilovolt
kW	Kilowatt
kWe	Kilowatts electric
kWt	Kilowatts thermal
LAER	Lowest Achievable Emission Rate
lb	Pound
lb/hr	Pounds per hour
lb/MMBtu	Pounds per million British thermal units
lb/MWh	Pounds per megawatt hour
lb/TBtu	Pounds per trillion British thermal units
LCOE	Levelized cost of electricity
LF_{Fn}	Levelization factor for category n fixed operating cost
LF_{Vn}	Levelization factor for category n variable operating cost
LHV	Lower heating value
LNB	Low NOx burner
LP	Low-pressure
lpm	Liters per minute

m	Meters
m/min	Meters per minute
m^3/min	Cubic meter per minute
md	Millidarcy (a measure of permeability)
MCR	Maximum continuous rate
MMBtu	Million British thermal units (also shown as 10^6 Btu)
MMBtu/hr	Million British thermal units (also shown as 10^6 Btu) per hour
MMscf	Million standard cubic feet
MPa	Megapascals
MVA	Mega volt-amps
MW	Megawatts
MWe	Megawatts electric
MWh	Megawatt-hour
N/A	Not applicable
NAAQS	National Ambient Air Quality Standards
NDL	North Dakota Lignite
NEMS	National Energy Modeling System
NERC	North American Electric Reliability Council
NETL	National Energy Technology Laboratory
NOAK	N^{th}-of-a-kind
NOx	Oxides of nitrogen
NSPS	New Source Performance Standards
NSR	New Source Review
O&M	Operation and maintenance
OC_{Fn}	Category n fixed operating cost for the initial year of operation
OC_{Vnq}	Category n variable operating cost for the initial year of operation
OD	Outside diameter
OFA	Overfire air
OP/VWO	Over pressure/valve wide open
PA	Primary air
PC	Pulverized coal
PM	Particulate matter
POTW	Publicly Owned Treatment Works
ppm	Parts per million
ppmv	Parts per million volume
PRB	Powder River Basin coal region
PSD	Prevention of Significant Deterioration
psia	Pounds per square inch absolute
psig	Pounds per square inch gage
PTFE	Teflon (Polytetrafluoroethylene)
Qty	Quantity
RDS	Research and Development Solutions, LLC
RH	Reheater

SC	Supercritical
scfm	Standard cubic feet per minute
SCR	Selective catalytic reduction process or equipment
SDA	Spray dryer absorber
SO_2	Sulfur dioxide
SOx	Oxides of sulfur
SNCR	Selective non-catalytic reduction process or equipment
SS	Stainless steel
STG	Steam turbine generator
tonne	Metric ton (1000 kg)
TOC	Total overnight cost
TPC	Total plant cost
tpd	Tons per day
tph	Tons per hour
TS&M	Transport, storage and monitoring
USC	Ultra-supercritical
WB	Wet bulb
wt%	Weight percent

EXECUTIVE SUMMARY

The objective of this report is to present an accurate, independent assessment of the cost and performance of Low-Rank Coal-Fired Power Systems, specifically pulverized coal (PC) and circulating fluidized bed (CFB) plants, using a consistent technical and economic approach that accurately reflects current or near term market conditions. This document is Volume 3b of the Low Rank Coal Baseline Reports, which are part of a four volume series consisting of the following:

- Volume 1: Bituminous Coal and Natural Gas to Electricity
- Volume 2: Coal to Synthetic Natural Gas and Ammonia (Various Coal Ranks)
- Volume 3: Low Rank Coal and Natural Gas to Electricity
- Volume 4: Bituminous Coal to Liquid Fuels with Carbon Capture

The cost and performance of the various fossil fuel-based technologies will most likely determine which combination of technologies will be utilized to meet the demands of the power market. Selection of new generation technologies will depend on many factors, including:

- Capital and operating costs
- Overall energy efficiency
- Fuel prices
- Cost of electricity (COE)
- Availability, reliability, and environmental performance
- Current and potential regulation of air, water, and solid waste discharges from fossil-fueled power plants.
- Market penetration of clean coal technologies that have matured and improved as a result of recent commercial-scale demonstrations under the Department of Energy's (DOE) Clean Coal Programs

Twelve combustion power plant configurations were analyzed as listed in Exhibit ES-1. The list includes four PC cases, two supercritical (SC) and two ultra-supercritical (USC), with and without carbon dioxide (CO_2) capture; and two CFB plants with and without CO_2 capture.

The methodology included performing steady-state simulations of the various technologies using the Aspen Plus® (Aspen) modeling software. The resulting mass and energy balance data from the Aspen model were used to size major pieces of equipment. These equipment sizes formed the basis for cost estimating. Performance and process limits were based upon published reports, information obtained from vendors and users of the technology, performance data from design/build utility projects, and/or best engineering judgment. Capital and operating costs were estimated based on simulation results and through a combination of vendor quotes, scaled estimates from previous design/build projects, or a combination of the two. Baseline fuel costs for this analysis were determined using data from the Energy Information Administration's (EIA) 2008 Annual Energy Outlook (AEO). The first year of capital expenditure (2007) delivered costs used are \$0.84/gigajoule (GJ) (\$0.89/million British thermal unit [MMBtu]) for

Powder River Basin (PRB) coal and \$0.79/GJ (\$0.83/MMBtu) for North Dakota Lignite (NDL), both on a higher heating value (HHV) basis and in June 2007 United States (U.S.) dollars.

Exhibit ES-1 Case Descriptions

Case	Unit Cycle	Steam Cycle, psig/°F/°F	Boiler Technology	Coal	NOx Control	Sulfur Removal[1]	CO_2 Separation
S12A	PC	3500/1100/1100	SC PC	PRB	LNB + SCR	Spray Dryer FGD	-
L12A	PC	3500/1100/1100	SC PC	Lignite	LNB + SCR	Spray Dryer FGD	-
S12B	PC	3500/1100/1100	SC PC	PRB	LNB + SCR	Spray Dryer FGD	Amine Absorber
L12B	PC	3500/1100/1100	SC PC	Lignite	LNB + SCR	Spray Dryer FGD	Amine Absorber
S13A	PC	4000/1200/1200	USC PC	PRB	LNB + SCR	Spray Dryer FGD	-
L13A	PC	4000/1200/1200	USC PC	Lignite	LNB + SCR	Spray Dryer FGD	-
S13B	PC	4000/1200/1200	USC PC	PRB	LNB + SCR	Spray Dryer FGD	Amine Absorber
L13B	PC	4000/1200/1200	USCPC	Lignite	LNB + SCR	Spray Dryer FGD	Amine Absorber
S22A	CFB	3500/1100/1100	SC CFB	PRB	SNCR	in-bed limestone	-
L22A	CFB	3500/1100/1100	SC CFB	Lignite	SNCR	in-bed limestone	-
S22B	CFB	3500/1100/1100	SC CFB	PRB	SNCR	in-bed limestone	Amine Absorber
L22B	CFB	3500/1100/1100	SC CFB	Lignite	SNCR	in-bed limestone	Amine Absorber

[1] In CO_2 capture cases a polishing scrubber is used to reduce SO_2 concentrations to less than 10 ppmv prior to the CO_2 absorber.

All plant configurations were evaluated based on installation at a greenfield site (Montana for PRB cases and North Dakota for NDL cases). Since these are state-of-the-art plants, they will have higher efficiencies than the average power plant population. Consequently, these plants would be expected to be near the top of the dispatch list and the study capacity factor (CF) is chosen to reflect the maximum availability demonstrated for the specific plant type, i.e., 85 percent for both PC and CFB configurations. Since variations in fuel costs and other factors can influence dispatch order and CF, sensitivity of COE to CF is evaluated and presented later in this Executive Summary (Exhibit ES-9).

The nominal net plant output for this study was set at 550 megawatts (MW). The boilers and steam turbines in the combustion cases are readily available in a wide range of capacities. Higher auxiliary load and extraction steam requirements in CO_2 capture cases are accommodated in the PC and CFB cases by using larger boilers and steam turbines.

Exhibit ES-2 shows the cost, performance, and environmental profile summary for all cases.

Exhibit ES-2 Cost and Performance Summary and Environmental Profile for Combustion Cases

	Supercritical Pulverized Coal Boiler				Ultra-supercritical Pulverized Coal Boiler				Supercritical CFB			
PERFORMANCE	**S12A**	**L12A**	**S12B**	**L12B**	**S13A**	**L13A**	**S13B**	**L13B**	**S22A**	**L22A**	**S22B**	**L22B**
CO_2 Capture	0%	0%	90%	90%	0%	0%	90%	90%	0%	0%	90%	90%
Gross Power Output (kW_e)	582,700	584,700	673,000	683,900	581,500	583,200	665,400	675,200	578,400	578,700	664,000	672,900
Auxiliary Power Requirement (kW_e)	32,660	34,640	122,940	133,850	31,430	33,170	115,320	125,170	28,330	28,670	113,990	122,820
Net Power Output (kW_e)	550,040	550,060	550,060	550,050	550,070	550,030	550,080	550,030	550,070	550,030	550,010	550,080
Coal Flowrate (lb/hr)	566,042	755,859	811,486	1,110,668	549,326	731,085	764,212	1,043,879	563,307	745,997	801,270	1,095,812
HHV Thermal Input (kW_{th})	1,420,686	1,465,801	2,036,717	2,153,863	1,378,732	1,417,757	1,918,067	2,024,343	1,413,821	1,446,676	2,011,075	2,125,054
Net Plant HHV Efficiency (%)	38.7%	37.5%	27.0%	25.5%	39.9%	38.8%	28.7%	27.2%	38.9%	38.0%	27.3%	25.9%
Net Plant HHV Heat Rate (Btu/kWh)	8,813	9,093	12,634	13,361	8,552	8,795	11,898	12,558	8,770	8,975	12,476	13,182
Raw Water Withdrawal (gpm/MW_{net})	4.8	4.9	13.9	14.2	4.7	4.7	12.9	13.2	4.4	4.3	14.1	14.5
Process Water Discharge (gpm/MW_{net})	1.0	1.0	3.8	4.3	1.0	1.0	3.6	4.0	1.0	1.0	3.7	4.2
Raw Water Consumption (gpm/MW_{net})	3.8	3.9	10.0	9.9	3.7	3.7	9.3	9.2	3.3	3.3	10.4	10.4
CO_2 Emissions (lb/MMBtu)	215	219	21	22	215	219	21	22	213	219	21	22
CO_2 Emissions (lb/MWh_{gross})	1,786	1,877	222	236	1,737	1,820	211	225	1,775	1,865	220	236
CO_2 Emissions (lb/MWh_{net})	1,892	1,996	271	293	1,836	1,930	255	276	1,866	1,963	265	288
SO_2 Emissions (lb/MMBtu)	0.119	0.132	0.002	0.002	0.119	0.132	0.002	0.002	0.102	0.113	0.002	0.002
SO_2 Emissions (lb/MWh_{gross})	0.990	1.130	0.020	0.020	0.960	1.100	0.020	0.020	0.850	0.970	0.020	0.020
NOx Emissions (lb/MMBtu)	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070
NOx Emissions (lb/MWh_{gross})	0.582	0.599	0.723	0.752	0.566	0.581	0.689	0.716	0.584	0.597	0.723	0.754
PM Emissions (lb/MMBtu)	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
PM Emissions (lb/MWh_{gross})	0.108	0.111	0.134	0.140	0.105	0.108	0.128	0.133	0.108	0.111	0.134	0.140
Hg Emissions (lb/TBtu)	0.597	1.121	0.597	1.121	0.597	1.121	0.597	1.121	0.302	0.482	0.302	0.482
Hg Emissions (lb/MWh_{gross})	4.96E-06	9.59E-06	6.16E-06	1.20E-05	4.83E-06	9.29E-06	5.87E-06	1.15E-05	2.52E-06	4.11E-06	3.12E-06	5.19E-06
COST												
Total Plant Cost (2007$/kW)	1,879	2,041	3,268	3,560	1,972	2,156	3,322	3,588	1,932	2,042	3,295	3,533
Total Overnight Cost (2007$/kW)	2,293	2,489	3,987	4,341	2,405	2,628	4,049	4,372	2,357	2,490	4,018	4,307
Bare Erected Cost	1,530	1,663	2,517	2,750	1,577	1,725	2,530	2,738	1,480	1,563	2,424	2,600
Home Office Expenses	145	157	238	261	149	163	239	259	141	149	230	247
Project Contingency	204	220	406	438	213	231	408	437	210	221	407	435
Process Contingency	0	0	107	112	33	37	144	154	102	110	233	251
Owner's Costs	414	448	718	781	433	472	727	783	425	448	722	773
Total Overnight Cost (2007$ x 1,000)	1,261,175	1,369,100	2,192,877	2,387,887	1,322,909	1,445,367	2,227,086	2,404,506	1,296,474	1,369,642	2,209,764	2,368,935
Total As Spent Capital (2007$/kW)	2,600	2,823	4,545	4,949	2,742	2,996	4,615	4,984	2,687	2,839	4,580	4,909
COE (mills/kWh, 2007$)[1]	57.8	62.2	107.5	116.4	62.2	67.3	107.7	115.4	61.5	64.6	108.0	115.2
CO_2 TS&M Costs	0.0	0.0	6.0	6.2	0.0	0.0	5.8	6.0	0.0	0.0	5.9	6.1
Fuel Costs	7.8	7.5	11.2	11.0	7.6	7.3	10.6	10.4	7.8	7.4	11.1	10.9
Variable Costs	5.1	6.1	9.3	11.0	5.1	6.1	9.0	10.3	5.3	6.1	9.5	11.0
Fixed Costs	9.0	9.7	14.5	15.7	9.3	10.1	14.7	15.8	9.1	9.5	14.5	15.4
Capital Costs	35.9	39.0	66.5	72.4	40.1	43.9	67.6	73.0	39.3	41.6	67.0	71.9
LCOE (mills/kWh, 2007$)[1]	73.3	78.8	136.3	147.5	78.8	85.3	136.5	146.3	78.0	81.9	136.9	146.0

[1] COE and Levelized COE are defined in Section 2.6

Energy Efficiency

The net plant efficiency (HHV basis) for all 12 cases is shown in Exhibit ES-3. There are competing effects that impact efficiency: the more aggressive USC steam conditions increase efficiency relative to SC conditions; poorer quality lignite coal decreases efficiency relative to PRB coal; and CFB technology increases efficiency relative to PC primarily because of the lower boiler exit temperature enabled by in-bed limestone injection (eliminates acid dew point concerns). The primary conclusions that can be drawn are:

- The USC PC with no CO_2 capture and PRB coal has the highest net efficiency of the technologies modeled in this study with an efficiency of 39.9 percent.
- The USC PC case with CO_2 capture and PRB coal results in the highest efficiency (28.7 percent) among all of the capture technologies.
- CO_2 capture results in an efficiency penalty of 11 to 12 absolute percent, relative to the non-capture case for all the technologies.
- The relative efficiency penalty also varies over a narrow range, from 28 to 32 percent. The relative penalty is lowest for the USC PC cases and nearly equal for the SC PC and SC CFB cases for both coal types.

Water Use

Three water values are presented for each technology in Exhibit ES-4: raw water withdrawal, process discharge, and raw water consumption. Each value is normalized by net output. Raw water withdrawal is the difference between demand and internal recycle. Demand is the amount of water required to satisfy a particular process (cooling tower makeup, flue gas desulfurization [FGD] makeup, etc.) and internal recycle is water available within the process. Raw water withdrawal is the water removed from the ground or diverted from a surface-water source for use in the plant. Raw water consumption is the portion of the raw water withdrawn that is evaporated, transpired, incorporated into products or otherwise not returned to the water source it was withdrawn from. Raw water consumption is the difference between withdrawal and process discharge, and it represents the overall impact of the process on the water source, which in this study is considered to be 50 percent from groundwater (wells) and 50 percent from a municipal source. The largest consumer of raw water in all cases is cooling tower makeup. Since plants located in the Western U.S. need to consider limited water supplies, a parallel wet/dry condenser was chosen for all plant configurations. In a parallel cooling system half of the turbine exhaust steam is condensed in an air-cooled condenser and half in a water-cooled condenser. The cooling water is provided by a mechanical draft, evaporative cooling tower. The primary conclusions that can be drawn are:

- Among non-capture cases the normalized water withdrawal and consumption of the USC PC cases are slightly less than the SC PC cases primarily because of the higher USC net efficiency. The same is true for both coal types.
- Also among non-capture cases the normalized withdrawal and consumption is lowest for SC CFB cases for both coal types. The CFB cases have reduced water demand because of using in-bed limestone injection for SO_2 control in place of a spray dryer FGD system.

Exhibit ES-3 Net Plant Efficiency (HHV Basis)

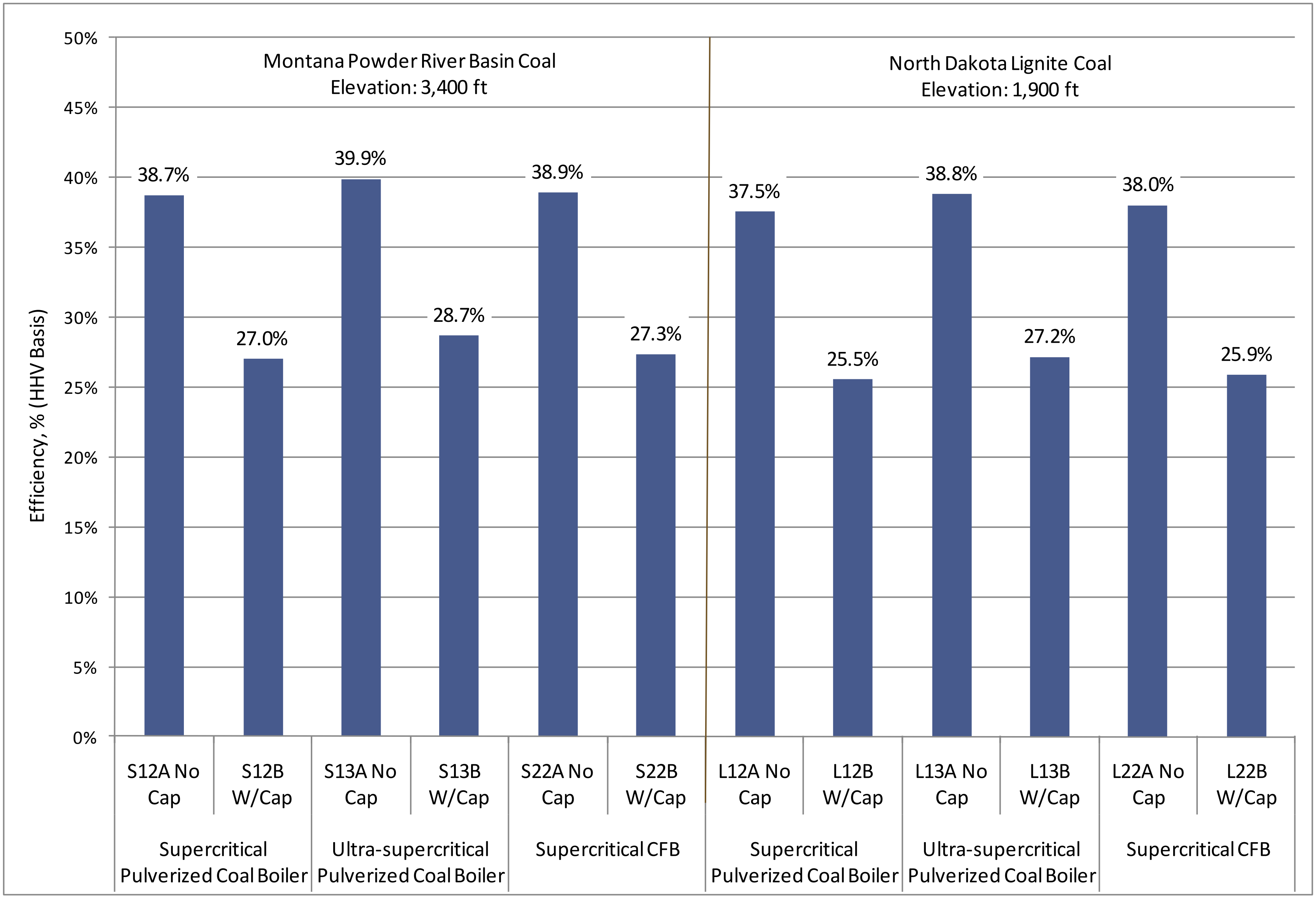
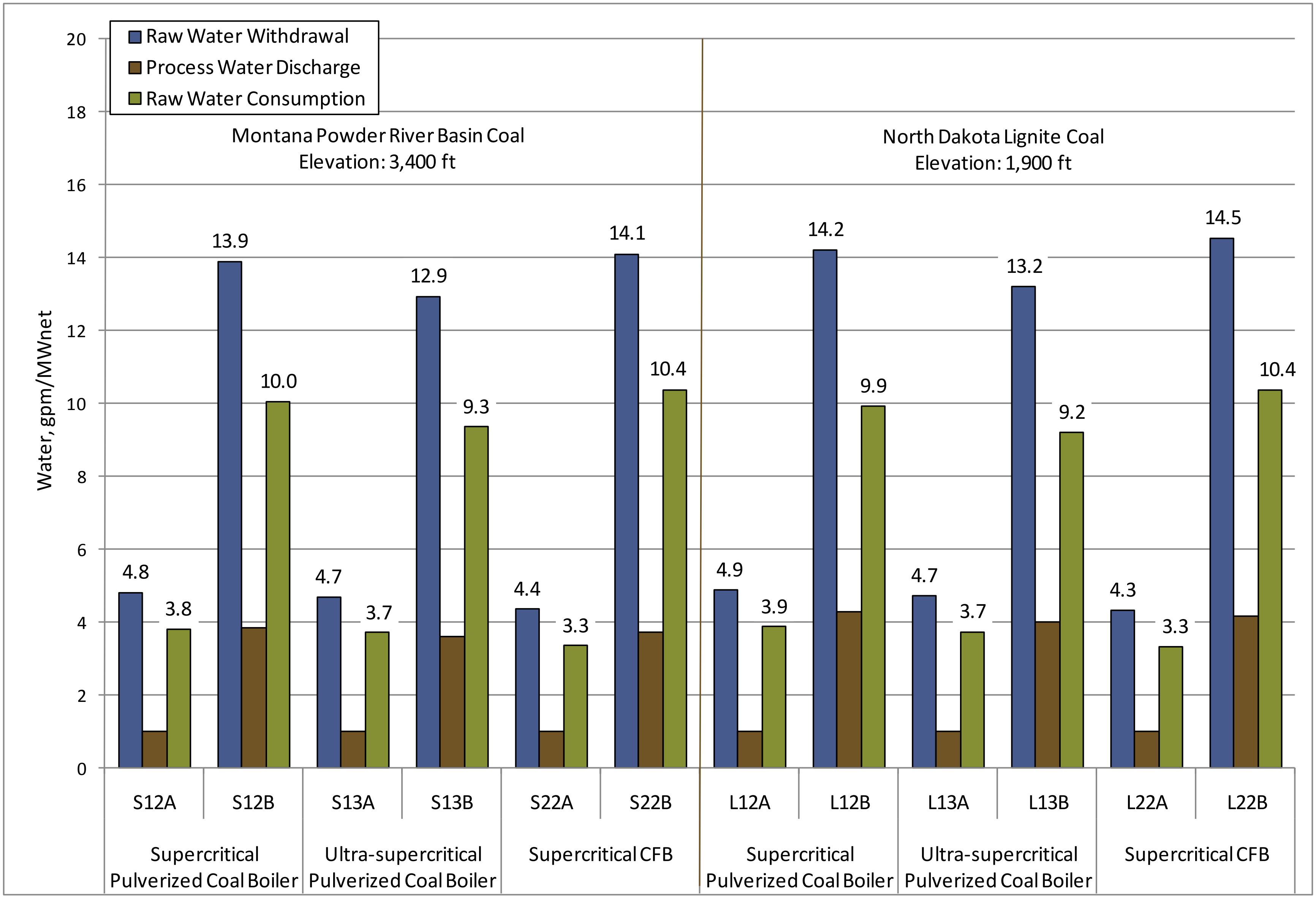


Exhibit ES-4 Raw Water Withdrawal and Consumption



- For CO_2 capture cases normalized water withdrawal is on average 3 times greater than the analogous non-capture case and normalized consumption is on average 2.7 times greater than the analogous non-capture case. The CO_2 capture process, Econamine FG Plus^{SM}, requires a significant amount of cooling water that is provided by an evaporative cooling tower, resulting in greatly increased water demand.
- Also for CO_2 capture cases normalized water consumption is nearly constant within each coal type because much of the water withdrawal is for the cooling tower makeup and 90 percent of the blowdown is returned to the source as process discharge.

Cost Results

The Total Plant Cost (TPC) for each technology was determined through a combination of vendor quotes, scaled estimates from previous design/build projects, or a combination of the two. TPC 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, including preproduction costs, inventory capital, initial cost for catalyst and chemicals, land, financing costs and other owner's costs were added to TPC to generate total overnight cost (TOC). Property taxes and insurance were included in the fixed operating costs as an additional owner's cost. Escalation and interest on debt during the capital expenditure period were estimated and added to the TOC to provide the Total As-Spent Cost (TASC).

The cost estimates carry an accuracy of -15/+30%, consistent with a "feasibility study" level of design engineering applied to the various cases in this study. The value of the study lies not in the absolute accuracy of the individual case results, but in the fact that all cases were evaluated under the same set of technical and economic assumptions. This consistency of approach allows meaningful relative comparisons among the cases evaluated.

Project contingencies were added to the Engineering/Procurement/Construction Management (EPCM) capital accounts to cover project uncertainty and the cost of any additional equipment that would result from a detailed design. The contingencies represent costs that are expected to occur. Each bare erected cost (BEC) account was evaluated against the level of estimate detail and field experience to determine project contingency. Process contingency was added to cost account items that were deemed to be first-of-a-kind (FOAK) or posed significant risk due to lack of operating experience. The cost accounts that received a process contingency include:

- Fluor Econamine FG Plus^{SM} (Econamine) CO_2 Removal System – 20 percent on all capture cases - unproven technology at commercial scale in PC service.
- USC Boiler and Steam Turbine – 5 percent. A contingency of only 5 percent was used since the advanced material requirements for the steam turbine and boiler only impact a fraction of the equipment cost.
- Instrumentation and Controls – 5 percent on all accounts for CO_2 capture cases.
- CFB Boiler – 15 percent. A contingency of 15 percent was used since the boiler in this study is significantly larger than any current CFB units, which typically have a maximum capacity in the range of 300 to 350 MW per boiler. The Lagisza plant in Poland is a 460 MW SC CFB and started operation in the summer of 2009 [1]. The CFB's in this study

have a gross output ranging from 580-670 MW per boiler, making these cases truly FOAK.

The normalized components of TOC and overall TASC are shown for each plant configuration in Exhibit ES-5. The following conclusions can be drawn:

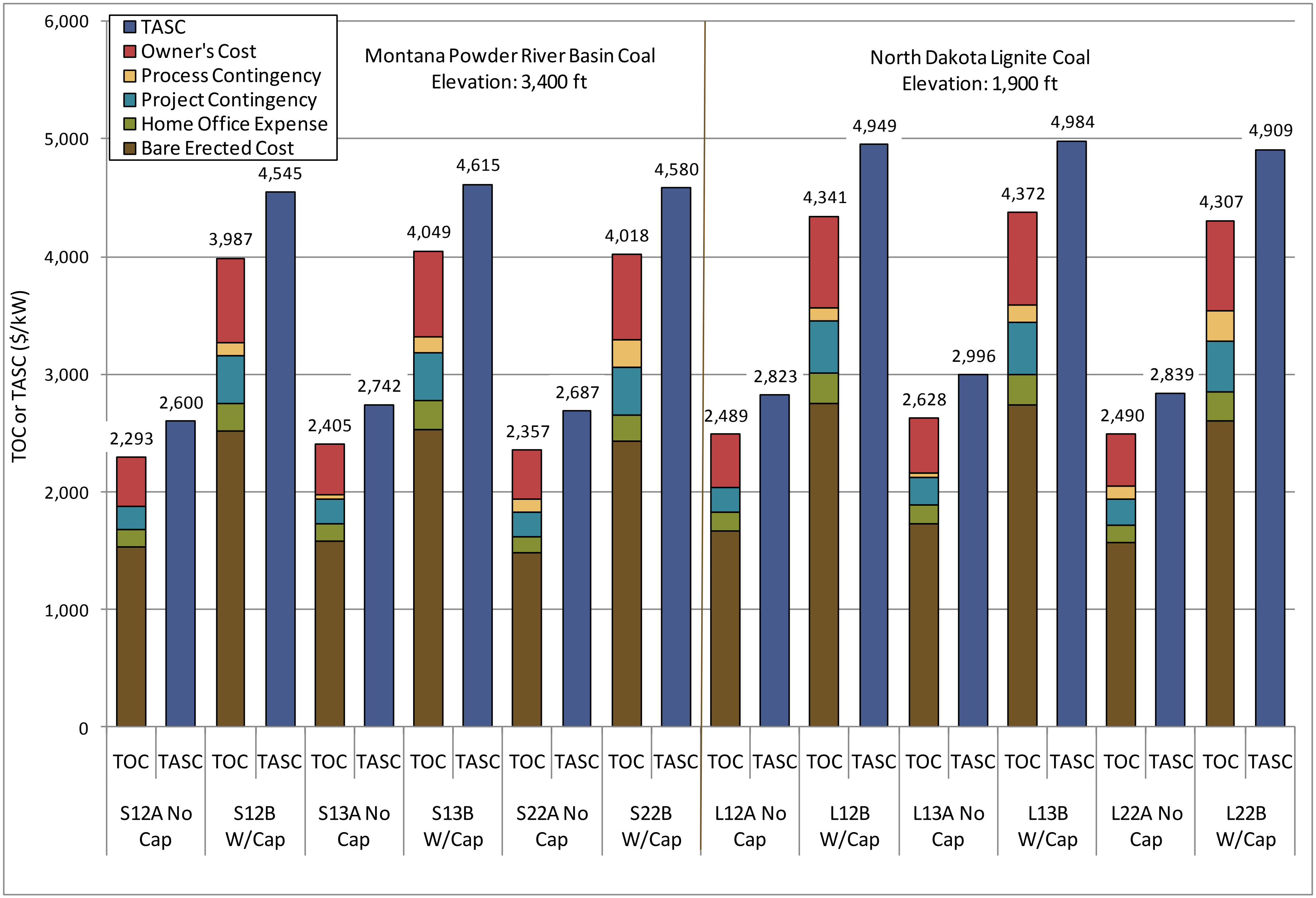
- For the SC PC cases the TOC is higher for the NDL coal cases as compared to the PRB coal cases: approximately 8.7 percent for both the non-capture and CO_2 capture case.
- For the SC PC cases the TOC increase to add CO_2 capture is approximately 74 percent for both the PRB and NDL cases.
- For the USC PC cases the TOC is also higher for the NDL coal cases as compared to the PRB coal cases: approximately 9 percent for the non-capture case and 8 percent for the CO_2 capture case.
- For the USC PC cases the TOC increase to add CO_2 capture is approximately 68 percent for the PRB case and 66 percent for the NDL case.
- Following the same trend as the SC PC and USC PC cases, for the SC CFB cases the TOC is higher for the NDL coal cases as compared to the PRB coal cases: approximately 5.6 percent for the non-capture case and 7.2 percent for the CO_2 capture case. The NDL cases have consistently higher TOC because of higher coal feed associated with lower boiler efficiency.
- For the SC CFB cases the TOC increase to add CO_2 capture is approximately 70 percent for the PRB case and 73 percent for the NDL case.

<u>Cost of Electricity</u>

The cost metric used in this study is the COE, which is the revenue received by the generator per net megawatt-hour during the power plant's first year of operation, *assuming that the COE escalates thereafter at a nominal annual rate equal to the general inflation rate, i.e., that it remains constant in real terms over the operational period of the power plant*. To calculate the COE, the Power Systems Financial Model (PSFM) [2] was used to determine a "base-year" (2007) COE that, when escalated at an assumed nominal annual general inflation rate of 3 percent[1], provided the stipulated internal rate of return on equity over the entire economic analysis period (capital expenditure period plus thirty years of operation). The first year capital charge factor (CCF) shown in Exhibit ES-6, which was derived using the PSFM, can also be used to calculate COE using a simplified equation as detailed in Section 2.6.4.

[1] This nominal escalation rate is equal to the average annual inflation rate between 1947 and 2008 for the U.S. Department of Labor's Producer Price Index for Finished Goods. This index was used instead of the Producer Price Index for the Electric Power Generation Industry because the Electric Power Index only dates back to December 2003 and the Producer Price Index is considered the "headline" index for all of the various Producer Price Indices.

Exhibit ES-5 Plant Capital Costs



Note: TOC expressed in 2007 dollars. TASC expressed in mixed-year 2007 to 2011 year dollars.

The project financial structure varies depending on the type of project (high risk or low risk). All cases were assumed to be undertaken at investor owned utilities (IOUs). High risk projects are those in which commercial scale operating experience is limited. The USC PC and CFB cases (with and without CO_2 capture) and SC PC cases with CO_2 capture were considered to be high risk and the non-capture SC PC cases were considered to be low risk. All cases were assumed to have a 5 year capital expenditure period. The current-dollar, 30-year levelized cost of electricity (LCOE) was also calculated and is shown in Exhibit ES-2, but the primary metric used in the balance of this study is COE. A more detailed discussion of the two metrics is provided in Section 2.6 of the report.

Exhibit ES-6 Economic Parameters Used to Calculate COE

	High Risk (5 year capital expenditure period)	Low Risk (5 year capital expenditure period)
First Year Capital Charge Factor	0.1243	0.1165

Commodity prices fluctuate over time based on overall economic activity and general supply and demand curves. While the cost basis for this study is June 2007, many price indices had similar values in January 2010 compared to June 2007. For example, the Chemical Engineering Plant Cost Index was 532.7 in June 2007 and 532.9 in January 2010, and the Gross Domestic Product Chain-type Price Index was 106.7 on July 1, 2007 and 110.0 on January 1, 2010. Hence the June 2007 dollar cost base used in this study is expected to be representative of January 2010 costs.

The COE results are shown in Exhibit ES-7 with the capital cost, fixed operating cost, variable operating cost, and fuel cost shown separately. In the capture cases, the CO_2 Transport, Storage and Monitoring (TS&M) costs are also shown as a separate bar segment. The following conclusions can be drawn:

- The COE is dominated by capital charges in all cases. The capital cost component of COE comprises 62-63 percent in all four SC PC cases, 63-65 percent in all four USC PC cases, and 62-64 percent in all four CFB cases.
- The fuel cost component is relatively minor in all cases, representing 10-14 percent of the COE costs in the PRB cases and 9-12 percent in the NDL cases.
- For each coal type and CO_2 capture scenario, the COE is lowest for the more conventional technology (SC PC) compared to the more advanced technologies (USC PC and SC CFB). The only exception is for NDL coal with CO_2 capture where USC PC and SC CFB have a very slight cost benefit because of the higher USC efficiency.
- The TS&M component of COE in the CO_2 capture cases is 5-6 percent for both PRB and NDL coal.
- The COE is 5-8 percent lower in both the CO_2 capture and non-capture PRB cases compared to the NDL coal cases because of higher efficiencies resulting in lower plant costs.

Exhibit ES-8 shows the COE sensitivity to coal costs. All cases show a linear increase in COE with an increase in coal prices. The slopes of the lines are relatively shallow, as expected given the small fraction of total COE represented by fuel costs.

The sensitivity of COE to CF is shown in Exhibit ES-9. The baseline CF is 85 percent for all cases. The curves plotted in Exhibit ES-9 assume that CF could be extended to 90 percent with no additional capital equipment. The three lignite coal cases with CO_2 capture and the three PRB coal cases with CO_2 capture fall nearly on the same line and are difficult to distinguish. All lines in the figure are nearly parallel indicating that a change in capacity factor affects all cases equally. This is a result of a nearly constant split between capital and fixed operating costs which are unaffected by CF, and variable operating costs and fuel costs which are affected.

Cost of CO_2 Avoided

The CO_2 emissions per megawatt-hour (MWh) are about the same for each technology for a given coal type and site, and slightly higher for the NDL cases compared to the comparable PRB cases. The first year cost of CO_2 avoided was calculated using the equation:

$$Avoided\ Cost = \frac{\{COE_{with\,removal} - COE_{reference}\}\ \$/MWh}{\{CO_2\ Emissions_{reference} - CO_2\ Emissions_{with\,removal}\}\ tons/MWh} \qquad \text{(ES-1)}$$

The COE with CO_2 removal includes the costs of capture and compression, as well as TS&M costs. The resulting avoided costs are shown in Exhibit ES-10 for each of the CO_2 capture technologies modeled. The avoided costs for each capture case are calculated using the analogous non-capture plant as the reference and again with SC PC without CO_2 capture as the reference. The cost of CO_2 avoided for analogous plant designs averages $68.8/tonne ($62.4/ton) with a range of $67-$70/tonne ($61-$64/ton) for the SC PC cases, $63.7/tonne ($57.8/ton) with a range of $63-$64/tonne ($57-$58/ton) for the USC PC cases, and $65.6/tonne ($59.5/ton) with a range of $64-$67/tonne ($58-$61/ton) for the CFB cases. The CO_2 avoided costs are lower for PRB coal than NDL, mainly because of the significant capital cost increase in the NDL fuel cases resulting from lower plant efficiency. CO_2 avoided costs are also shown compared to the baseline SC PC plant (12 series cases) firing the same coal.

Exhibit ES-7 COE by Cost Component

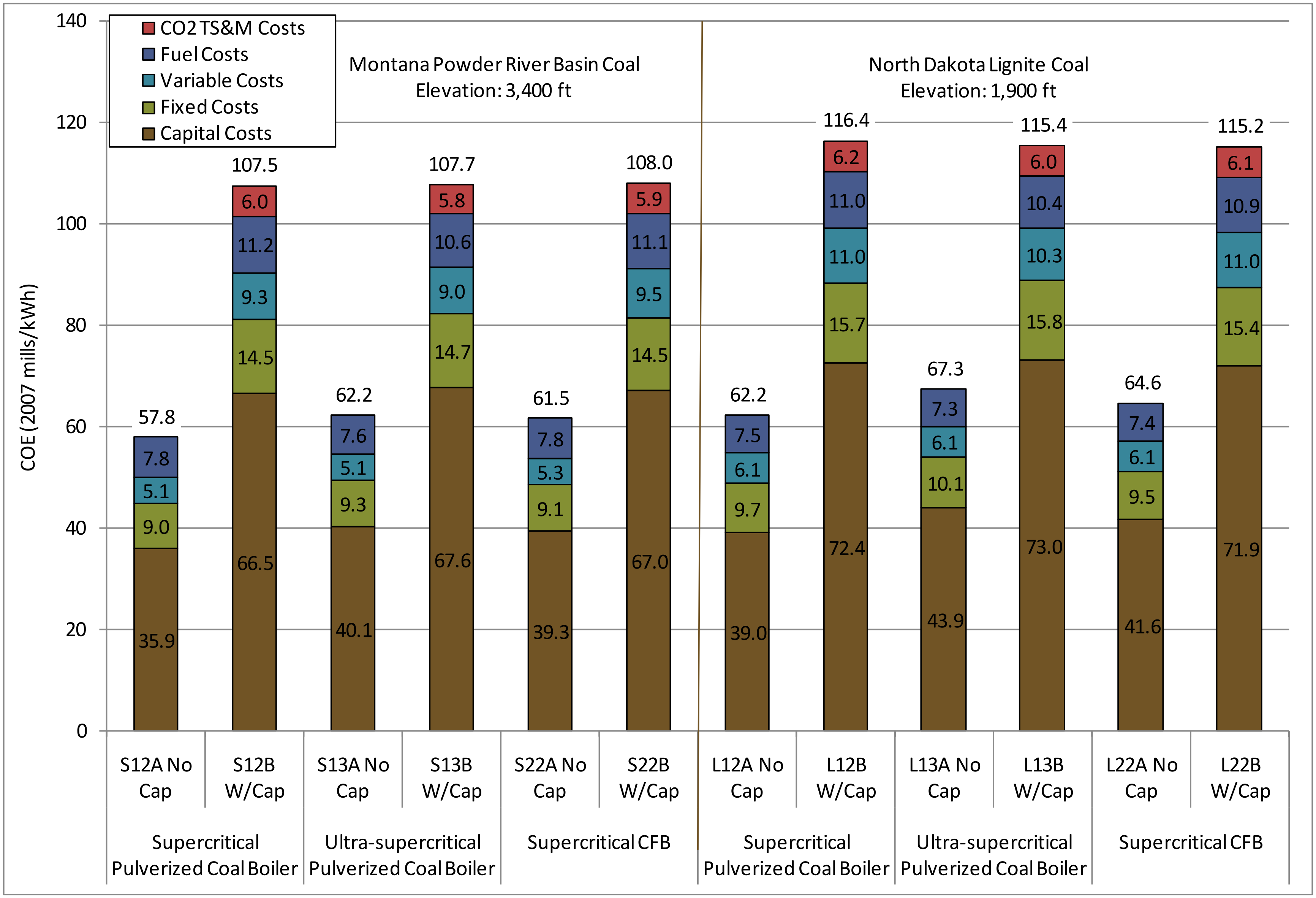


Exhibit ES-8 COE Sensitivity to Coal Cost

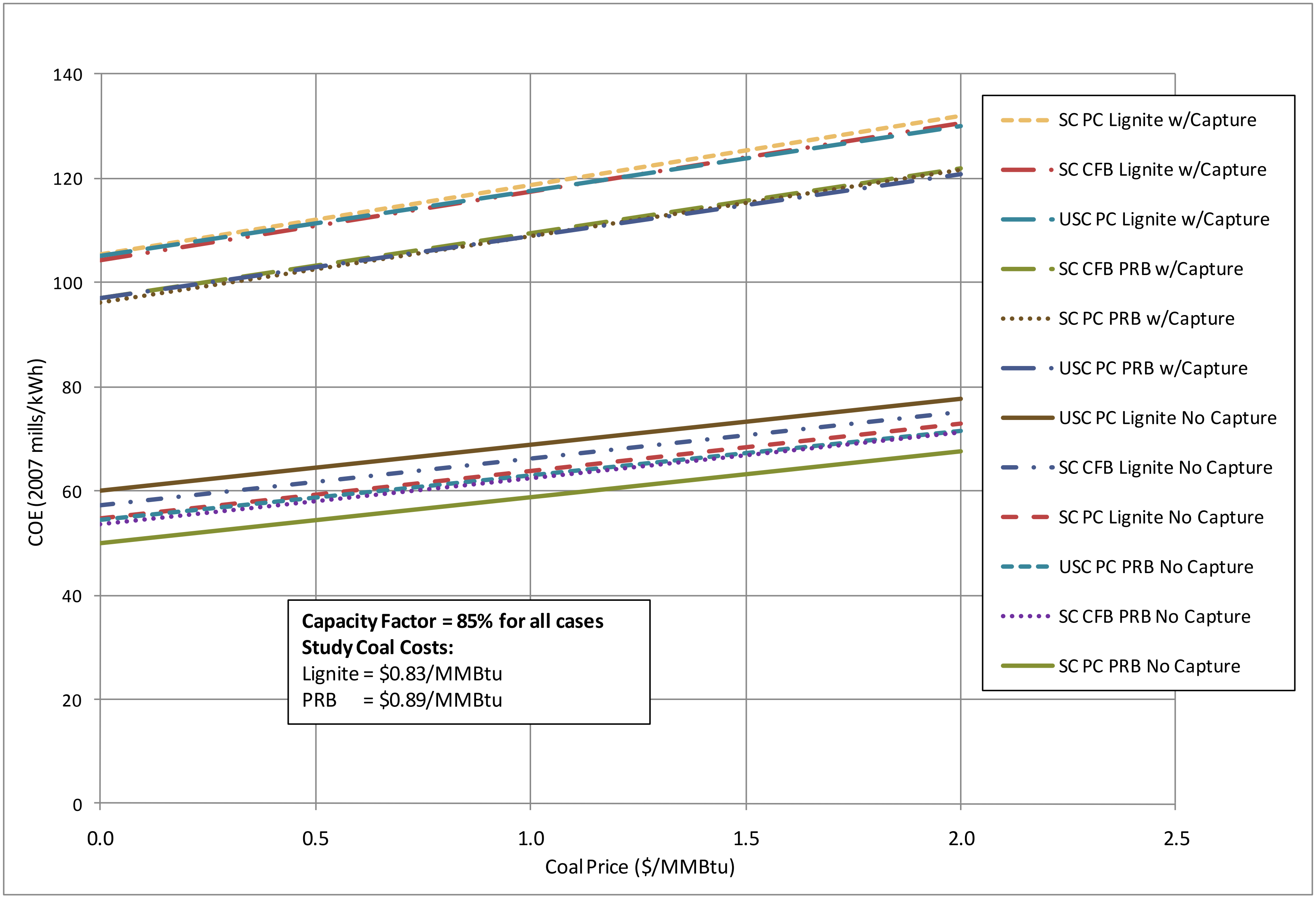


Exhibit ES-9 COE Sensitivity to Capacity Factor

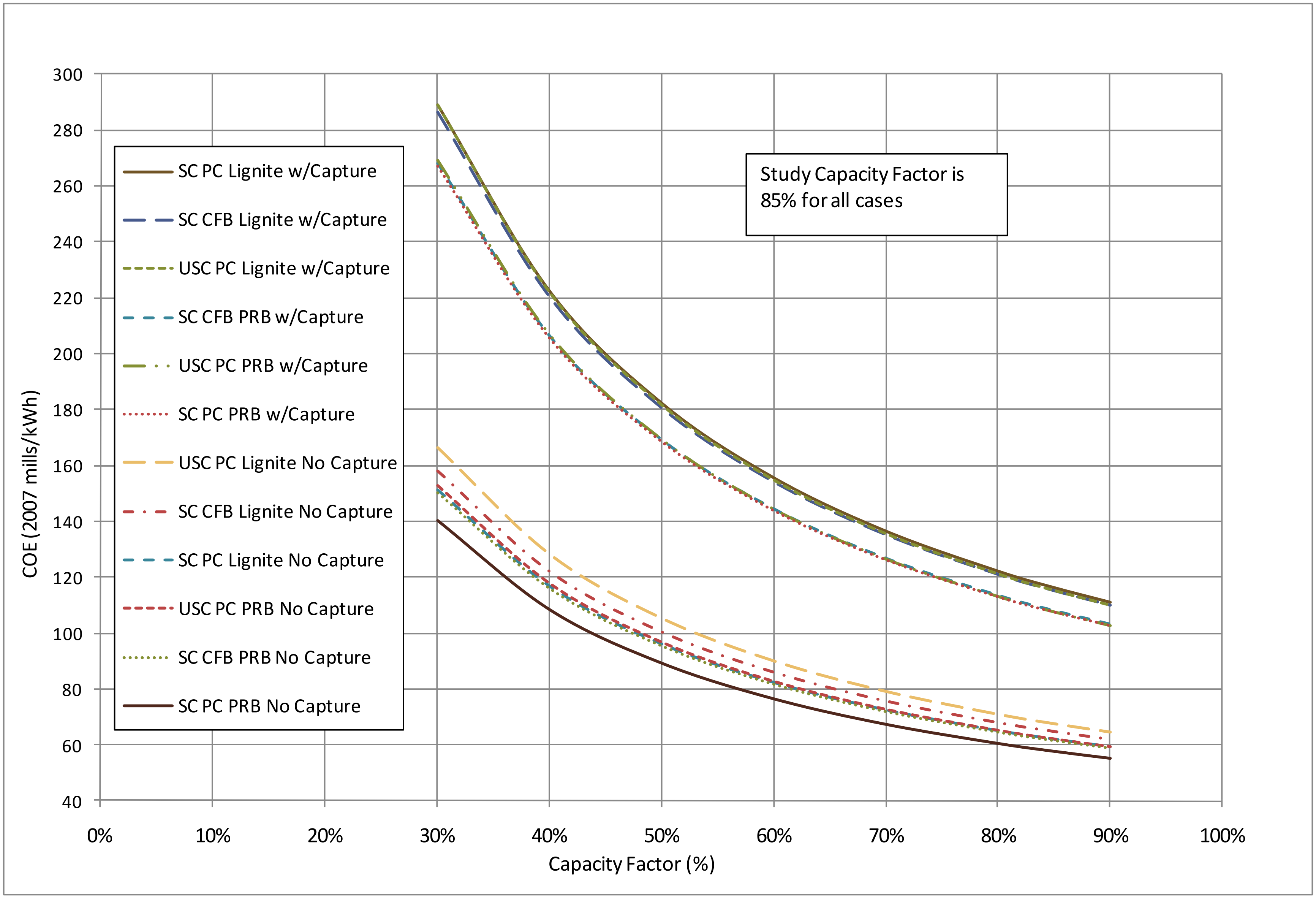
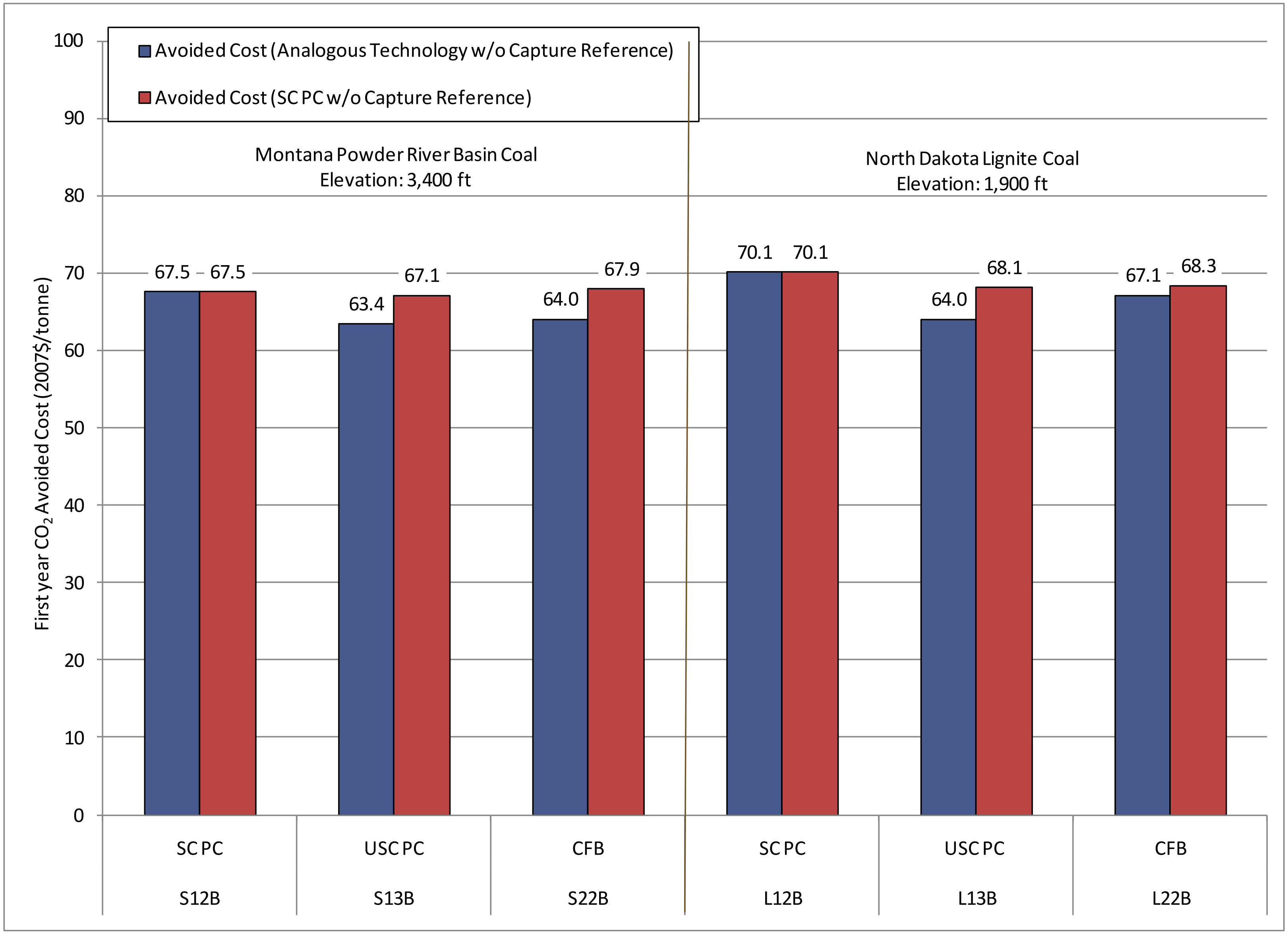


Exhibit ES-10 First Year CO_2 Avoided Cost



Environmental Performance

The environmental targets are based on presumed best available control technology (BACT) for each technology and are summarized in Exhibit ES-11. The targets are identical for all pollutants except mercury, which is coal type and technology type dependent. Emission rates of sulfur dioxide (SO_2), nitrogen oxide (NOx), and particulate matter (PM) are shown graphically in Exhibit ES-12, and emission rates of mercury (Hg) are shown separately in Exhibit ES-13 because of the orders of magnitude difference in emission rate values.

Exhibit ES-11 Study Environmental Targets

	Technology		
Pollutant	**SC PC**	**USC PC**	**SC CFB**
SO_2	0.132 lb/MMBtu	0.132 lb/MMBtu	0.132 lb/MMBtu
NOx	0.07 lb/MMBtu	0.07 lb/MMBtu	0.07 lb/MMBtu
PM (Filterable)	0.013 lb/MMBtu	0.013 lb/MMBtu	0.013 lb/MMBtu
Hg (PRB Coal)	0.60 lb/TBtu	0.60 lb/TBtu	3.0 lb/TBtu
Hg (Lignite Coal)	1.12 lb/TBtu	1.12 lb/TBtu	4.8 lb/TBtu

The primary conclusions that can be drawn are:

- The NOx emissions are constant for all cases because a study assumption was that low NOx burners with overfire air and selective catalytic reduction in the PC cases and low bed temperature and selective non-catalytic reduction in the CFB cases could achieve the 0.07 lb/MMBtu emission limit.
- Similarly particulate emissions are constant because a study assumption was that a dry FGD with baghouse in PC cases and cyclones and a baghouse in the CFB cases could achieve the 0.013 lb/MMBtu emission limit.
- SO_2 emissions vary with coal type and technology type. In-bed limestone injection in the CFB cases is assumed to have an SO_2 removal efficiency of 94 percent while the spray dryer absorbers used in the PC cases is assumed to have a removal efficiency of 93 percent. While PRB and lignite coals have the same sulfur content on an as-received basis, more lignite coal is required to generate the same amount of electricity because of its lower heating value. As a consequence, more SO_2 is emitted at a constant capture efficiency in the lignite coal cases.
- In capture cases the SO_2 concentration is reduced to the equivalent of 10 ppmv through the use of a polishing scrubber ahead of the amine absorber.
- Mercury emissions are higher for lignite coal cases compared to the analogous technology PRB coal case because there is no co-benefit capture observed with lignite coals while PRB coal cases achieve some co-benefit capture. In addition, lignite coal has a higher Hg concentration and a lower heating value.

- Hg emissions are lower for the CFB cases because of the higher co-benefit capture in addition to the use of carbon injection.

Overall Conclusions

- The increase in TOC to add CO_2 capture ranges from 66 to 74 percent.
- The increase in COE to add CO_2 capture ranges from 71 to 87 percent.
- COE for plants using PRB coal is 5 – 8 percent less than a similar plant using NDL.

Exhibit ES-12 SO_2, NOx and Particulate Emission Rates

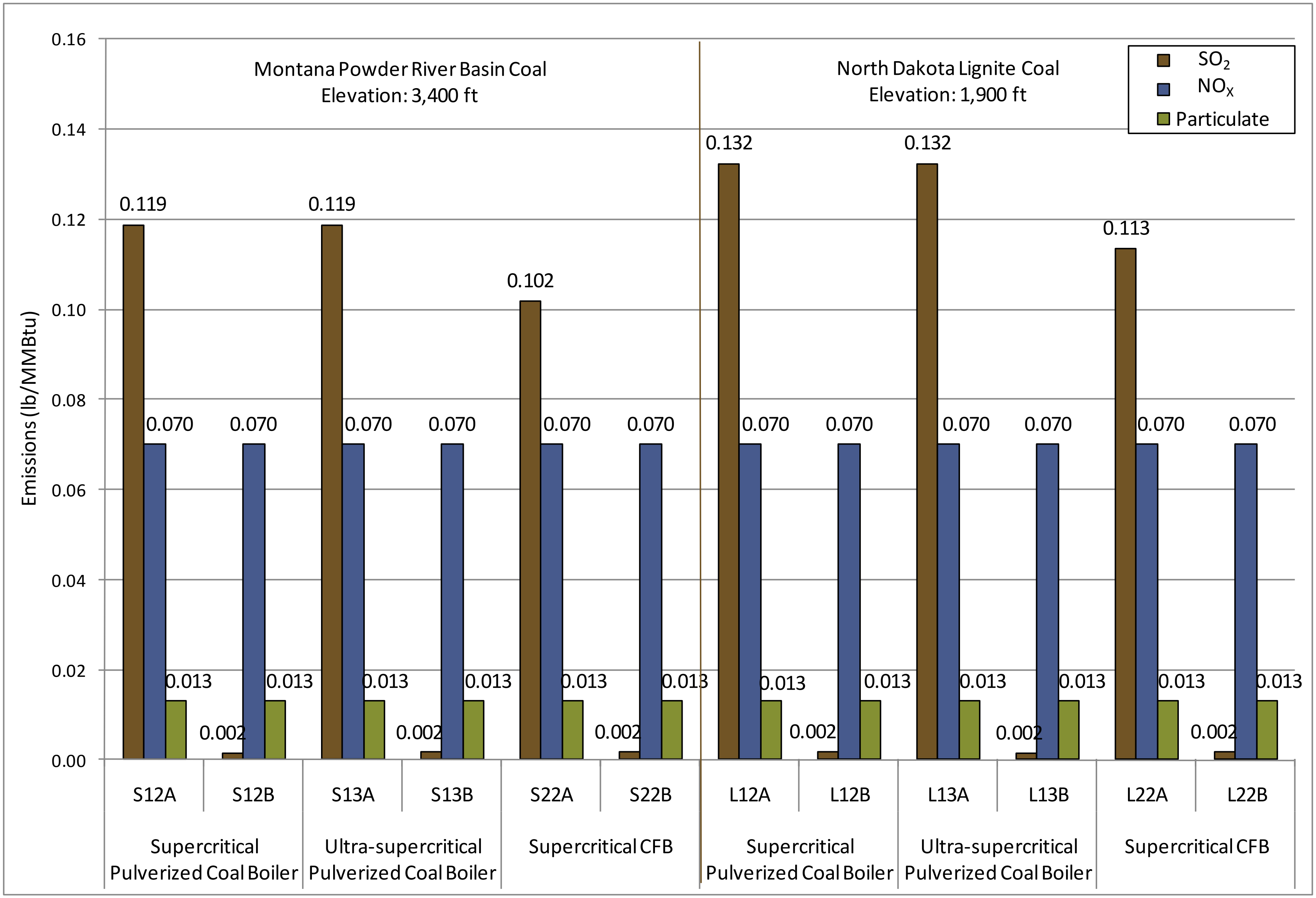
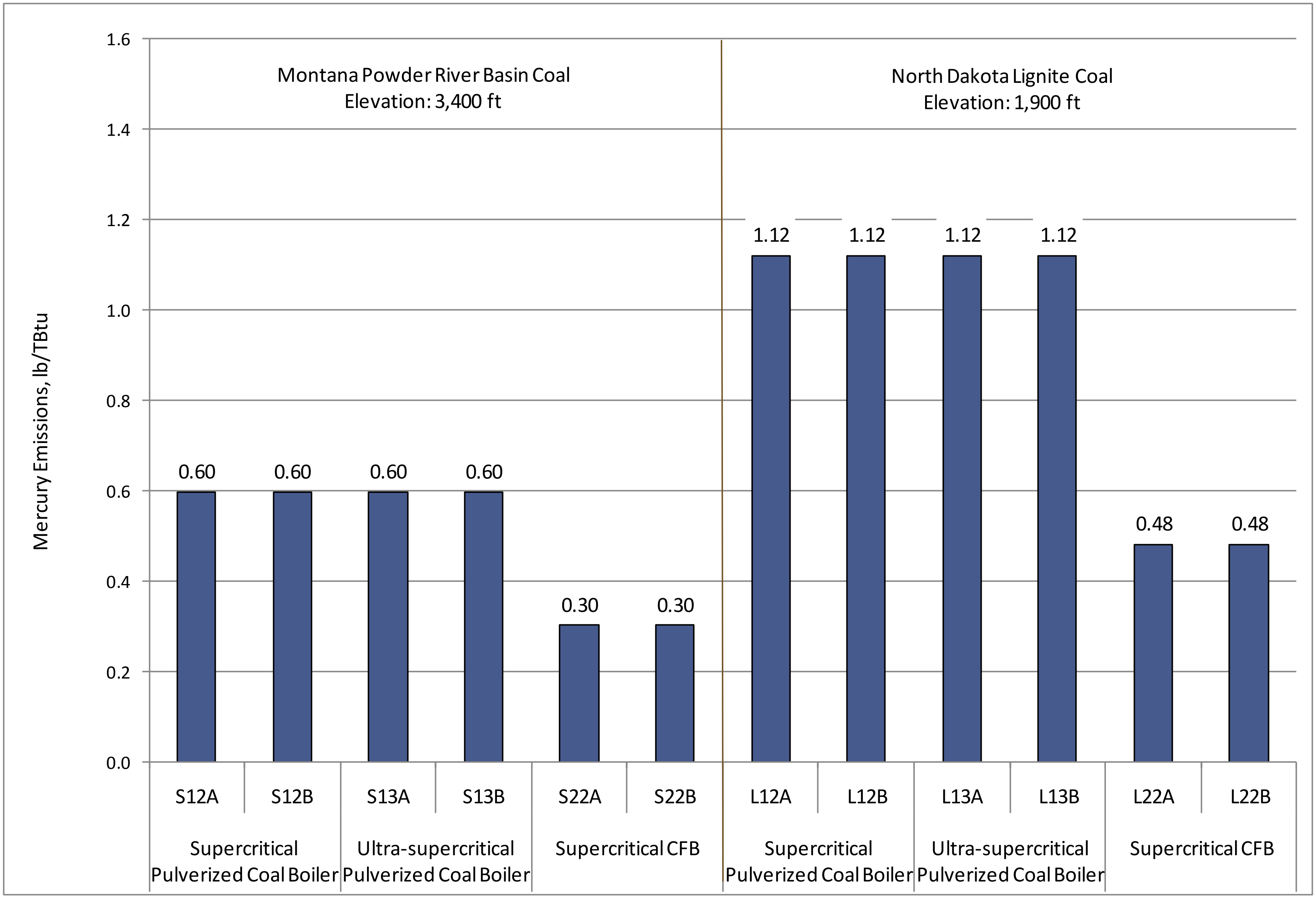


Exhibit ES-13 Mercury Emission Rates



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1. INTRODUCTION

The objective of this report is to present an accurate, independent assessment of the cost and performance of fossil energy power systems, specifically SC and USC PC Rankine cycle power plants and SC CFB power plants using low rank coals, in a consistent technical and economic manner that accurately reflects current or near term market conditions. This document is Volume 3a of the Low Rank Coal Baseline Reports, which are part of a four volume series consisting of the following:

- Volume 1: Bituminous Coal and Natural Gas to Electricity
- Volume 2: Coal to Synthetic Natural Gas and Ammonia (Various Coal Ranks)
- Volume 3: Low Rank Coal and Natural Gas to Electricity
- Volume 4: Bituminous Coal to Liquid Fuels with Carbon Capture

Typically four cases are modeled and analyzed for each technology. Two cases use PRB subbituminous coal, with and without CO_2 capture, and two cases use NDL coal, with and without CO_2 capture. The naming convention for the cases covered in this report is as follows:

- First letter represents coal type: S = subbituminous (PRB) coal; L = NDL coal
- Two digit number represents technology type: 12 = SC PC; 13 = USC PC; 22 = CFB
- Final letter indicates CO_2 capture: A = no capture; B = capture

Volume 3b covers all the combustion process cases:

Case S12A – This case is based on an SC PC plant without CO_2 capture. Rosebud PRB coal is the fuel and the plant is located in Montana.

Case S12B – This case is the same as S12A except it includes CO_2 capture.

Case L12A – This case is based on an SC PC plant without CO_2 capture. NDL coal is the fuel, and the plant is located at a minemouth site in North Dakota.

Case L12B – This case is the same as L12A except it includes CO_2 capture.

Case S13A – This case is based on an USC PC plant without CO_2 capture. Rosebud PRB coal is the fuel, and the plant is located in Montana.

Case S13B – This case is the same as S13A except it includes CO_2 capture.

Case L13A – This case is based on an USC PC plant without CO_2 capture. NDL coal is the fuel, and the plant is located at a minemouth site in North Dakota.

Case L13B – This case is the same as L13A except it includes CO_2 capture.

Case S22A – This case is based on an SC CFB plant without CO_2 capture. Rosebud PRB coal is the fuel, and the plant is located in Montana.

Case S22B – This case is the same as S22A except it includes CO_2 capture.

Case L22A – This case is based on an SC CFB plant without CO_2 capture. NDL coal is the fuel, and the plant is located at a minemouth site in North Dakota.

Case L22B – This case is the same as L22A except it includes CO_2 capture.

While input was sought from various technology vendors, the final assessment of performance and cost was determined independently, and may not represent the views of the technology vendors.

Generating Unit Configurations

All twelve combustion cases have a net output of 550 MW. The boiler and steam turbine industry's ability to match unit size to a custom specification has been commercially demonstrated enabling a common net output comparison of the cases in this study. While the CFB industry has not commercially demonstrated a unit as large in size as that needed for the cases in this study, it is assumed that such a design will be possible in the near future [3]. The coal feed rate was increased in the CO_2 capture cases to increase the gross steam turbine output and account for the higher auxiliary load, resulting in a constant net output.

The balance of this report is organized as follows:

- Chapter 2 provides the basis for technical, environmental, and cost evaluations.
- Chapter 3 describes the systems common to all eight SC and USC PC cases and four SC CFB cases.
- Chapter 4 provides the detailed results of the eight SC and USC PC cases.
- Chapter 5 provides the detailed results of the four SC CFB cases.
- Chapter 6 describes the SC PC sensitivity to MEA system performance and cost (from the bituminous coal study)
- Chapter 7 summarizes the results of the twelve combustion cases.
- Chapter 8 contains the reference list.

2. GENERAL EVALUATION BASIS

For each of the plant configurations in this study an Aspen model was developed and used to generate material and energy balances, which provided the design basis for items in the major equipment list. The equipment list and material balances were used as the basis for generating the capital and operating cost estimates. Performance and process limits were based upon published reports, information obtained from vendors and users of the technology, performance data from design/build utility projects, and/or best engineering judgment. Capital and operating costs were estimated by WorleyParsons based on simulation results and through a combination of vendor quotes and scaled estimates from previous design/build projects. Ultimately, a COE was calculated for each of the cases and is reported as the economic figure-of-merit.

The balance of this chapter documents the design basis, environmental targets and cost assumptions used in the study.

2.1 SITE CHARACTERISTICS

The plants are located at two different generic plant sites. Plants using PRB coal are assumed to be located at a site in Montana. Plants using lignite coal are assumed to be located at a minemouth site in North Dakota. The ambient conditions for the two sites are shown in Exhibit 2-1 and Exhibit 2-2.

Exhibit 2-1 Montana Site Ambient Conditions for PRB Coal Cases

Elevation, m (ft)	1,036 (3,400)
Barometric Pressure, MPa (psia)	0.09 (13.0)
Design Ambient Temperature, Dry Bulb, °C (°F)	5.6 (42)
Design Ambient Temperature, Wet Bulb, °C (°F)	2.8 (37)
Design Ambient Relative Humidity, %	62

Exhibit 2-2 North Dakota Site Ambient Conditions for Lignite Coal Cases

Elevation, m (ft)	579 (1,900)
Barometric Pressure, MPa (psia)	0.10 (13.8)
Design Ambient Temperature, Dry Bulb, °C (°F)	4.4 (40)
Design Ambient Temperature, Wet Bulb, °C (°F)	2.2 (36)
Design Ambient Relative Humidity, %	68

The site characteristics are assumed to be the same for both plant locations as shown in Exhibit 2-3.

Exhibit 2-3 Site Characteristics

Location	Greenfield, Montana (PRB coal) or North Dakota (lignite)
Topography	Level
Size, acres	300
Transportation	Rail
Ash/Slag Disposal	Off Site
Water	Municipal (50%) / Groundwater (50%)
Access	Land locked, having access by rail and highway
CO_2 Storage	Compressed to 15.3 MPa (2,215 psia), transported 80 kilometers (50 miles) and sequestered in a saline formation at a depth of 1,239 m (4,055 ft)

The land area for all cases assumes 30 acres are required for the plant proper and the balance provides a buffer of approximately 0.25 miles to the fence line. The extra land could also provide for a rail loop if required.

In all cases it was assumed that buildings are included to house the steam turbine and boiler. The following design parameters are considered site-specific, and are not quantified for this study. Allowances for normal conditions and construction are included in the cost estimates.

- Flood plain considerations
- Existing soil/site conditions
- Water discharges and reuse
- Rainfall/snowfall criteria
- Seismic design
- Buildings/enclosures
- Fire protection
- Local code height requirements
- Noise regulations – Impact on site and surrounding area

2.2 COAL CHARACTERISTICS

The two design coals are a subbituminous PRB coal from Montana and lignite coal from North Dakota. The coal properties are from NETL's Coal Quality Guidelines and are shown in Exhibit 2-4 and Exhibit 2-5 [4].

The Power Systems Financial Model (PSFM) was used to derive the first year capital charge factor for this study. The PSFM requires that all cost inputs have a consistent cost year basis. Because the capital and operating cost estimates are in June 2007 dollars, the fuel costs must also be in June 2007 dollars.

The cost of coal used in this study is $0.84/GJ ($0.89/MMBtu) for PRB coal and $0.78/GJ ($0.83/MMBtu) for NDL coal (2007 cost of coal in June 2007 dollars). All coal costs are based on HHV. These costs were determined using the following information from the EIA 2008 AEO:

- The 2007 minemouth cost of PRB coal in 2006 dollars, $13.02/metric ton (tonne) ($11.81/ton), was obtained from Supplemental Table 112 of the EIA's 2008 AEO for western Montana medium-sulfur subbituminous coal. The 2007 minemouth cost of NDL coal in 2006 dollars, $11.67/tonne ($10.59/ton), was obtained from the same source.
- The 2007 cost of PRB coal was escalated to June 2007 dollars using the gross domestic product (GDP) chain-type price index from AEO 2008, resulting in a price of $13.42/tonne ($12.17/ton) [5]. Similarly, the 2007 cost of NDL coal in June 2007 dollars is $12.04/tonne ($10.92/ton) or $0.79/GJ ($0.83/MMBtu).
- Transportation costs for PRB coal were estimated to be 25 percent of the minemouth cost based on the average transportation rate for medium subbituminous coal from the western Montana region delivered to the mountain region [6]. The final delivered cost of PRB coal used in the calculations is $16.78/tonne ($15.22/ton) or $0.85/GJ ($0.89/MMBtu).

Note: The PRB coal cost conversion of $15.22/ton to dollars per million Btu results in $0.8884/MMBtu, which was used in calculations, but only two decimal places are shown in the report. Similarly, the NDL fuel cost converts to $0.8251/MMBtu, which was used in calculations, but only two decimal places are shown.

Exhibit 2-4 Montana Rosebud PRB, Area D, Western Energy Co. Mine, Subbituminous Design Coal Analysis

Proximate Analysis	**Dry Basis, %**	**As Received, %**
Moisture	0.0	25.77
Ash	11.04	8.19
Volatile Matter	40.87	30.34
Fixed Carbon	48.09	35.70
Total	100.0	100.0
Ultimate Analysis	**Dry Basis, %**	**As Received, %**
Carbon	67.45	50.07
Hydrogen	4.56	3.38
Nitrogen	0.96	0.71
Sulfur	0.98	0.73
Chlorine	0.01	0.01
Ash	11.03	8.19
Moisture	0.00	25.77
Oxygen[1]	15.01	11.14
Total	100.0	100.0
Heating Value	**Dry Basis**	**As Received, %**
HHV, kJ/kg	26,787	19,920
HHV, Btu/lb	11,516	8,564
LHV, kJ/kg	25,810	19,195
LHV, Btu/lb	11,096	8,252
Hardgrove Grindability Index	57	
Ash Mineral Analysis		**%**
Silica	SiO_2	38.09
Aluminum Oxide	Al_2O_3	16.73
Iron Oxide	Fe_2O_3	6.46
Titanium Dioxide	TiO_2	0.72
Calcium Oxide	CaO	16.56
Magnesium Oxide	MgO	4.25
Sodium Oxide	Na_2O	0.54
Potassium Oxide	K_2O	0.38
Sulfur Trioxide	SO_3	15.08
Phosphorous Pentoxide	P_2O_5	0.35
Barium Oxide	Ba_2O	0.00
Strontium Oxide	SrO	0.00
Unknown	---	0.84
	Total	100.0
Trace Components		**ppmd**
Mercury[2]	Hg	0.081

[1] By Difference

[2] Mercury value is the mean plus one standard deviation using EPA's ICR data

Exhibit 2-5 North Dakota Beulah-Zap Lignite, Freedom, ND Mine, Lignite Design Coal Analysis

Proximate Analysis	Dry Basis, %	As Received, %
Moisture	0.0	36.08
Ash	15.43	9.86
Volatile Matter	41.49	26.52
Fixed Carbon	43.09	27.54
Total	100.0	100.0
Ultimate Analysis	**Dry Basis, %**	**As Received, %**
Carbon	61.88	39.55
Hydrogen	4.29	2.74
Nitrogen	0.98	0.63
Sulfur	0.98	0.63
Chlorine	0.00	0.00
Ash	15.43	9.86
Moisture	0.00	36.08
Oxygen[1]	16.44	10.51
Total	100.0	100.0
Heating Value	**Dry Basis**	**As Received, %**
HHV, kJ/kg	24,254	15,391
HHV, Btu/lb	10,427	6,617
LHV, kJ/kg	23,335	14,804
LHV, Btu/lb	10,032	6,364
Hardgrove Grindability Index	Not applicable	
Ash Mineral Analysis		**%**
Silica	SiO_2	35.06
Aluminum Oxide	Al_2O_3	12.29
Iron Oxide	Fe_2O_3	5.12
Titanium Dioxide	TiO_2	0.58
Calcium Oxide	CaO	14.39
Magnesium Oxide	MgO	6.61
Sodium Oxide	Na_2O	5.18
Potassium Oxide	K_2O	0.64
Sulfur Trioxide	SO_3	16.27
Barium Oxide	Ba_2O	0.56
Strontium Oxide	SrO	0.27
Manganese Dioxide	MnO_2	0.02
Unknown	---	3.00
	Total	100.0
Trace Components		**ppmd**
Mercury[2]	Hg	0.116

[1] By Difference
[2] Mercury value is the mean plus one standard deviation using EPA's ICR data

2.3 ENVIRONMENTAL TARGETS

The environmental targets for the study were considered on a technology- and fuel-specific basis. In setting the environmental targets a number of factors were considered, including current emission regulations, regulation trends, results from recent permitting activities, and the status of current best available control technology (BACT).

The current federal regulation governing new fossil-fuel fired electric utility steam generating units is the New Source Performance Standards (NSPS) as amended in June 2007 and shown in Exhibit 2-6. This represents the minimum level of control that would be required for a new fossil energy plant [7].

The new NSPS standards apply to units with the capacity to generate greater than 73 MW of power by burning fossil fuels, as well as cogeneration units that sell more than 25 MW of power and more than one-third of their potential output capacity to any utility power distribution system. In cases where both an emission limit and a percent reduction are presented, the unit has the option of meeting one or the other. All limits with the unit pounds per megawatt hour (lb/MWh) are based on gross power output.

Exhibit 2-6 Standards of Performance for Electric Utility Steam Generating Units Built, Reconstructed, or Modified After February 28, 2005

Pollutant	New Units		Reconstructed Units		Modified Units	
	Emission Limit	% Reduction	Emission Limit (lb/MMBtu)	% Reduction	Emission Limit (lb/MMBtu)	% Reduction
PM	0.015 lb/MMBtu	99.9	0.015	99.9	0.015	99.97
SO_2	1.4 lb/MWh	95	0.15	95	0.15	90
NOx	1.0 lb/MWh	N/A	0.11	N/A	0.15	N/A

Other regulations that could affect emissions limits from a new plant include the New Source Review (NSR) permitting process and Prevention of Significant Deterioration (PSD). The NSR process requires installation of emission control technology meeting either BACT determinations for new sources being located in areas meeting ambient air quality standards (attainment areas), or Lowest Achievable Emission Rate (LAER) technology for sources being located in areas not meeting ambient air quality standards (non-attainment areas). The Clean Air Act authorizes EPA to establish regulations to prevent significant deterioration of air quality due to emissions of any pollutant for which a national ambient air quality standard (NAAQS) has been promulgated. Environmental area designation varies by county and can be established only for a specific site location. Based on the EPA Green Book Non-attainment Area Map relatively few areas in the Western U.S. are classified as “non-attainment” so the plant site for this study was assumed to be in an attainment area [8].

In addition to federal regulations, state and local jurisdictions can impose even more stringent regulations on a new facility. However, since each new plant has unique environmental requirements, it was necessary to apply some judgment in setting the environmental targets for this study.

Mercury

The Clean Air Mercury Rule (CAMR) issued on March 15, 2005 established NSPS limits for mercury (Hg) emissions from new PC-fired power plants. These rules were vacated by court action on February 8, 2008, and the final resolution of these rules is unknown. Even though the rules are vacated, the CAMR emission limits are included for reference only. There were two NSPS limits for mercury in combination with subbituminous coal, one for wet units and one for dry units. Wet units were defined as plants located in a county that receives more than 25 inches (in) per year mean annual precipitation according to the U.S. Department of Agriculture's (USDA) most recent publicly available 30 year data, and dry units were plants located in a county receiving 25 in or less. The subbituminous coal plants in this study are located in the state of Montana. Most of the PRB coal in Montana is located in areas that receive substantially less than 25 in of rainfall, and therefore the "dry unit" designation is used for the NSPS limit [9, 10]. The vacated NSPS limits, based on gross output, are shown in Exhibit 2-7.

Exhibit 2-7 NSPS Mercury Emission Limits

Coal Type / Technology	Hg Emission Limit
Bituminous	20×10^{-6} lb/MWh
Subbituminous (wet units)	66×10^{-6} lb/MWh
Subbituminous (dry units)	**97×10^{-6} lb/MWh**
Lignite	**175×10^{-6} lb/MWh**
Coal refuse	16×10^{-6} lb/MWh
IGCC	20×10^{-6} lb/MWh

The coal mercury concentration used for this study was determined from the EPA Information Collection Request (ICR) database. The ICR database has 137 records of Montana Rosebud subbituminous coal with an average Hg concentration of 0.056 parts per million (ppm) (dry) and a standard deviation of 0.025 ppm. There are 266 records for NDL from the Beulah seam with an average Hg concentration of 0.081 ppm (dry) and a standard deviation of 0.035 ppm. The mercury values in Exhibit 2-4 and Exhibit 2-5 are the mean plus one standard deviation, or 0.081 ppm (dry) for PRB coal and 0.116 ppm (dry) for NDL [11]. It was further assumed that all of the coal Hg enters the gas phase and none leaves with the bottom ash or slag.

Design Targets

The environmental targets for combustion cases were established using a presumed BACT and are the same for subbituminous and lignite coal, with the exception of mercury, as shown in Exhibit 2-8.

Exhibit 2-8 Environmental Target

Pollutants	Environmental Target	NSPS Limit[1]	Type of Technology
Filterable PM	0.013 lb/MMBtu	0.015 lb/MMBtu	Fabric Filter
SO_2	0.132 lb/MMBtu	1.4 lb/MWh (0.105 lb/MMBtu)	Low-Sulfur Fuel and Dry FGD or Low-Sulfur Fuel and In-bed Limestone Injection
NOx	0.07 lb/MMBtu	1.0 lb/MWh (0.075 lb/MMBtu)	LNB's, OFA and SCR or CFB with SNCR
Hg, Subbituminous (PC only)	0.60 lb/TBtu (~ 5.0 x 10^{-6} lb/MWh)	97 x 10^{-6} lb/MWh[2] (7.7 lb/TBtu)	Co-benefit capture, low coal Hg content, and carbon injection
Hg, Lignite (PC only)	1.12 lb/TBtu (~ 9.6 x 10^{-6} lb/MWh)	175 x 10^{-6} lb/MWh[2] (13.1 lb/TBtu)	Low coal Hg content and carbon injection
Hg, Subbituminous (CFB only)	3.0 lb/TBtu (~ 25 x 10^{-6} lb/MWh)	97 x 10^{-6} lb/MWh[2] (7.8 lb/TBtu)	Co-benefit capture and low coal Hg content [12,13]
Hg, Lignite(CFB only)	4.8 lb/TBtu (~ 41 x 10^{-6} lb/MWh)	175 x 10^{-6} lb/MWh[2] (13.3 lb/TBtu)	Co-benefit capture and low coal Hg content [12,13]

[1] The values in parenthesis are calculated using the lowest efficiency plant heat rate for the applicable technology limit (CO_2 capture cases, PC or CFB as described).

[2] CAMR limits were vacated on February 8, 2008 by court action.

The environmental target represents the maximum allowable emissions for any of the combustion cases. In some cases actual emissions are less than the target. For example, the CO_2 capture cases require a polishing scrubber to reduce sulfur dioxide (SO_2) concentrations to less than 10 parts per million volume (ppmv). In those cases the SO_2 emissions are substantially less than the environmental target. The CFB cases utilize in-bed limestone injection for SO_2 control with a CO_2 capture efficiency of 94 percent. The spray dryer absorber (SDA) used in the combustion cases has a CO_2 capture efficiency of 93 percent so the CFB cases have SO_2 emissions less than the environmental target. Deeper SO_2 reductions are possible in the CFB cases with the addition of a downstream spray dryer, but that option was not included in this study.

Carbon Dioxide

CO_2 is not currently regulated nationally. However, the possibility exists that carbon limits will be imposed in the future and this study examines cases that include a reduction in CO_2 emissions. CO_2 emissions are reported on both a pound (lb)/(gross) MWh and lb/(net) MWh basis in each capture case emissions table.

For the combustion cases that have CO_2 capture, the basis is a nominal post-combustion 90 percent removal based on carbon input from the coal.

The cost of CO_2 capture was calculated as an avoided cost as illustrated in the equation below. Analogous non-capture technologies and SC non-capture PC were chosen as separate reference cases. The COE in the CO_2 capture cases includes TS&M as well as capture and compression.

$$Avoided\ Cost = \frac{\{COE_{with\,removal} - COE_{reference}\}\ \$/MWh}{\{CO_2\ Emissions_{reference} - CO_2\ Emissions_{with\,removal}\}\ tons/MWh}$$

2.4 CAPACITY FACTOR

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 and availability are equal. The availability for combustion cases was determined using the Generating Availability Data System (GADS) from the North American Electric Reliability Council (NERC) [14].

NERC defines an equivalent availability factor (EAF) as a measure of the plant CF assuming there is always a demand for the output. The EAF accounts for planned and scheduled derated hours, as well as seasonal derated hours. As such, the EAF matches this study's definition of CF.

The average EAF for coal-fired plants in the 400-599 MW size range was 84.9 percent in 2004 and averaged 83.9 percent from 2000-2004. Given that many of the plants in this size range are older, the EAF was rounded up to 85 percent and that value was used as the PC and CFB plant CF.

The addition of CO_2 capture was assumed not to impact the CF even without redundant pipelines, wells or subsurface infrastructure. This assumption was made to enable a comparison based on the impact of capital and variable operating costs only. Any reduction in assumed CF would further increase the COE.

2.5 RAW WATER WITHDRAWAL AND CONSUMPTION

A water balance was performed for each case on the major water consumers in the process. The total water demand for each major subsystem was determined. The internal recycle water available from various sources was used to offset the water demand and determine the total water withdrawal. Discharge water stream quantities were estimated and subtracted from the water withdrawal to determine the water consumption from the environment required for the plant.

Fifty percent of the raw water withdrawal was assumed to be provided by a publicly owned treatment works (POTW) and 50 percent was provided from groundwater. Raw water withdrawal is defined as the water metered from a raw water source and used in the plant processes for any and all purposes, such as cooling tower makeup and flue gas desulfurization (FGD) makeup.

The largest consumer of raw water in all cases is cooling tower makeup. Since plants located in the Western U.S. need to consider limited water supplies, a parallel wet/dry condenser was chosen for all plant configurations similar to the system being installed at the currently under construction Comanche 3 plant. In a parallel cooling system half of the turbine exhaust steam is condensed in an air-cooled condenser and half in a water-cooled condenser. The cooling water is provided by a mechanical draft, evaporative cooling tower, and all process blowdown streams were assumed to be treated and recycled to the cooling tower. The cooling tower blowdown was assumed to be treated and 90 percent returned to the water source with the balance sent to the ash ponds for evaporation. The design ambient wet bulb (WB) temperature of 3°C (37°F) at the Montana site and 2°C (36°F) at the NDL site (Exhibit 2-1 and Exhibit 2-2) was used to achieve a cooling water temperature of 9°C (48°F) and 8°C (47°F), respectively at the two sites using an approach of 6°C (11°F). The cooling water range was assumed to be 11°C (20°F). The cooling tower makeup rate was determined using the following [15]:

- Evaporative losses = 0.8 percent of the circulating water flow rate per 10°F of range
- Drift losses = 0.001 percent of the circulating water flow rate
- Blowdown losses = Evaporative Losses / (Cycles of Concentration - 1)
  Where cycles of concentration are a measure of water quality, and a mid-range value of 4 was chosen for this study.

Typical design conditions for air-cooled condensers include an initial temperature difference (ITD) of 40-55°F [16]. The ITD is the temperature difference between saturated steam at the steam turbine generator (STG) exhaust and the inlet dry bulb cooling air temperature. The ITDs at the two locations in this study are 48 and 50°F. The fan power requirement is estimated at 3.5 times the power required for a wet cooling tower with equivalent heat duty [17].

The water balances presented in subsequent sections include the water demand of the major water consumers within the process, the amount provided by internal recycle, the amount of raw water withdrawal by difference, the amount of process water returned to the source and the raw water consumption, again by difference.

2.6 COST ESTIMATING METHODOLOGY

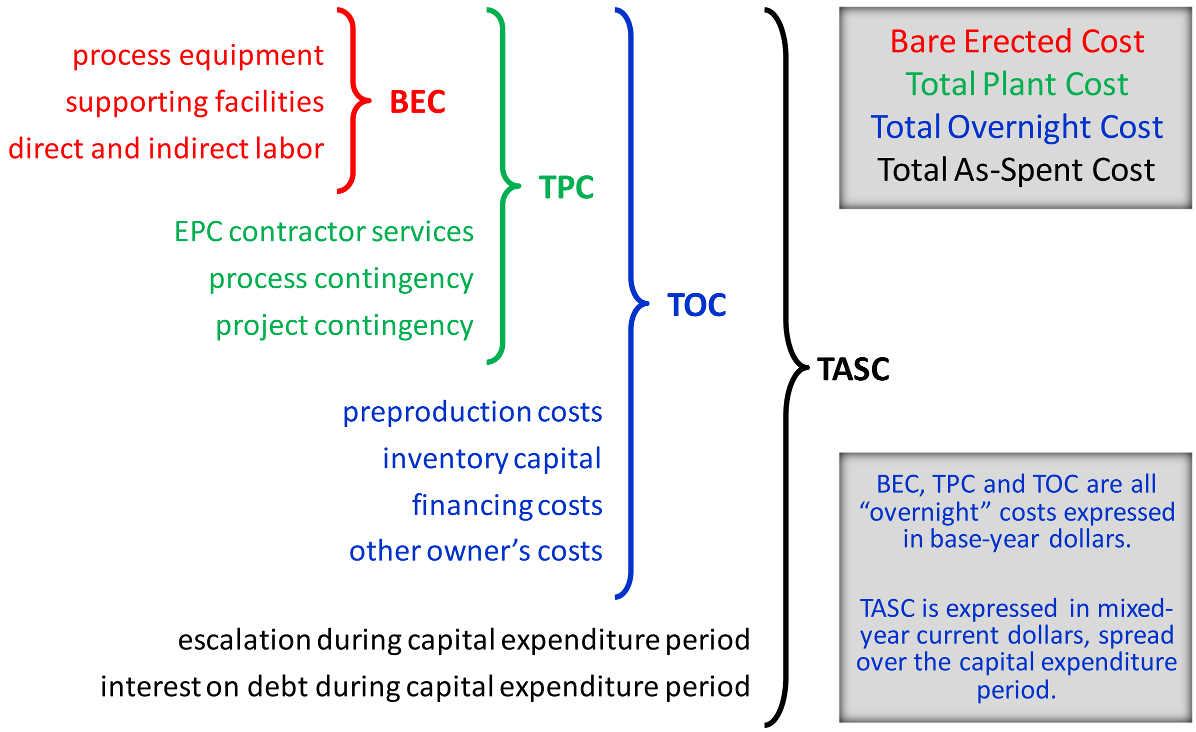
The estimating methodology for capital costs, operations and maintenance costs, and CO_2 TS&M costs are described below. The finance structure, basis for the discounted cash flow analysis, and first-year COE cost calculations are also described.

2.6.1 Capital Costs

As illustrated in Exhibit 2-9, this study reports capital cost at four levels: Bare Erected Cost (BEC), Total Plant Cost (TPC), Total Overnight Cost (TOC) and Total As-spent Capital (TASC). BEC, TPC and TOC are "overnight" costs and are expressed in "base-year" dollars. The base year is the first year of capital expenditure, which for this study is assumed to be 2007. TASC is expressed in mixed-year, current-year dollars over the entire capital expenditure period, which is assumed to last five years for coal plants (2007 to 2012).

The BEC comprises the cost of process equipment, on-site facilities and infrastructure that support the plant (e.g., shops, offices, labs, road), and the direct and indirect labor required for its construction and/or installation. The cost of EPC services and contingencies is not included in BEC. BEC is an overnight cost expressed in base-year (2007) dollars.

Exhibit 2-9 Capital Cost Levels and their Elements



The TPC comprises the BEC plus the cost of services provided by the engineering, procurement and construction (EPC) contractor and project and process contingencies. EPC services include: detailed design, contractor permitting (i.e., those permits that individual contractors must obtain to perform their scopes of work, as opposed to project permitting, which is not included here), and project/construction management costs. TPC is an overnight cost expressed in base-year (2007) dollars.

The TOC comprises the TPC plus owner's costs. TOC is an "overnight" cost, expressed in base-year (2007) dollars and as such does not include escalation during construction or interest during construction.

The TASC is the sum of all capital expenditures as they are incurred during the capital expenditure period including their escalation. TASC also includes interest during construction. Accordingly, TASC is expressed in mixed, current-year dollars over the capital expenditure period.

Cost Estimate Basis and Classification

The TPC and Operation and Maintenance (O&M) costs for each of the cases in the study were estimated by WorleyParsons using an in-house database and conceptual estimating models. Costs were further calibrated using a combination of adjusted vendor-furnished and actual cost data from recent design projects.

Recommended Practice 18R-97 of the Association for the Advancement of Cost Engineering International (AACE) describes a Cost Estimate Classification System as applied in Engineering, Procurement and Construction for the process industries [18].

Most techno-economic studies completed by NETL feature cost estimates intended for the purpose of a “Feasibility Study” (AACE Class 4). Exhibit 2-10 describes the characteristics of an AACE Class 4 Cost Estimate. Cost estimates in this study have an expected accuracy range of -15%/+30%.

Exhibit 2-10 Features of an AACE Class 4 Cost Estimate

Project Definition	Typical Engineering Completed	Expected Accuracy
1 to 15%	Plant capacity, block schematics, indicated layout, process flow diagrams for main process systems, and preliminary engineered process and utility equipment lists	-15% to -30% on the low side, and +20% to +50% on the high side

The capital costs for each cost account were reviewed by comparing individual accounts across all cases to ensure an accurate representation of the relative cost differences between the cases and accounts. All capital costs are presented as “overnight costs” expressed in June 2007 dollars. The dollar values have been held at June 2007 to allow direct comparison with earlier results. Significant pricing fluctuations have occurred between June 2007 and March 2009. A retrospective look suggests that pricing for these commodities peaked in mid 2008 and generally declined during the latter parts of 2008 into 2009. Based on published information, pricing at the end of 2008 remains higher than June 2007 values.

System Code-of-Accounts

The costs are grouped according to a process/system oriented code of accounts. This type of code-of-account structure has the advantage of grouping all reasonably allocable components of a system or process, so they are included within the specific system account. (This would not be the case had a facility, area, or commodity account structure been chosen instead).

Non-CO_2 Capture Plant Maturity

Non-capture SC PC cases are based on commercial offerings for a mature technology n^{th}-of-a-kind (NOAK) cost. Thus, each of these cases reflects the expected cost for the next commercial sale of this technology.

Non-capture USC PC cases are based on technologies that have not been proven and are consequently treated as FOAK with appropriate process contingencies applied.

Non-capture CFB cases are based on available technologies that have not been proven at a scale equivalent to that required in this study and are consequently treated as FOAK with appropriate process contingencies applied.

CO_2 Removal Plant Maturity

While the post-combustion technology for the PC plants has been practiced at smaller scale, it has never been practiced at a scale equivalent to that required in this study. There are domestic amine-based CO_2 capture systems operating on coal-derived flue gas at scales ranging from 150-800 tons per day (TPD) [19]. The plants in this study will capture an average 16,000 TPD of CO_2. Consequently the CO_2 capture cases are treated as FOAK.

Contracting Strategy

The estimates are based on an EPCM approach utilizing multiple subcontracts. This approach provides the Owner with greater control of the project, while minimizing, if not eliminating most of the risk premiums typically included in an Engineer/Procure/Construct (EPC) contract price.

In a traditional lump sum EPC contract, the Contractor assumes all risk for performance, schedule, and cost. As a result of current market conditions, EPC contractors appear more reluctant to assume that overall level of risk. The current trend appears to be a modified EPC approach where much of the risk remains with the Owner. Where Contractors are willing to accept the risk in EPC type lump-sum arrangements, it is reflected in the project cost. In today's market, Contractor premiums for accepting these risks, particularly performance risk, can be substantial and increase the overall project costs dramatically.

The EPCM approach used as the basis for the estimates here is anticipated to be the most cost effective approach for the Owner. While the Owner retains the risks and absorbs higher project management costs, the risks become reduced with time, as there is better scope definition at the time of contract award(s).

Estimate Scope

The estimates represent a complete power plant facility on a generic site. The plant boundary limit is defined as the total plant facility within the "fence line" including coal receiving and water supply system, but terminating at the high voltage side of the main power transformers. TS&M cost is not included in the reported capital cost or O&M costs, but is treated separately and added to the COE.

Capital Cost Assumptions

WorleyParsons developed the capital cost estimates for each plant using the company's in-house database and conceptual estimating models for each of the specific technologies. This database and the respective models are maintained by WorleyParsons as part of a commercial power plant design base of experience for similar equipment in the company's range of power and process projects. A reference bottoms-up estimate for each major component provides the basis for the estimating models. This provides a basis for subsequent comparisons and easy modification when comparing between specific case-by-case variations.

Other key estimate considerations include the following:

- Labor costs are based on Midwest, Merit Shop using factors from PAS, Inc [20]. PAS presents information for eight separate regions. Volume 1 of this study used a generic Midwestern site, typical of Region 5 (IL, IN, MI, MN, OH, and WI). The weighted average rate for Region 8 (CO, MT, ND, SD, UT, and WY) is within less than one-half of one percent of that for Region 5. The difference is inconsequential so the same rates used in Volume 1 were maintained in this study. Costs would need to be re-evaluated for projects employing union labor.
- The estimates are based on a competitive bidding environment, with adequate skilled craft labor available locally.
- Labor is based on a 50-hour work-week (5-10s). No additional incentives such as per-diems or bonuses have been included to attract craft labor.

- While not included at this time, labor incentives may ultimately be required to attract and retain skilled labor depending on the amount of competing work in the region, and the availability of skilled craft in the area at the time the projects proceed to construction.
- The estimates are based on a greenfield site.
- The site is considered to be Seismic Zone 1, relatively level, and free from hazardous materials, archeological artifacts, or excessive rock. Soil conditions are considered adequate for spread footing foundations. The soil bearing capability is assumed adequate such that piling is not needed to support the foundation loads.
- Costs are limited to within the “fence line,” terminating at the high voltage side of the main power transformers with the exception of costs included for TS&M, which are treated as an addition to COE.
- Engineering and Construction Management were estimated as a percent of BEC. These costs consist of all home office engineering and procurement services as well as field construction management costs. Site staffing generally includes a construction manager, resident engineer, scheduler, and personnel for project controls, document control, materials management, site safety, and field inspection.

Price Fluctuations

During the course of this study, the prices of equipment and bulk materials fluctuated quite substantially. Some reference quotes pre-dated the 2007 year cost basis while others were received post-2007. All vendor quotes used to develop these estimates were adjusted to June 2007 dollars accounting for the price fluctuations. Adjustments of costs pre-dating 2007 benefitted from a vendor survey of actual and projected pricing increases from 2004 through mid-2007 that WorleyParsons conducted for another project. The results of that survey were used to validate/recalibrate the corresponding escalation factors used in the conceptual estimating models. The more recent economic down turn has resulted in a reduction of commodity prices such that many price indices have similar values in January 2010 compared to June 2007. For example, the Chemical Engineering Plant Cost Index was 532.7 in June 2007 and 532.9 in January 2010, and the Gross Domestic Product Chain-type Price Index was 106.7 on July 1, 2007 and 110.0 on January 1, 2010. While these overall indices are nearly constant, it should be noted that the cost of individual equipment types may still deviate from the June 2007 reference point.

Cross-comparisons

In all technology comparison studies, the relative differences in costs are often more important than the absolute level of TPC. This requires cross-account comparison between technologies to review the consistency of the direction of the costs.

Exclusions

The capital cost estimate includes all anticipated costs for equipment and materials, installation labor, professional services (Engineering and Construction Management), and contingency. The following items are excluded from the capital costs:

- All taxes, with the exception of payroll and property taxes (property taxes are included with the fixed O&M costs)

- Site specific considerations – including, but not limited to, seismic zone, accessibility, local regulatory requirements, excessive rock, piles, laydown space, etc.
- Labor incentives in excess of 5-10s
- Additional premiums associated with an EPC contracting approach

Contingency

Process and project contingencies are included in estimates to account for unknown costs that are omitted or unforeseen due to a lack of complete project definition and engineering. Contingencies are added because experience has shown that such costs are likely, and expected, to be incurred even though they cannot be explicitly determined at the time the estimate is prepared.

Capital cost contingencies do not cover uncertainties or risks associated with

- scope changes
- changes in labor availability or productivity
- delays in equipment deliveries
- changes in regulatory requirements
- unexpected cost escalation
- performance of the plant after startup (e.g., availability, efficiency)

Project Contingency

AACE 16R-90 states that project contingency for a "budget-type" estimate (AACE Class 4 or 5) should be 15 to 30 percent of the sum of BEC, EPC fees and process contingency. This was used as a general guideline, but some project contingency values outside of this range occur based on WorleyParsons' in-house experience.

Process Contingency

Process contingency is intended to compensate for uncertainty in cost estimates caused by performance uncertainties associated with the development status of a technology. Process contingencies are applied to each plant section based on its current technology status.

As shown in Exhibit 2-11, AACE International Recommended Practice 16R-90 provides guidelines for estimating process contingency based on EPRI philosophy [21].

Process contingencies have been applied to the estimates in this study as follows:

- CO_2 Removal System (Econamine) – 20 percent on all CO_2 capture cases - unproven technology at commercial scale in PC service.
- USC Boiler and Steam Turbine – five percent. A contingency of only five percent was used since the advanced material requirements for the steam turbine and boiler only impact a fraction of the equipment.
- Instrumentation and Controls – five percent on all accounts for CO_2 capture cases.
- CFB Boiler – 15 percent. A contingency of 15 percent was used since the boiler in this study is significantly larger than any current SC CFB units, which typically have a

maximum capacity in the range of 300 to 350 MW per boiler making these cases truly FOAK.

Exhibit 2-11 AACE Guidelines for Process Contingency

Technology Status	Process Contingency (% of Associated Process Capital)
New concept with limited data	40+
Concept with bench-scale data	30-70
Small pilot plant data	20-35
Full-sized modules have been operated	5-20
Process is used commercially	0-10

Process contingency is typically not applied to costs that are set equal to a research goal or programmatic target since these values presume to reflect the total cost.

All contingencies included in the TPC, both project and process, represent costs that are expected to be spent in the development and execution of the project.

Owner's Costs

Exhibit 2-13 explains the estimation method for owner's costs. With some exceptions, the estimation method follows guidelines in Sections 12.4.7 to 12.4.12 of AACE International Recommended Practice No. 16R-90 [21]. The Electric Power Research Institute's "Technical Assessment Guide (TAG®) – Power Generation and Storage Technology Options" also has guidelines for estimating owner's costs. The EPRI and AACE guidelines are very similar. In instances where they differ, this study has sometimes adopted the EPRI approach.

Interest during construction and escalation during construction are not included as owner's costs but are factored into the COE and are included in TASC. These costs vary based on the capital expenditure period and the financing scenario. Ratios of TASC/TOC determined from the PSFM are used to account for escalation and interest during construction. Given TOC, TASC can be determined from the ratios given in Exhibit 2-12.

Exhibit 2-12 TASC/TOC Factors

Finance Structure	IOU High Risk	IOU Low Risk
TASC/TOC	1.140	1.134

Exhibit 2-13 Owner's Costs Included in TOC

Owner's Cost	Estimate Basis
Prepaid Royalties	Any technology royalties are assumed to be included in the associated equipment cost, and thus are not included as an owner's cost.
Preproduction (Start-Up) Costs	• 6 months operating labor • 1 month maintenance materials at full capacity • 1 month non-fuel consumables at full capacity • 1 month waste disposal • 25% of one month's fuel cost at full capacity • 2% of TPC Compared to AACE 16R-90, this includes additional costs for operating labor (6 months versus 1 month) to cover the cost of training the plant operators, including their participation in startup, and involving them occasionally during the design and construction. AACE 16R-90 and EPRI TAG® differ on the amount of fuel cost to include; this estimate follows EPRI.
Working Capital	Although inventory capital (see below) is accounted for, no additional costs are included for working capital.
Inventory Capital	• 0.5% of TPC for spare parts • 60 day supply (at full capacity) of fuel. Not applicable for natural gas. • 60 day supply (at full capacity) of non-fuel consumables (e.g., chemicals and catalysts) that are stored on site. Does not include catalysts and adsorbents that are batch replacements such as WGS, COS, and SCR catalysts and activated carbon. AACE 16R-90 does not include an inventory cost for fuel, but EPRI TAG® does.
Land	• $3,000/acre (300 acres for IGCC and PC, 100 acres for NGCC)
Financing Cost	• 2.7% of TPC This financing cost (not included by AACE 16R-90) covers the cost of securing financing, including fees and closing costs but not including interest during construction (or AFUDC). The "rule of thumb" estimate (2.7% of TPC) is based on a 2008 private communication with a capital services firm.
Other Owner's Costs	• 15% of TPC This additional lumped cost is not included by AACE 16R-90 or EPRI TAG®. The "rule of thumb" estimate (15% of

<table>
<tr><th>Owner's Cost</th><th>Estimate Basis</th></tr>
<tr><td></td><td>TPC) is based on a 2009 private communication with WorleyParsons. Significant deviation from this value is possible as it is very site and owner specific. The lumped cost includes:
− Preliminary feasibility studies, including a Front-End Engineering Design (FEED) study
− Economic development (costs for incentivizing local collaboration and support)
− Construction and/or improvement of roads and/or railroad spurs outside of site boundary
− Legal fees
− Permitting costs
− Owner's engineering (staff paid by owner to give third-party advice and to help the owner oversee/evaluate the work of the EPC contractor and other contractors)
− Owner's contingency (Sometimes called "management reserve", these are funds to cover costs relating to delayed startup, fluctuations in equipment costs, unplanned labor incentives in excess of a five-day/ten-hour-per-day work week. Owner's contingency is NOT a part of project contingency.)
This lumped cost does NOT include:
− EPC Risk Premiums (Costs estimates are based on an Engineering Procurement Construction Management approach utilizing multiple subcontracts, in which the owner assumes project risks for performance, schedule and cost)
− Transmission interconnection: the cost of interconnecting with power transmission infrastructure beyond the plant busbar.
− Taxes on capital costs: all capital costs are assumed to be exempt from state and local taxes.
− Unusual site improvements: normal costs associated with improvements to the plant site are included in the bare erected cost, assuming that the site is level and requires no environmental remediation. Unusual costs associated with the following design parameters are excluded: flood plain considerations, existing soil/site conditions, water discharges and reuse, rainfall/snowfall criteria, seismic design, buildings/enclosures, fire protection, local code height requirements, and noise regulations.</td></tr>
<tr><td>Initial Cost for Catalysts and Chemicals</td><td>• All initial fills not included in BEC</td></tr>
<tr><td>Taxes & Insurance</td><td>• 2% of TPC (Fixed O&M Cost)</td></tr>
</table>

2.6.2 Operations and Maintenance Costs

The production costs or operating costs and related maintenance expenses (O&M) pertain to those charges associated with operating and maintaining the power plants over their expected life. These costs include:

- Operating labor
- Maintenance – material and labor
- Administrative and support labor
- Consumables
- Fuel
- Waste disposal
- Co-product or by-product credit (that is, a negative cost for any by-products sold)

There are two components of O&M costs; fixed O&M, which is independent of power generation, and variable O&M, which is proportional to power generation.

Operating Labor

Operating labor cost was determined based on the number of operators required for each specific case. The average base labor rate used to determine annual cost is $34.65/hour (hr). The associated labor burden is estimated at 30 percent of the base labor rate. Taxes and insurance are included as fixed O&M costs totaling 2 percent of the TPC.

Maintenance Material and Labor

Maintenance cost was evaluated on the basis of relationships of maintenance cost to initial capital cost. This represents a weighted analysis in which the individual cost relationships were considered for each major plant component or section.

Administrative and Support Labor

Labor administration and overhead charges are assessed at a rate of 25 percent of the burdened O&M labor.

Consumables

The cost of consumables, including fuel, was determined on the basis of individual rates of consumption, the unit cost of each specific consumable commodity, and the plant annual operating hours.

Quantities for major consumables such as fuel were taken from technology-specific heat and mass balance diagrams developed for each plant application. Other consumables were evaluated on the basis of the quantity required using reference data.

The quantities for initial fills and daily consumables were calculated on a 100 percent operating capacity basis. The annual cost for the daily consumables was then adjusted to incorporate the annual plant operating basis, or CF.

Initial fills of the consumables, fuels and chemicals, are different from the initial chemical loadings (such as reactor catalyst), which are included with the equipment pricing in the capital cost.

Waste Disposal

Waste quantities and disposal costs were determined similarly to the consumables. In this study fly ash and bottom ash from the PC cases are considered a waste with a disposal cost of $17.89/tonne ($16.23/ton).

Co-Products and By-Products (Other than CO_2)

By-product quantities were also determined similarly to the consumables. However, due to the variable marketability of these by-products (bottom ash; fly ash co-mingled with FGD products; or CFB bed ash co-mingled with FGD products) no credit was taken for potential saleable value.

It should be noted that by-product credits and/or disposal costs could potentially be an additional determining factor in the choice of technology for some companies and in selecting some sites. A high local value of the product can establish whether or not added capital should be included in the plant costs to produce a particular co-product. Ash is a potential by-product in certain markets and would have potential marketability. However, as stated above, since in these cases the fly ash contains mercury from carbon injection and FGD byproducts, it was assumed to be a waste material rather than a saleable byproduct.

2.6.3 CO_2 Transport, Storage and Monitoring

For those cases that feature carbon sequestration, the capital and operating costs for CO_2 TS&M were independently estimated by NETL. Those costs were converted to a TS&M COE increment that was added to the plant COE.

CO_2 TS&M was modeled based on the following assumptions:

- CO_2 is supplied to the pipeline at the plant fence line at a pressure of 15.3 MPa (2,215 psia). The CO_2 product gas composition varies in the cases presented, but is expected to meet the specification described in Exhibit 2-14 [22]. A glycol dryer located near the mid-point of the compression train is used to meet the moisture specification.
- The CO_2 is transported 80 km (50 miles) via pipeline to a geologic sequestration field for injection into a saline formation.
- The CO_2 is transported and injected as a SC fluid in order to avoid two-phase flow and achieve maximum efficiency [23]. The pipeline is assumed to have an outlet pressure (above the SC pressure) of 8.3 MPa (1,200 psia) with no recompression along the way. Accordingly, CO_2 flow in the pipeline was modeled to determine the pipe diameter that results in a pressure drop of 6.9 MPa (1,000 psi) over an 80 km (50 mile) pipeline length [24]. (Although not explored in this study, the use of boost compressors and a smaller pipeline diameter could possibly reduce capital costs for sufficiently long pipelines.) The diameter of the injection pipe will be of sufficient size that frictional losses during injection are minimal and no booster compression is required at the well-head in order to achieve an appropriate down-hole pressure, with hydrostatic head making up the difference between the injection and reservoir pressure.

Exhibit 2-14 CO_2 Pipeline Specification

Parameter	Units	Parameter Value
Inlet Pressure	MPa (psia)	15.3 (2,215)
Outlet Pressure	MPa (psia)	10.4 (1,515)
Inlet Temperature	°C (°F)	35 (95)
N_2 Concentration	ppmv	< 300
O_2 Concentration	ppmv	< 40
Ar Concentration	ppmv	< 10
H_2O Concentration	ppmv	< 150

- The saline formation is at a depth of 1,236 m (4,055 ft) and has a permeability of 22 millidarcy (md) (22 μm^2) and formation pressure of 8.4 MPa (1,220 psig) [25]. This is considered an average storage site and requires roughly one injection well for each 9,360 tonnes (10,320 short tons) of CO_2 injected per day [25]. The assumed aquifer characteristics are tabulated in Exhibit 2-15.

Exhibit 2-15 Deep Saline Aquifer Specification

Parameter	Units	Base Case
Pressure	MPa (psi)	8.4 (1,220)
Thickness	m (ft)	161 (530)
Depth	m (ft)	1,236 (4,055)
Permeability	md (μm^2)	22 (22)
Pipeline Distance	Km (miles)	80 (50)
Injection Rate per Well	Tonne (ton) CO_2/day	9,360 (10,320)

The cost metrics utilized in this study provide a best estimate of TS&M costs for a "favorable" sequestration project, and may vary significantly based on variables such as terrain to be crossed by the pipeline, reservoir characteristics, and number of land owners from which sub-surface rights must be acquired. Raw capital and operating costs are derived from detailed cost metrics found in the literature, escalated to June 2007-year dollars using appropriate price indices. These costs were then verified against values quoted by industrial sources where possible. Where regulatory uncertainty exists or costs are undefined, such as liability costs and the acquisition of underground pore volume, analogous existing policies were used for representative cost scenarios.

The following subsections describe the sources and methodology used for each metric.

TS&M Capital Costs

TS&M capital costs include both a 20 percent process contingency and 30 percent project contingency.

In several areas, such as Pore Volume Acquisition, Monitoring, and Liability, cost outlays occur over a longer time period, up to 100 years. In these cases a capital fund is established based on the net present value of the cost outlay, and this fund is then levelized similar to the other costs.

Transport Costs

CO_2 transport costs are broken down into three categories: pipeline costs, related capital expenditures, and O&M costs.

Pipeline costs are derived from data published in the Oil and Gas Journal's (O&GJ) annual Pipeline Economics Report for existing natural gas, oil, and petroleum pipeline project costs from 1991 to 2003. These costs are expected to be analogous to the cost of building a CO_2 pipeline, as noted in various studies [23, 25, 26]. The University of California performed a regression analysis to generate cost curves from the O&GJ data: (1) Pipeline Materials, (2) Direct Labor, (3) Indirect Costs, and (4) Right-of-way acquisition, with each represented as a function of pipeline length and diameter [26]. These cost curves were escalated to the June 2007 year dollars used in this study.

Related capital expenditures were based on the findings of a previous study funded by DOE/NETL, Carbon Dioxide Sequestration in Saline Formations – Engineering and Economic Assessment [25]. This study utilized a similar basis for pipeline costs (O&GJ Pipeline cost data up to the year 2000) but added a CO_2 surge tank and pipeline control system to the project.

Transport O&M costs were assessed using metrics published in a second DOE/NETL sponsored report entitled Economic Evaluation of CO_2 Storage and Sink Enhancement Options [23]. This study was chosen due to the reporting of O&M costs in terms of pipeline length, whereas the other studies mentioned above either (a) do not report operating costs, or (b) report them in absolute terms for one pipeline, as opposed to as a length- or diameter-based metric.

Storage Costs

Storage costs were divided into five categories: (1) Site Screening and Evaluation, (2) Injection Wells, (3) Injection Equipment, (4) O&M Costs, and (5) Pore Volume Acquisition. With the exception of Pore Volume Acquisition, all of the costs were obtained from Economic Evaluation of CO_2 Storage and Sink Enhancement Options [23]. These costs include all of the costs associated with determining, developing, and maintaining a CO_2 storage location, including site evaluation, well drilling, and the capital equipment required for distributing and injecting CO_2.

Pore Volume Acquisition costs are the costs associated with acquiring rights to use the sub-surface volume where the CO_2 will be stored, i.e., the pore space in the geologic formation. These costs were based on recent research by Carnegie Mellon University, which examined existing sub-surface rights acquisition as it pertains to natural gas storage [27]. The regulatory uncertainty in this area combined with unknowns regarding the number and type (private or government) of property owners, require a number of "best engineering judgment" decisions to be made. In this study it was assumed that long-term lease rights were acquired from the property owners in the projected CO_2 plume growth region for a nominal fee, and that an annual "rent" was paid when the plume reached each individual acre of their property for a period of up to 100 years from the injection start date. The present value of the life cycle pore volume costs are assessed at a 10 percent discount rate and a capital fund is set up to pay for these costs over the 100 year rent scenario.

Liability Protection

Liability Protection addresses the fact that if damages are caused by injection and long-term storage of CO_2, the injecting party may bear financial liability. Several types of liability protection schemes have been suggested for CO_2 storage, including Bonding, Insurance, and Federal Compensation Systems combined with either tort law (as with the Trans-Alaska Pipeline Fund), or with damage caps and preemption, as is used for nuclear energy under the Price Anderson Act [28]. However, at present, a specific liability regime has yet to be dictated either at a Federal or (to our knowledge) State level. However, certain state governments have enacted legislation which assigns liability to the injecting party, either in perpetuity (Wyoming) or until ten years after the cessation of injection operations, pending reservoir integrity certification, at which time liability is turned over to the state (North Dakota and Louisiana) [29, 30, 31]. In the case of Louisiana, a trust fund totaling five million dollars is established over the first ten years (120 months) of injection operations for each injector. This fund is then used by the state for CO_2 monitoring and, in the event of an at-fault incident, damage payments.

Liability costs assume that a bond must be purchased before injection operations are permitted in order to establish the ability and good will of an injector to address damages where they are deemed liable. A figure of five million dollars was used for the bond based on the Louisiana fund level. This bond level may be conservatively high, in that the Louisiana fund covers both liability and monitoring, but that fund also pertains to a certified reservoir where injection operations have ceased, having a reduced risk compared to active operations. The bond cost was not escalated.

Monitoring Costs

Monitoring costs were evaluated based on the methodology set forth in the International Energy Agency (IEA) Greenhouse Gas (GHG) R&D Programme's Overview of Monitoring Projects for Geologic Storage Projects report [32]. In this scenario, operational monitoring of the CO_2 plume occurs over thirty years (during plant operation) and closure monitoring occurs for the following fifty years (for a total of eighty years). Monitoring is via electromagnetic (EM) survey, gravity survey, and periodic seismic survey; EM and gravity surveys are ongoing while seismic survey occurs in years 1, 2, 5, 10, 15, 20, 25, and 30 during the operational period, then in years 40, 50, 60, 70, and 80 after injection ceases.

2.6.4 <u>Finance Structure, Discounted Cash Flow Analysis, and COE</u>

The global economic assumptions are listed in Exhibit 2-16.

Finance structures were chosen based on the assumed type of developer/owner (investor-owned utility (IOU) or independent power producer) and the assumed risk profile of the plant being assessed (low-risk or high-risk). For this study the owner/developer was assumed to be an IOU. The SC non-capture PC plants are categorized as low risk and all the CO_2 capture cases, USC plants, and CFB plants are categorized as high risk. Exhibit 2-17 describes the low-risk IOU and high-risk IOU finance structures that were assumed for this study. These finance structures were recommended in a 2008 NETL report based on interviews with project developers/owners, financial organizations and law firms [33].

Exhibit 2-16 Global Economic Assumptions

Parameter	Value
TAXES	
Income Tax Rate	38% (Effective 34% Federal, 6% State)
Capital Depreciation	20 years, 150% declining balance
Investment Tax Credit	0%
Tax Holiday	0 years
CONTRACTING AND FINANCING TERMS	
Contracting Strategy	Engineering Procurement Construction Management (owner assumes project risks for performance, schedule and cost)
Type of Debt Financing	Non-Recourse (collateral that secures debt is limited to the real assets of the project)
Repayment Term of Debt	15 years
Grace Period on Debt Repayment	0 years
Debt Reserve Fund	None
ANALYSIS TIME PERIODS	
Capital Expenditure Period	5 Years
Operational Period	30 years
Economic Analysis Period (used for IRROE)	35 Years (capital expenditure period plus operational period)
TREATMENT OF CAPITAL COSTS	
Capital Cost Escalation During Capital Expenditure Period (nominal annual rate)	3.6%[2]
Distribution of Total Overnight Capital over the Capital Expenditure Period (before escalation)	5-Year Period: 10%, 30%, 25%, 20%, 15%
Working Capital	zero for all parameters
% of Total Overnight Capital that is Depreciated	100% *(this assumption introduces a very small error even if a substantial amount of TOC is actually non-depreciable)*
ESCALATION OF OPERATING REVENUES AND COSTS	
Escalation of COE (revenue), O&M Costs, and Fuel Costs (nominal annual rate)	3.0%[3]

[2] A nominal average annual rate of 3.6 percent is assumed for escalation of capital costs during construction. This rate is equivalent to the nominal average annual escalation rate for process plant construction costs between 1947 and 2008 according to the *Chemical Engineering* Plant Cost Index.

[3] An average annual inflation rate of 3.0 percent is assumed. This rate is equivalent to the average annual escalation rate between 1947 and 2008 for the U.S. Department of Labor's Producer Price Index for Finished Goods, the so-called "headline" index of the various Producer Price Indices. (The Producer Price Index for the Electric Power Generation Industry may be more applicable, but that data does not provide a long-term historical perspective since it only dates back to December 2003.)

Exhibit 2-17 Financial Structure for Investor Owned Utility High and Low Risk Projects

Type of Security	% of Total	Current (Nominal) Dollar Cost	Weighted Current (Nominal) Cost	After Tax Weighted Cost of Capital
Low Risk				
Debt	50	4.5%	2.25%	
Equity	50	12%	6%	
Total			8.25%	7.39%
High Risk				
Debt	45	5.5%	2.475%	
Equity	55	12%	6.6%	
Total			9.075%	8.13%

DCF Analysis and Cost of Electricity

The NETL Power Systems Financial Model (PSFM) is a nominal-dollar[4] (current dollar) discounted cash flow (DCF) analysis tool. As explained below, the PSFM was used to calculate COE[5] in two ways: a COE and a levelized COE (LCOE). To illustrate how the two are related, COE solutions are shown in Exhibit 2-18 for a generic pulverized coal (PC) power plant and a generic natural gas combined cycle (NGCC) power plant, each with carbon capture and sequestration installed.

- The **COE** is the revenue received by the generator per net megawatt-hour during the power plant's first year of operation, *assuming that the COE escalates thereafter at a nominal annual rate equal to the general inflation rate, i.e., that it remains constant in real terms over the operational period of the power plant*. To calculate the COE, the PSFM was used to determine a "base-year" (2007) COE that, when escalated at an assumed nominal annual general inflation rate of 3 percent[6], provided the stipulated internal rate of return on equity over the entire economic analysis period (capital expenditure period plus thirty years of operation). The COE solutions are shown as curved lines in the upper portion of Exhibit 2-18 for a PC power plant and a NGCC power plant. Since this analysis assumes that COE increases over the economic analysis period at the nominal annual general inflation rate, it remains constant in real terms and the first-year COE is equivalent to the base-year COE when expressed in base-year (2007) dollars.

[4] Since the analysis takes into account taxes and depreciation, a nominal dollar basis is preferred to properly reflect the interplay between depreciation and inflation.

[5] For this calculation, "cost of electricity" is somewhat of a misnomer because from the power plant's perspective it is actually the "price" received for the electricity generated to achieve the stated IRROE. However, since the price paid for generation is ultimately charged to the end user, from the customer's perspective it is part of the cost of electricity.

[6] This nominal escalation rate is equal to the average annual inflation rate between 1947 and 2008 for the U.S. Department of Labor's Producer Price Index for Finished Goods. This index was used instead of the Producer Price Index for the Electric Power Generation Industry because the Electric Power Index only dates back to December 2003 and the Producer Price Index is considered the "headline" index for all of the various Producer Price Indices.

- The **LEVELIZED COE** is the revenue received by the generator per net megawatt-hour during the power plant's first year of operation, *assuming that the COE escalates thereafter at a nominal annual rate of 0 percent, i.e., that it remains constant in nominal terms over the operational period of the power plant.* This study reports LCOE on a current-dollar basis over thirty years. "Current dollar" refers to the fact that levelization is done on a nominal, rather than a real, basis[7]. "Thirty-years" refers to the length of the operational period assumed for the economic analysis. To calculate the LCOE, the PSFM was used to calculate a base-year COE that, when escalated at a nominal annual rate of 0 percent, provided the stipulated return on equity over the entire economic analysis period. For the example PC and NGCC power plant cases, the LCOE solutions are shown as horizontal lines in the upper portion of Exhibit 2-18.

Exhibit 2-18 also illustrates the relationship between COE and the assumed developmental and operational timelines for the power plants. As shown in the lower portion of Exhibit 2-18, the capital expenditure period is assumed to start in 2007 for all cases in this report. All capital costs included in this analysis, including project development and construction costs, are assumed to be incurred during the capital expenditure period. Coal-fueled plants are assumed to have a capital expenditure period of five years and natural gas-fueled plants are assumed to have a capital expenditure period of three years. Since both types of plants begin expending capital in the base year (2007), this means that the analysis assumes that they begin operating in different years: 2012 for coal plants and 2010 for natural gas plants in this study (see Volume 3c for cost and performance of NGCC plants). Note that, according to the *Chemical Engineering* Plant Cost Index, June-2007 dollars are nearly equivalent to January-2010 dollars.

In addition to the capital expenditure period, the economic analysis considers thirty years of operation.

Since 2007 is the first year of the capital expenditure period, it is also the base year for the economic analysis. Accordingly, it is convenient to report the results of the economic analysis in base-year (June 2007) dollars, except for TASC, which is expressed in mixed-year, current dollars over the capital expenditure period.

Consistent with our nominal-dollar discounted cash flow methodology, the COEs shown on Exhibit 2-18 are expressed in current dollars. However, they can also be expressed in constant, base year dollars (June 2007) as shown in Exhibit 2-19 by adjusting them with the assumed nominal annual general inflation rate (3 percent).

Exhibit 2-19 illustrates the same information as in Exhibit 2-18 for a PC plant with CCS only on a constant 2007 dollar basis. With an assumed nominal COE escalation rate equal to the rate of inflation, the COE line now becomes horizontal and the LCOE decreases at a rate of 3 percent per year.

[7] For this current-dollar analysis, the LCOE is uniform in current dollars over the analysis period. In contrast, a constant-dollar analysis would yield an LCOE that is uniform in constant dollars over the analysis period.

Exhibit 2-18 Illustration of COE Solutions using DCF Analysis

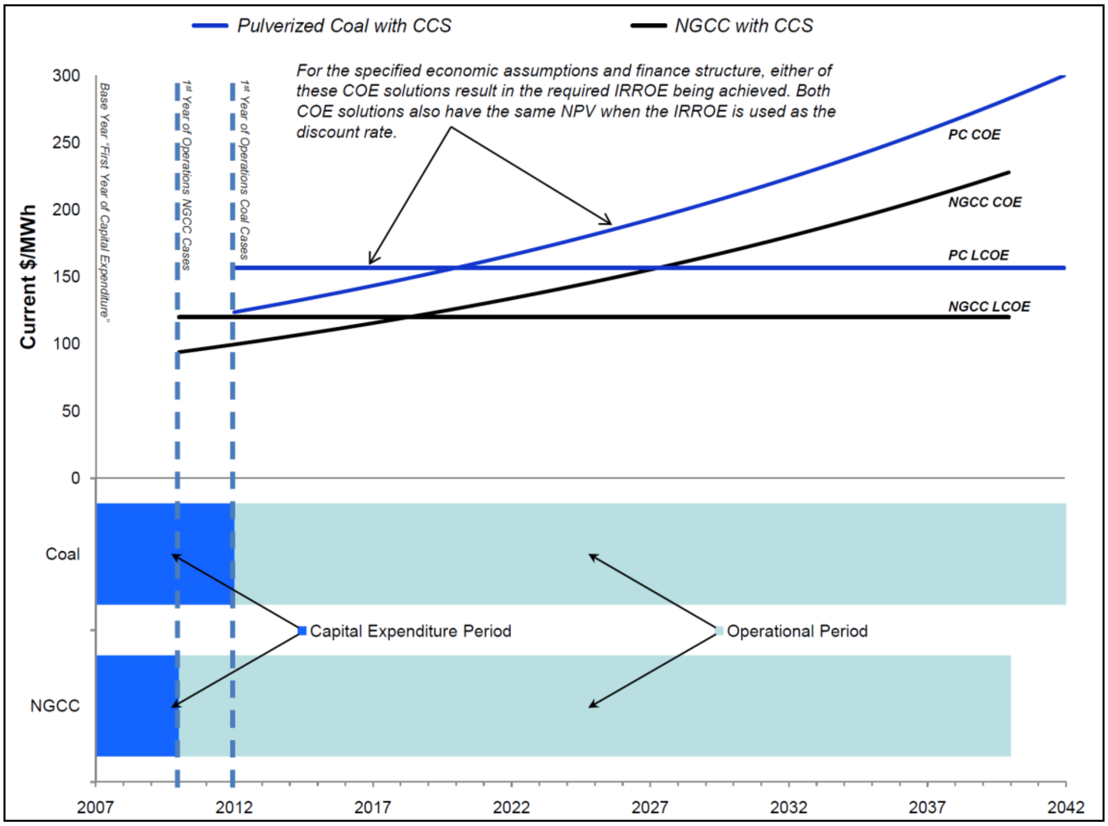
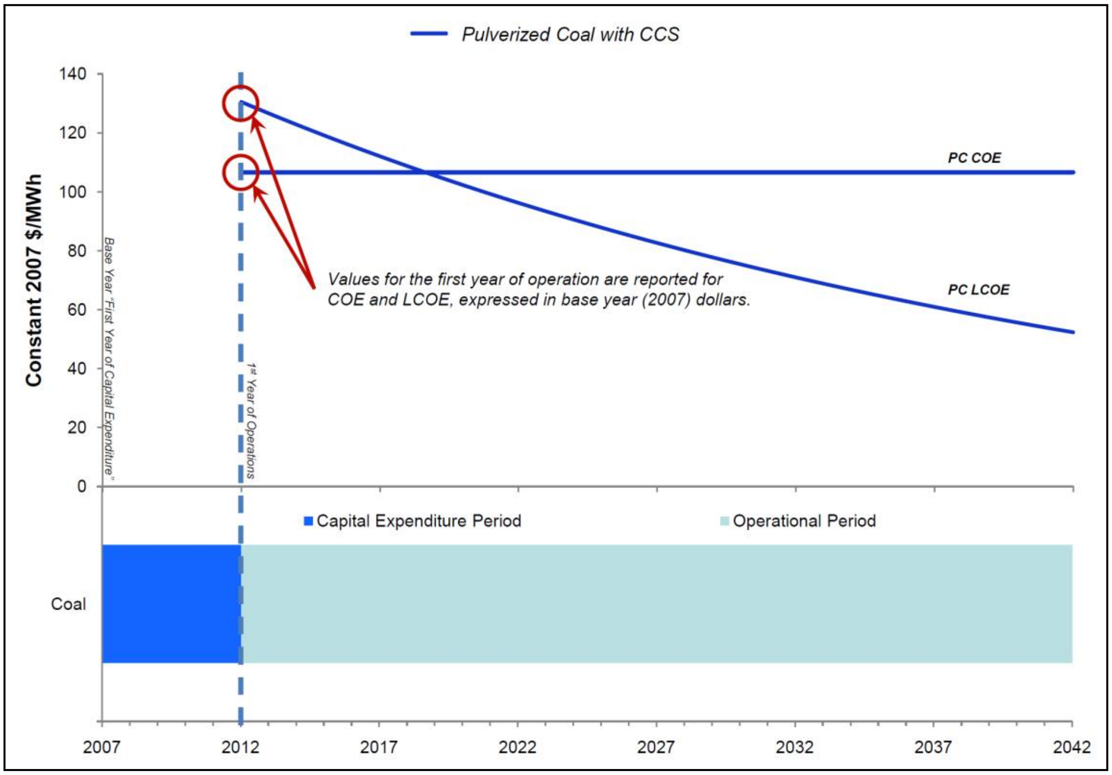


Exhibit 2-19 PC with CCS in Current 2007 Dollars



Estimating COE with Capital Charge Factors

For scenarios that adhere to the global economic assumptions listed in Exhibit 2-16 and utilize one of the finance structures listed in Exhibit 2-17, the following simplified equation can be used to estimate COE as a function of TOC[8], fixed O&M, variable O&M (including fuel), capacity factor and net output. The equation requires the application of one of the capital charge factors (CCF) listed in Exhibit 2-20. These CCFs are valid only for the global economic assumptions listed in Exhibit 2-16, the stated finance structure, and the stated capital expenditure period.

Exhibit 2-20 Capital Charge Factors for COE Equation

Finance Structure	High Risk IOU	Low Risk IOU
Capital Charge Factor (CCF)	0.1243	0.1165

All factors in the COE equation are expressed in base-year dollars. The base year is the first year of capital expenditure, which for this study is assumed to be 2007. As shown in Exhibit 2-16, all factors (COE, O&M and fuel) are assumed to escalate at a nominal annual general inflation rate of 3.0 percent. Accordingly, all first-year costs (COE and O&M) are equivalent to base-year costs when expressed in base-year (2007) dollars.

$$COE = \frac{\begin{matrix} first\ year \\ capital\ charge \end{matrix} + \begin{matrix} first\ year \\ fixed\ operating \\ costs \end{matrix} + \begin{matrix} first\ year \\ variable\ operating \\ costs \end{matrix}}{\begin{matrix} annual\ net\ megawatt\ hours \\ of\ power\ generated \end{matrix}}$$

$$COE = \frac{(CCF)(TOC) + OC_{FIX} + (CF)(OC_{VAR})}{(CF)(MWH)}$$

where:

COE = revenue received by the generator (\$/MWh, equivalent to mills/kWh) during the power plant's first year of operation (*but expressed in base-year dollars*), assuming that the COE escalates thereafter at a nominal annual rate equal to the general inflation rate, i.e., that it remains constant in real terms over the operational period of the power plant.

CCF = capital charge factor taken from Exhibit 2-20 that matches the applicable finance structure and capital expenditure period

TOC = total overnight capital, *expressed in base-year dollars*

[8] Although TOC is used in the simplified COE equation, the CCF that multiplies it accounts for escalation during construction and interest during construction (along with other factors related to the recovery of capital costs).

OC_{FIX} = the sum of all fixed annual operating costs, *expressed in base-year dollars*

OC_{VAR} = the sum of all variable annual operating costs, including fuel at 100 percent capacity factor, *expressed in base-year dollars*

CF = plant capacity factor, assumed to be constant over the operational period

MWH = annual net megawatt-hours of power generated at 100 percent capacity factor

The primary cost metric in this study is the COE, which is the base-year cost presented in base-year dollars. Exhibit 2-21 presents this cost metric along with the COE escalated to the first year of operation (2010 for NGCC cases and 2012 for coal cases) using the average annual inflation rate of 3 percent. Similarly, the LCOE is presented in both base-year dollars and first year of operation dollars. Using a similar methodology, the reader may generate either metric in the desired cost year basis.

Exhibit 2-21 COE and LCOE Summary

Case	COE		LCOE	
	Base-Year	First Operational Year	Base-Year	First Operational Year
	2007$	2012$	2007$	2012$
S12A	57.80	67.00	73.27	84.93
S12B	107.50	124.62	136.27	157.97
L12A	62.20	72.10	78.84	91.40
L12B	116.36	134.90	147.51	171.00
S13A	62.17	72.07	78.81	91.36
S13B	107.66	124.80	136.47	158.20
L13A	67.31	78.03	85.32	98.91
L13B	115.38	133.76	146.26	169.56
S22A	61.53	71.33	78.00	90.42
S22B	107.97	125.17	136.87	158.67
L22A	64.57	74.86	81.85	94.89
L22B	115.19	133.54	146.02	169.27

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3. COMBUSTION POWER PLANT PROCESS DESCRIPTIONS

3.1 COMMON PROCESS AREAS FOR ALL COMBUSTION CASES

The combustion cases have process areas that are common to each plant configuration such as coal receiving and storage, emissions control technologies, power generation, etc. As detailed descriptions of these process areas in each case section would be burdensome and repetitious, they are presented in this section for general background information. The performance features of these sections are then presented in the case-specific sections.

3.1.1 Coal and Sorbent Receiving and Storage

The function of the coal portion of the Coal and Sorbent Receiving and Storage system is to provide the equipment required for unloading, conveying, preparing, and storing the fuel delivered to the plant. The scope of the system is from the coal conveyor receiving hoppers up to the coal storage silos. The system is designed to support short-term operation at maximum power output at the five percent over pressure/valves wide open (OP/VWO) condition (16 hours) and long-term operation of 90 days or more at the maximum continuous rating (MCR).

The scope of the sorbent receiving and storage systems includes truck roadways, turnarounds, unloading hoppers, conveyors, and the day storage bin. The limestone system for the CFB cases also includes reclaim hoppers and feeders.

Operation Description – The NDL plants are located at the minemouth and coal is delivered to the plant from the mine by conveyor into two receiving hoppers. Coal is delivered to the PRB plants by 100-car unit trains comprised of 91 tonne (100 ton) rail cars. The unloading is done by a trestle dumper, which unloads the coal into two receiving hoppers.

For both plant types, coal from each hopper is fed directly into a vibratory feeder. The 8 centimeter (cm) x 0 (3” x 0) coal from the feeder is discharged onto a belt conveyor. Two conveyors with an intermediate transfer tower are assumed to convey the coal to the coal stacker, which transfer the coal to either the long-term storage pile or to the reclaim area. The conveyor passes under a magnetic plate separator to remove tramp iron and then to the reclaim pile.

Coal from the reclaim pile is fed by two vibratory feeders, located under the pile, onto a belt conveyor, which transfers the coal to the coal surge bin located in the crusher tower. The coal is reduced in size to 2.5 cm x 0 (1” x 0) by the coal crushers. The coal is then transferred by conveyor to the transfer tower. In the transfer tower the coal is routed to the tripper that loads the coal into one of the six boiler silos.

For the PC cases, lime is delivered to the site using 23 tonne (25 ton) trucks and conveyed to storage. Lime is stored in a bulk storage lime silo. The lime is pneumatically conveyed to a day bin.

For the CFB cases, limestone is delivered to the site using 23 tonne (25 ton) trucks. The trucks empty into a below grade hopper where a feeder transfers the limestone to a conveyor for delivery to the storage pile. Limestone from the storage pile is transferred to a reclaim hopper and conveyed to a day bin.

3.1.2 Steam Generator and Ancillaries

The steam generating boilers are described in Section 3.2.1 for the PC case and Section 3.3.1 for the CFB cases. The steam generator operates as follows:

Feedwater and Steam

For the SC and USC steam systems, feedwater (FW) enters the bottom header of the economizer and passes upward through the economizer tube bank, through stringer tubes that support the primary superheater, and discharges to the economizer outlet headers. From the outlet headers, water flows to the furnace hopper inlet headers via external downcomers. Water then flows upward through the furnace hopper and furnace wall tubes. From the furnace, water flows to the steam water separator. During low load operation (operation below the Benson point), the water from the separator is returned to the economizer inlet with the boiler recirculating pump. Operation at loads above the Benson point is once through.

Steam flows from the separator through the furnace roof to the convection pass enclosure walls, primary superheater, through the first stage of water attemperation, to the furnace platens. From the platens, the steam flows through the second stage of attemperation and then to the intermediate superheater. The steam then flows to the final superheater and on to the outlet pipe terminal. Two stages of spray attemperation are used to provide tight temperature control in all high temperature sections during rapid load changes.

Steam returning from the turbine passes through the primary reheater (RH) surface, then through crossover piping containing inter-stage attemperation. The crossover piping feeds the steam to the final RH banks and then out to the turbine. Inter-stage attemperation is used to provide outlet temperature control during load changes.

3.1.3 Particulate Control

A pulse-jet baghouse with air to cloth ratio of 3.5 feet per minute (ft/min) is provided. The baghouse is provided with a spare compartment for off line cleaning to maintain the opacity at 10 percent or less. The waste is pneumatically conveyed to a waste storage silo with a 3-day storage capacity, which is in accordance with typical utility design. Flue gas exits the baghouse and enters the Induced Draft (ID) fan suction.

3.1.4 Carbon Dioxide Recovery Facility

A Carbon Dioxide Recovery (CDR) facility is used in Cases S12B, S13B, L12B, L13B, S22B, and L22B to remove 90 percent of the CO_2 in the flue gas exiting the baghouse unit, purify it, and compress it to a SC condition. The CDR is comprised of the flue gas supply, SO_2 polishing, CO_2 absorption, solvent stripping and reclaiming, and CO_2 compression and drying.

The CO_2 absorption/stripping/solvent reclaim process for the CO_2 capture cases is based on the Fluor Econamine FG Plus^{SM} technology [34,35]. A typical flowsheet is shown in Exhibit 3-1. The Econamine FG Plus process uses a formulation of monoethanolamine (MEA) and a proprietary corrosion inhibitor to recover CO_2 from the flue gas. This process is designed to recover high-purity CO_2 from low-pressure (LP) streams that contain O_2, such as flue gas from coal-fired power plants, gas turbine exhaust gas, and other waste gases. The Econamine process used in this study differs from previous studies, including the 2004 IEA study [34], in the following ways:

- The complexity of the control and operation of the plant is significantly decreased
- Solvent consumption is decreased
- Hard to dispose waste from the plant is greatly reduced

The above are achieved at the expense of a slightly higher steam requirement in the stripper reboiler (3,556 kJ/kg [1,530 Btu/lb] versus 3,242 kJ/kg [1,395 Btu/lb] used in the IEA study) [36]. A recent Fluor publication [43] indicates that a reboiler steam duty of 1,270 Btu/lb$_{CO2}$ is possible with higher MEA concentration and improved corrosion inhibitors. A sensitivity analysis was conducted to estimate the impact of the lower reboiler steam consumption on the COE. This sensitivity study is included in Section 6.

SO_2 Polishing and FG Cooling and Supply

To minimize the accumulation of heat stable salts (HSS), the incoming flue gas must have an SO_2 concentration of 10 ppmv or less. The gas exiting the FGD system passes through an SO_2 polishing step to achieve this objective. The polishing step consists of a non-plugging, low-differential-pressure, spray-baffle-type scrubber using a 20 weight percent (wt%) solution of sodium hydroxide (NaOH). A removal efficiency of about 80 percent is necessary to reduce SO_2 emissions from the FGD outlet to 10 ppmv as required by the Econamine process. The polishing scrubber proposed for this application has been demonstrated in numerous industrial applications throughout the world and can achieve removal efficiencies of over 95 percent if necessary.

The polishing scrubber also serves as the flue gas cooling system. Cooling water from the PC/CFB plant is used to reduce the flue gas temperature to below the adiabatic saturation temperature resulting in a reduction of the flue gas moisture content. Flue gas is cooled beyond the CO_2 absorption process requirements to 32°C (90°F) to account for the subsequent temperature increase of about 17°C (30°F) in the flue gas blower. Downstream from the Polishing Scrubber flue gas pressure is boosted in the Flue Gas Blowers by approximately 0.014 MPa (2 pounds per square inch [psi]) to overcome pressure drop in the CO_2 absorber tower.

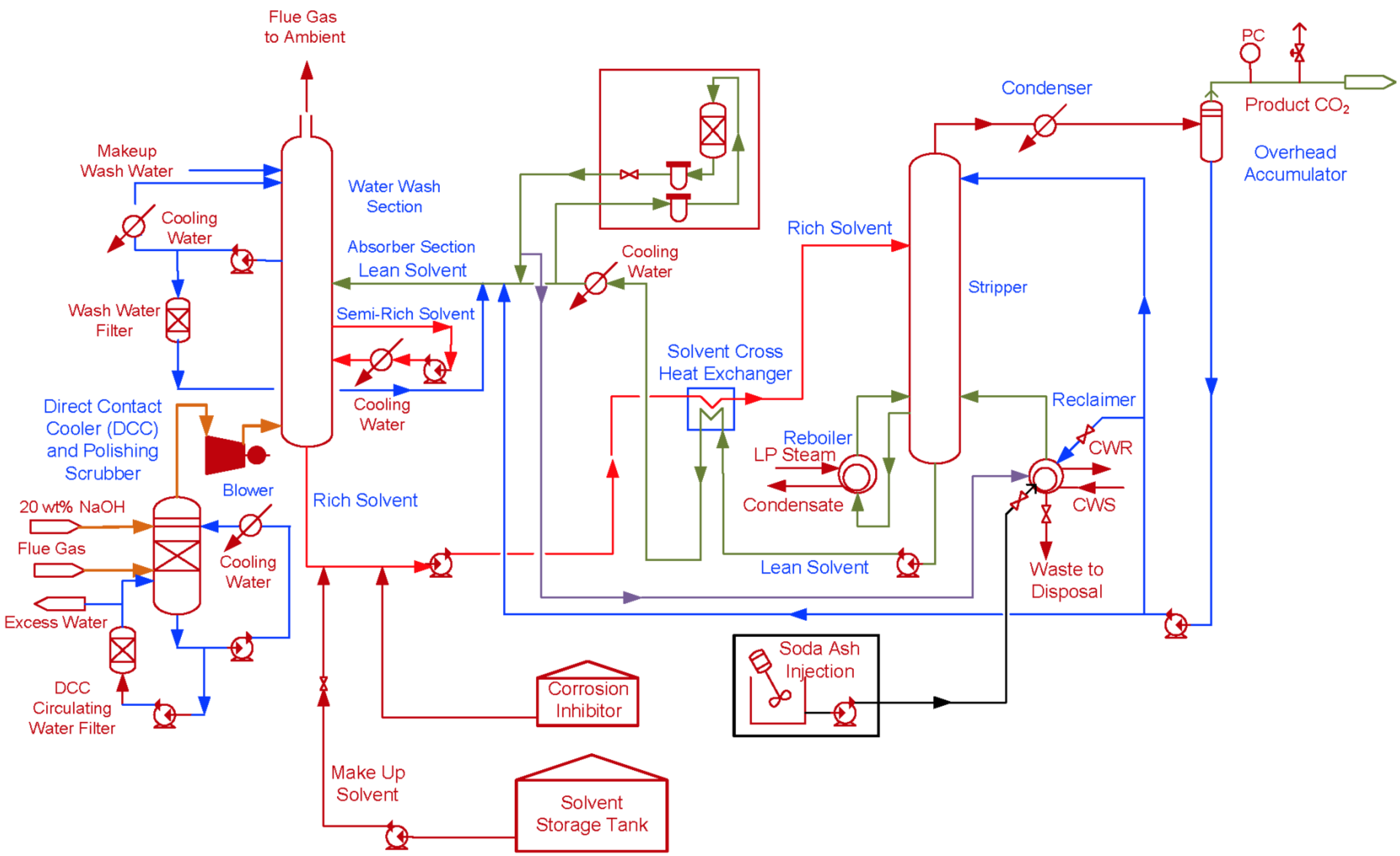
Circulating Water System

Cooling water is provided from the PC/CFB plant circulating water system (CWS) and returned to the plant cooling tower. The CDR facility requires a significant amount of cooling water for flue gas cooling, water wash cooling, absorber intercooling, reflux condenser duty, reclaimer cooling, the lean solvent cooler, and CO_2 compression interstage cooling.

CO_2 Absorption

The cooled flue gas enters the bottom of the CO_2 Absorber and flows up through the tower countercurrent to a stream of lean MEA-based solvent. Approximately 90 percent of the CO_2 in the feed gas is absorbed into the lean solvent, and the rest leaves the top of the absorber section and flows into the water wash section of the tower. The lean solvent enters the top of the absorber section, absorbs the CO_2 from the flue gas, and leaves the bottom of the absorber with the absorbed CO_2. The FG Plus process also includes solvent intercooling. The semi-rich solvent is extracted from the column, cooled using cooling water, and returned to the absorber section just below the extraction point. The CO_2 carrying capacity of the solvent is increased at lower temperature, which reduces the solvent circulation rate.

Exhibit 3-1 Fluor Econamine FG Plus[SM] Typical Flow Diagram



Water Wash Section

The purpose of the Water Wash section is to minimize solvent losses due to mechanical entrainment and evaporation. The flue gas from the top of the CO_2 Absorption section is contacted with a re-circulating stream of water for the removal of most of the lean solvent. The scrubbed gases, along with unrecovered solvent, exit the top of the wash section for discharge to the atmosphere via the vent stack. The water stream from the bottom of the wash section is collected on a chimney tray. A portion of the water collected on the chimney tray spills over to the absorber section as water makeup for the amine with the remainder pumped via the Wash Water Pump, cooled by the Wash Water Cooler, and recirculated to the top of the CO_2 Absorber. The wash water level is maintained by wash water makeup.

Rich/Lean Amine Heat Exchange System

The rich solvent from the bottom of the CO_2 Absorber is preheated by the lean solvent from the Solvent Stripper in the Lean/Rich Cross Exchanger. The heated rich solvent is routed to the Solvent Stripper for removal of the absorbed CO_2. The stripped solvent from the bottom of the Solvent Stripper is pumped via the Lean Solvent Pump to the Lean Solvent Cooler. A slipstream of the lean solvent is then sent through the Amine Filter Package to prevent buildup of contaminants in the solution. The filtered lean solvent is mixed with the remaining lean solvent from the Lean Solvent Cooler and sent to the CO_2 Absorber, completing the circulating solvent circuit.

Solvent Stripper

The purpose of the Solvent Stripper is to separate the CO_2 from the rich solvent feed exiting the bottom of the CO_2 Absorber. The rich solvent is collected on a chimney tray below the bottom packed section of the Stripper and routed to the Reboiler where the rich solvent is heated by steam, stripping the CO_2 from the solution. Steam is provided from the crossover pipe between the IP and LP sections of the steam turbine at 0.51 MPa (74 psia) and 292°C (557°F). The hot wet vapor from the top of the stripper containing CO_2, steam, and solvent vapor, is partially condensed in the Reflux Condenser by cross exchanging the hot wet vapor with cooling water. The partially condensed stream then flows to the Reflux Drum where the vapor and liquid are separated. The uncondensed CO_2-rich gas is then delivered to the CO_2 product compressor. The condensed liquid from the Reflux Drum is pumped via the Reflux Pump where a portion of condensed overhead liquid is combined with the lean solvent entering the CO_2 Absorber. The rest of the pumped liquid is routed back to the Solvent Stripper as reflux, which aids in limiting the amount of solvent vapors entering the stripper overhead system.

Solvent Reclaimer

The low temperature reclaimer technology is a recent development for the FG Plus technology. A small slipstream of the lean solvent is fed to the Solvent Reclaimer for the removal of high-boiling nonvolatile impurities including HSS, volatile acids and iron products from the circulating solvent solution. Reclaiming occurs in two steps, the first is an ion-exchange process. There is a small amount of degradation products that cannot be removed via ion-exchange, and a second atmospheric pressure reclaiming process is used to remove the degradation products. The solvent reclaimer system reduces corrosion, foaming and fouling in the solvent system. The reclaimed solvent is returned to the Solvent Stripper and the spent solvent is pumped via the

Solvent Reclaimer Drain Pump to the Solvent Reclaimer Drain Tank for disposal. The quantity of spent solvent is greatly reduced from the previously used thermal reclaimer systems.

Steam Condensate

Steam condensate from the Solvent Stripper Reclaimer accumulates in the Solvent Reclaimer Condensate Drum and is level controlled to the Solvent Reboiler Condensate Drum. Steam condensate from the Solvent Stripper Reboilers is also collected in the Solvent Reboiler Condensate Drum and returned to the steam cycle between BFW heaters 4 and 5 via the Solvent Reboiler Condensate Pumps.

Corrosion Inhibitor System

A proprietary corrosion inhibitor is continuously injected into the CO_2 Absorber rich solvent bottoms outlet line. This additive is to help control the rate of corrosion throughout the CO_2 recovery plant system.

Gas Compression and Drying System

In the compression section, the CO_2 is compressed to 15.3 MPa (2,215 psia) by a six-stage centrifugal compressor. The discharge pressures of the stages were balanced to give reasonable power distribution and discharge temperatures across the various stages as shown in Exhibit 3-2.

Exhibit 3-2 CO_2 Compressor Interstage Pressures

Stage	Outlet Pressure, MPa (psia)
1	0.35 (51)
2	0.77 (112)
3	1.69 (245)
4	3.71 (538)
5	8.16 (1,184)
6	15.3 (2,215)

Power consumption for this large compressor was estimated assuming a polytropic efficiency of 86 percent and mechanical efficiency of 98 percent for all stages. During compression to 15.3 MPa (2,215 psia) in the multiple-stage, intercooled compressor, the CO_2 stream is dehydrated to a dew point of -40ºC (-40°F) with triethylene glycol (TEG). The virtually moisture-free SC CO_2 stream is delivered to the plant battery limit as sequestration ready. CO_2 TS&M costs were estimated and included in LCOE and COE using the methodology described in Section 2.6.

3.1.5 Power Generation

Since there is no single consensus definition of USC conditions, a literature search was conducted to identify conditions to be used in this study. Main steam conditions of 24.1 MPa/593°C (3,500 psig/1,100°F) are used for SC PC and CFB cases and 27.6 MPa/649°C (4,000 psig/1,200°F) for USC PC cases in this study.

Reasons for this decision include:

- The SC steam conditions are consistent with SC PC cases in Volume 1 of this study [37]
- Even without a precise definition for USC, these steam conditions would be categorized as USC by all
- The SC and USC steam conditions are sufficiently different to see a meaningful difference in plant efficiency

The steam turbine is designed for long-term operation (90 days or more) at MCR with throttle control valves 95 percent open. It is also capable of a short-term five percent OP/VWO condition (16 hours).

The steam turbine is a tandem compound type, consisting of HP-intermediate pressure (IP)-two LP (double flow) sections enclosed in three casings, designed for condensing single reheat operation, and equipped with non-automatic extractions and four-flow exhaust. The turbine drives a hydrogen cooled generator. The turbine has direct current (DC) motor-operated lube oil pumps, and main lube oil pumps, which are driven off the turbine shaft [38]. The exhaust pressure is 35.6 centimeter (cm) (1.4 in) Hg in the single pressure condenser. The condenser is two-shell, transverse, single pressure with divided waterbox for each shell.

Turbine bearings are lubricated by a closed-loop (CL), water-cooled pressurized oil system. Turbine shafts are sealed against air in-leakage or steam blowout using a labyrinth gland arrangement connected to a LP steam seal system. The generator stator is cooled with a CL water system consisting of circulating pumps, shell and tube or plate and frame type heat exchangers, filters, and deionizers, all skid-mounted. The generator rotor is cooled with a hydrogen gas recirculation system using fans mounted on the generator rotor shaft.

<u>Operation Description</u>

The turbine stop valves, control valves, reheat stop valves, and intercept valves are controlled by an electro-hydraulic control system. Main steam from the boiler passes through the stop valves and control valves and enters the turbine at 24.1 MPa/593°C (3,500 psig/1,100°F) for the SC cases and 27.6 MPa/649°C (4,000 psig/1,200°F) for the USC cases. The steam initially enters the turbine near the middle of the HP span, flows through the turbine, and returns to the boiler for reheating. The reheat steam flows through the reheat stop valves and intercept valves and enters the IP section at 593°C (1,100°F) in the SC cases and 649°C (1,200°F) in the USC cases. After passing through the IP section, the steam enters a crossover pipe, which transports the steam to the two LP sections. The steam divides into four paths and flows through the LP sections exhausting downward into the condenser.

The turbine is designed to operate at constant inlet steam pressure over the entire load range.

3.1.6 <u>Balance of Plant</u>

The balance of plant components consist of the condensate, FW, main and reheat steam, extraction steam, ash handling, ducting and stack, waste treatment, and miscellaneous systems as described below.

<u>Condensate</u>

The function of the condensate system is to pump condensate from both the air-cooled and water-cooled condenser to the deaerator, through the LP FW heaters. Each system consists of two main condensers (one air-cooled and one water-cooled); two variable speed electric motor-driven vertical condensate pumps each sized for 50 percent capacity; four LP heaters; and one deaerator with storage tank.

Condensate is delivered to a common discharge header through two separate pump discharge lines, each with a check valve and a gate valve. A common minimum flow recirculation line discharging to the condenser is provided downstream of the gland steam condenser to maintain minimum flow requirements for the gland steam condenser and the condensate pumps.

LP FW heaters 1 through 4 are 50 percent capacity, parallel flow, and are located in the condenser neck. All remaining FW heaters are 100 percent capacity shell and U-tube heat exchangers. Each LP FW heater is provided with inlet/outlet isolation valves and a full capacity bypass. LP FW heater drains cascade down to the next lowest extraction pressure heater and finally discharge into the condenser. Pneumatic level control valves control normal drain levels in the heaters. High heater level dump lines discharging to the condenser are provided for each heater for turbine water induction protection. Pneumatic level control valves control dump line flow.

Feedwater

The function of the FW system is to pump the FW from the deaerator storage tank through the HP FW heaters to the economizer. One turbine-driven BFW pump sized at 100 percent capacity is provided to pump FW through the HP FW heaters. One 25 percent motor-driven BFW pump is provided for startup. The pumps are provided with inlet and outlet isolation valves, and individual minimum flow recirculation lines discharging back to the deaerator storage tank. The recirculation flow is controlled by automatic recirculation valves, which are a combination check valve in the main line and in the bypass, bypass control valve, and flow sensing element. The suction of the boiler feed pump is equipped with startup strainers, which are utilized during initial startup and following major outages or system maintenance.

Each HP FW heater is provided with inlet/outlet isolation valves and a full capacity bypass. FW heater drains cascade down to the next lowest extraction pressure heater and finally discharge into the deaerator. Pneumatic level control valves control normal drain level in the heaters. High heater level dump lines discharging to the condenser are provided for each heater for turbine water induction protection. Dump line flow is controlled by pneumatic level control valves.

The deaerator is a horizontal, spray tray type with internal direct contact stainless steel (SS) vent condenser and storage tank. The boiler feed pump turbine is driven by main steam up to 60 percent plant load. Above 60 percent load, extraction from the IP turbine exhaust provides steam to the boiler feed pump steam turbine.

Main and Reheat Steam

The function of the main steam system is to convey main steam from the boiler superheater outlet to the HP turbine stop valves. The function of the reheat system is to convey steam from the HP turbine exhaust to the boiler RH and from the boiler RH outlet to the IP turbine stop valves.

Main steam exits the boiler superheater through a motor-operated stop/check valve and a motor-operated gate valve and is routed in a single line feeding the HP turbine. A branch line off the IP turbine exhaust feeds the BFW pump turbine during unit operation starting at approximately 60 percent load.

Cold reheat steam exits the HP turbine, flows through a motor-operated isolation gate valve and a flow control valve, and enters the boiler RH. Hot reheat steam exits the boiler RH through a motor-operated gate valve and is routed to the IP turbine.

Extraction Steam

The function of the extraction steam system is to convey steam from turbine extraction points to the FW heaters, deaerator, and CDR facility for CO_2 capture cases.

The turbine is protected from overspeed on turbine trip, from flash steam reverse flow from the heaters through the extraction piping to the turbine. This protection is provided by positive closing, balanced disc non-return valves located in all extraction lines except the lines to the LP FW heaters in the condenser neck. The extraction non-return valves are located only in horizontal runs of piping and as close to the turbine as possible.

The turbine trip signal automatically trips the non-return valves through relay dumps. The remote manual control for each heater level control system is used to release the non-return valves to normal check valve service when required to restart the system.

Circulating Water System

Exhaust steam from the steam turbine is split 50/50 to a surface condenser cooled with cooling water and to an air-cooled condenser using ambient air and forced convection. A decision to use a parallel wet/dry cooling system was based primarily on the plans for the Xcel Energy Comanche 3 PC plant currently under construction, and the desire to reduce the plant water requirement.

The major impact of parallel cooling is a significant reduction in water requirement when compared to a wet cooling system. This impact is included in the water balance presented later in this report.

Because of the low ambient temperatures at the sites in this study, a condenser pressure of 4.81 kilopascal absolute (kPa) (0.698 psia) (condensing temperature of 32°C [90°F]) is used in the model as compared to 6.77 kPa (0.983 psia) (condensing temperature of 38°C [101°F]) used in Volume 1 of this report [37].

The CWS is a closed-cycle cooling water system that rejects heat through a wet cooling tower and supplies cooling water to the surface condenser to condense one-half of the main turbine exhaust steam. The system also supplies cooling water to the CDR plant as required, and to the auxiliary cooling system. The auxiliary cooling system is a CL process that utilizes a higher quality water to remove heat from compressor intercoolers, oil coolers and other ancillary equipment and transfers that heat to the main circulating cooling water system in plate and frame heat exchangers. The heat transferred to the circulating water in the surface condenser and other applications is removed by a mechanical draft cooling tower.

The system consists of two 50 percent capacity vertical CWPs, a mechanical draft evaporative cooling tower, and carbon steel (CS) cement-lined interconnecting piping. The pumps are single-stage vertical pumps. The piping system is equipped with isolation valves and all required expansion joints. The cooling tower is a multi-cell wood frame counterflow mechanical draft cooling tower.

The water-cooled surface condenser is a single-pass, horizontal type with divided water boxes. There are two separate circulating water circuits in each box. One-half of the condenser can be removed from service for cleaning or for plugging tubes. This can be done during normal operation at reduced load. The air-cooled condenser utilizes ambient air and forced convection across tube bundles to condense the remaining one-half of the turbine exhaust steam.

Both condensers are equipped with an air extraction system to evacuate the condenser steam space for removal of non-condensable gases during steam turbine operation and to rapidly reduce the condenser pressure from atmospheric pressure before unit startup and admission of steam to the condenser.

Ash Handling System

The function of the ash handling system is to provide the equipment required for conveying, preparing, storing, and disposing of the fly ash and bottom ash produced on a daily basis by the boiler. The scope of the system is from the baghouse hoppers, air heater, and economizer hopper collectors, and bottom ash hoppers to the dewatering bins (for bottom ash) and truck filling stations (for fly ash). The system is designed to support short-term operation at the five percent OP/VWO condition (16 hours) and long-term operation at the 100 percent guarantee point (90 days or more).

The fly ash collected in the baghouse and the air heaters is conveyed to the fly ash storage silo. A pneumatic transport system using low-pressure air from a blower provides the transport mechanism for the fly ash. Fly ash is discharged through a wet unloader, which conditions the fly ash and conveys it through a telescopic unloading chute into a truck for disposal. Bottom ash removal is handled by truck.

For systems that include an SDA FGD, ash collected in the baghouse includes particulates from the FGD that include unreacted lime. Sorbent utilization is increased by about 40 percent by slurrying and recycling a portion of the baghouse ash into the absorber with the virgin lime slurry.

Ash from the economizer hoppers and pyrites (rejected from the coal pulverizers in the PC cases) is conveyed using water to the economizer/pyrites transfer tank. This material is then sluiced on a periodic basis to the hydrobins.

Ducting and Stack

One stack is provided with a single fiberglass-reinforced plastic (FRP) liner. The stack is constructed of reinforced concrete. The stack is 152 m (500 ft) high for adequate particulate dispersion. The ID fans were sized large enough to allow for additional stack velocity to overcome the buoyancy losses resulting from colder than normal flue gas temperatures for the CO_2 capture cases.

Waste Treatment/Miscellaneous Systems

An onsite water treatment facility treats all runoff, cleaning wastes, blowdown, and backwash to within the U.S. EPA standards for suspended solids, oil and grease, pH, and miscellaneous metals. Waste treatment equipment is housed in a separate building. The waste treatment system consists of a water collection basin, three raw waste pumps, an acid neutralization system, an oxidation system, flocculation, clarification/thickening, and sludge dewatering. The water collection basin is a synthetic-membrane-lined earthen basin, which collects rainfall runoff, maintenance cleaning wastes, and backwash flows.

The raw waste is pumped to the treatment system at a controlled rate by the raw waste pumps. The neutralization system neutralizes the acidic wastewater with hydrated lime in a two-stage system, consisting of a lime storage silo/lime slurry makeup system, dry lime feeder, lime slurry tank, slurry tank mixer, and lime slurry feed pumps.

The oxidation system consists of an air compressor, which injects air through a sparger pipe into the second-stage neutralization tank. The flocculation tank is fiberglass with a variable speed agitator. A polymer dilution and feed system is also provided for flocculation. The clarifier is a plate-type, with the sludge pumped to the dewatering system. The sludge is dewatered in filter presses and disposed offsite. Trucking and disposal costs are included in the cost estimate. The filtrate from the sludge dewatering is returned to the raw waste sump.

Miscellaneous systems consisting of fuel oil, service air, instrument air, and service water are provided. A storage tank provides a supply of No. 2 fuel oil used for startup and for a small auxiliary boiler. Fuel oil is delivered by truck. All truck roadways and unloading stations inside the fence area are provided.

<u>Buildings and Structures</u>

Foundations are provided for the support structures, pumps, tanks, and other plant components. The following buildings are included in the design basis:

- Steam turbine building
- Boiler building
- Administration and service building
- Makeup water and pretreatment building
- Fuel oil pump house
- Coal crusher building
- Continuous emissions monitoring building
- Pump house and electrical equipment building
- Guard house
- Runoff water pump house
- Industrial waste treatment building
- FGD system buildings

3.1.7 Accessory Electric Plant

The accessory electric plant consists of switchgear and control equipment, generator equipment, station service equipment, conduit and cable trays, and wire and cable. It also includes the main power transformer, required foundations, and standby equipment.

3.1.8 Instrumentation and Control

An integrated plant-wide control and monitoring distributed control system (DCS) is provided. The DCS is a redundant microprocessor-based, functionally distributed system. The control room houses an array of multiple video monitor and keyboard units. The monitor/keyboard units are the primary interface between the generating process and operations personnel. The DCS incorporates plant monitoring and control functions for all the major plant equipment. The DCS is designed to provide 99.5 percent availability. The plant equipment and the DCS are designed for automatic response to load changes from minimum load to 100 percent. Startup and shutdown routines are implemented as supervised manual, with operator selection of modular automation routines available.

3.2 COMMON PROCESS AREAS FOR PC CASES ONLY

3.2.1 Steam Generator and Ancillaries

The steam generator for the super and USC plants is a once-through, spiral-wound, Benson-boiler, wall-fired, balanced draft type unit with a water-cooled dry bottom furnace. It includes a superheater, RH, economizer, and air heater.

It is assumed for the purposes of this study that the power plant is designed to be operated as a base-loaded unit but with some consideration for daily or weekly cycling, as can be cost effectively included in the base design.

The combustion systems for SC and USC steam conditions are equipped with low NOx burners (LNBs) and OFA.

Scope

The steam generator includes the following:

- Once-through type steam generator
- Economizer
- Low NOx Coal burners and light oil igniters/ warmup system
- Startup circuit, including integral separators
- Spray type desuperheater
- OFA
- Water-cooled furnace, dry bottom
- Soot blower system
- Forced draft (FD) fans
- Two-stage superheater
- Air preheaters (Regenerative type)
- Primary air (PA) fans
- RH
- Coal feeders and pulverizers
- ID fans

Air and Combustion Products

Combustion air from the FD fans is heated in regenerative type air preheaters, recovering heat energy from the exhaust gases exiting the boiler. This air is distributed to the burner windbox as secondary air. Air for conveying PC to the burners is supplied by the PA fans. This air is heated in the regenerative type air preheaters to permit drying of the PC, and a portion of the air from the PA fans bypasses the air preheaters to be used for regulating the outlet coal/air temperature leaving the mills.

The PC and air mixture flows to the coal nozzles at various elevations of the furnace. The hot combustion products rise to the top of the boiler and pass through the superheater and RH sections. The gases then pass through the economizer and air preheater. The gases exit the steam generator at this point and flow to the Selective Catalytic Reduction (SCR) reactor, FGD system, fabric filter, ID fan, and stack.

Fuel Feed

The crushed coal is fed through feeders to each of the mills (pulverizers), where its size is reduced to approximately 72 percent passing 200 mesh with less than 0.5 percent remaining on 50 mesh [39]. The PC exits each mill via the coal piping and is distributed to the coal nozzles in the furnace walls using air supplied by the PA fans.

Ash Removal

The furnace bottom comprises several hoppers, with a clinker grinder under each hopper. The hoppers are of welded steel construction, lined with refractory. The hopper design incorporates a water-filled seal trough around the upper periphery for cooling and sealing. Water and ash discharged from the hopper pass through the clinker grinder to an ash sluice system for conveyance to hydrobins, where the ash is dewatered before it is transferred to trucks for offsite disposal. The bottom ash from the boiler is fed into a clinker grinder. The clinker grinder is provided to break up any clinkers that may form. From the clinker grinders the bottom ash is sluiced to hydrobins for dewatering and offsite removal by truck. The steam generator incorporates fly ash hoppers under the economizer outlet and air heater outlet.

Burners

A boiler of this capacity employs approximately 24 to 36 coal nozzles arranged at multiple elevations. Each burner is designed as a low-NOx configuration, with staging of the coal combustion to minimize NOx formation. In addition, OFA nozzles are provided to further stage combustion and thereby minimize NOx formation.

Oil-fired pilot torches are provided for each coal burner for ignition, warm-up and flame stabilization at startup and low loads.

Air Preheaters

Each steam generator is furnished with two vertical-shaft, tri-sector, regenerative type air preheaters with an assumed total air leakage of 5.5 percent. These units are driven by electric motors through gear reducers.

Soot Blowers

The soot-blowing system utilizes an array of 50 to 150 retractable nozzles and lances that clean the furnace walls and convection surfaces with jets of HP steam. The blowers are sequenced to provide an effective cleaning cycle depending on the coal quality and design of the furnace and convection surfaces. Electric motors drive the soot blowers through their cycles.

3.2.2 NO_x Control System

The plant is designed to achieve the environmental target of 0.07 lb NOx/MMBtu. Two measures are taken to reduce the NOx. The first is a combination of LNBs and the introduction of staged OFA in the boiler. The LNBs and OFA reduce the emissions to about 0.2 lb/MMBtu.

The second measure taken to reduce the NOx emissions is the installation of a SCR system prior to the air heater. SCR uses aqueous ammonia and a catalyst to reduce NOx to N_2 and water (H_2O). The SCR system consists of three subsystems: reactor vessel, ammonia storage and injection, and gas flow control. The SCR system is designed for 65 percent reduction with 2 ppmv ammonia slip at the end of the catalyst life. This, along with the LNBs, achieves the emission limit of 0.07 lb/MMBtu.

The SCR capital costs are included with the boiler costs, as is the cost for the initial load of catalyst.

SNCR was considered for this application. However, with the installation of the LNBs and OFA system, the boiler exhaust gas contains relatively small amounts of NOx, which makes removal of the quantity of NOx with SNCR to reach the emissions limit of 0.07 lb/MMBtu difficult. SNCR works better in applications that contain medium to high quantities of NOx and require removal efficiencies in the range of 40 to 60 percent. SCR, because of the catalyst used in the reaction, can achieve higher efficiencies with lower concentrations of NOx.

SCR Operation Description

The reactor vessel is designed to allow proper retention time for the ammonia to contact the NOx in the boiler exhaust gas. Ammonia is injected into the gas immediately prior to entering the reactor vessel. The catalyst contained in the reactor vessel enhances the reaction between the ammonia and the NOx in the gas. Catalysts consist of various active materials such as titanium dioxide, vanadium pentoxide, and tungsten trioxide. The operating range for vanadium/titanium-based catalysts is 260°C (500°F) to 455°C (850°F). The boiler is equipped with economizer bypass to provide flue gas to the reactors at the desired temperature during periods of low flow rate, such as low load operation. Also included with the reactor vessel is soot-blowing equipment used for cleaning the catalyst.

The aqueous ammonia storage and injection system consists of the unloading facilities, bulk storage tank, vaporizers, dilution air skid, and injection grid.

The flue gas flow control consists of ductwork, dampers, and flow straightening devices required to route the boiler exhaust to the SCR reactor and then to the air heater. The economizer bypass and associated dampers for low load temperature control are also included.

3.2.3 Flue Gas Desulfurization

The FGD process uses a lime- SDA system. The function of the FGD system is to scrub the boiler exhaust gases to remove the SO_2 prior to release to the environment, or entering the CDR facility. Sulfur removal efficiency is 93 percent in the FGD unit for all cases. The scope of the FGD system is from the outlet of the combustion air preheater to the ID fan.

As discussed in Section 3.1.4, the CDR unit includes a polishing scrubber to further reduce the flue gas SO_2 concentration from about 55 ppmv at the FGD exit to the required 10 ppmv prior to the CDR absorber.

Lime-spray drying is a dry scrubbing process that is generally used for low-sulfur coal [40]. Flue gas is treated in an absorber by mixing the gas stream concurrently with atomized lime slurry droplets. The lime slurry is atomized through rotary cup spray atomizers or through dual fluid nozzles. Water in the spray droplets evaporates, cooling the gas from the inlet temperature of 149°C (300°F) or higher to 71°C to 82°C (160°F to 180°F). The final temperature is maintained at approximately 17°C (30ºF) above the flue gas adiabatic saturation temperature by regulating the quantity of the slurry water. The droplets absorb SO_2 from the gas and react the SO_2 with the lime in the slurry. The desulfurized flue gas, along with reaction products, unreacted lime, and the fly ash pass out of the dry scrubber to the baghouse. Sorbent utilization is increased by about 40 percent by slurrying and recycling a portion of the solid effluent collected in the baghouse into the absorber with the virgin lime slurry.

The system description is divided into three sections:

- Lime Handling and Reagent Preparation
- SO_2 Removal
- Particulate Control (described in Section 3.1.3)

Lime Reagent Handling and Preparation

Lime is received by truck and conveyed to storage. Lime is stored in a 14-day capacity bulk storage lime silo. The lime is pneumatically conveyed to a 16-hour capacity day bin. The lime day bin and a gravimetric feeder supply the lime to a 150 percent slaking system. This will allow two shift operations for the unit operating continuously at 100 percent load. A conventional lime slaker with high-efficiency grit removal and lime recovery system is used. Two 100 percent capacity slurry transfer pumps are used to provide high reliability to transfer the slurry to the slurry tank. The process makeup water is added to the slaker to produce 20 percent solids slurry. The slurry is diluted on line, if required, prior to injection into an absorber. The slurry is fed to the absorber by a dedicated reagent feed pump (100 percent spare capacity provided).

SO_2 Removal

Two absorbers, each treating 50 percent of the flue gas, are provided to achieve 93 percent SO_2 removal efficiency in the absorber and baghouse. The absorber is a vertical, open chamber with cocurrent contact between the flue gas and lime slurry. The slurry is injected into the tower at the top using a rotary atomizer to remove SO_2. A spare rotary atomizer is provided. The hopper in the bottom of the CS absorber also removes large particles that may drop in the absorber. The absorber will be operated at 30°F adiabatic approach to saturation temperature. In the past, a lower approach had been proposed. However, over the years, operational problems associated with the lower adiabatic approach to saturation temperature, due to wetting of the walls and large deposits in the absorber, were alleviated by designs with 17°C (30°F) adiabatic approach to saturation temperature.

3.2.4 Mercury Removal

Mercury removal is based on a coal Hg content of 0.081 ppm (dry) for PRB coal and 0.116 ppm (dry) for NDL. The basis for the coal Hg concentration was discussed in Section 2.3. The combination of pollution control technologies used in the PC plants, SCR, dry FGD, and fabric filters, result in a range of estimated co-benefit capture depending on the study source [12, 41]. Average values of 15 percent co-benefit Hg reduction for the PRB coal and 0 percent co-benefit reduction for the NDL coal were assumed.

An injection system utilizing brominated carbon is included to reduce Hg emission by 90 percent beyond the co-benefit capture levels. This requires an injection rate of 1.0 and 1.5 lb carbon/ million standard cubic feet (MMscf) flue gas for PRB and NDL coals, respectively.

The carbon injection system includes a carbon silo with a capacity to store a 30-day supply of carbon. The silo houses the equipment to regulate and pneumatically convey the carbon to the flue gas duct.

3.3 COMMON PROCESS AREAS FOR CFB CASES ONLY

3.3.1 Steam Generator and Ancillaries

The steam generator for the SC CFB plant is an atmospheric CFB boiler. It includes a superheater, RH, economizer, and air heater. It is assumed for the purposes of this study that the power plant is designed to be operated as a base-loaded unit but with some consideration for daily or weekly cycling, as can be cost effectively included in the base design.

Scope

The steam generator includes the following:

- CFB combustor
- Economizer
- FD Fans
- Startup circuit, including integral cyclone separators
- Air preheaters
- PA Fans
- Coal feeders
- Limestone feeders
- ID Fans
- Backpass

Air, Coal, Limestone, and Combustion Products

Fluidizing combustion air enters the furnace through an air plenum and distribution nozzles with the balance injected through secondary air ports above the fluidizing grid. Combustion air from the PA and FD fans is heated in regenerative air preheaters, recovering heat energy from the exhaust gases exiting the boiler. The crushed coal and limestone are fed to the furnace through the lower walls. The upward flow of solids decreases with increased furnace height as heavier particles recirculate back down the furnace, resulting in declining local density with increased furnace height. Particle separators in the top of the furnace enclosure collect most of the solids that remain in the flue gas and return them to the furnace while passing the flue gas to the convection pass (backpass) of the heat transfer surfaces. The dense bed does not contain any in-bed tube bundle heating surfaces. Because the mass flow rate of the recycled solids is many times the mass flow rate of the incoming fuel and air and the combustion gas, the bed solids temperature remains relatively uniform throughout the surface height. Thus the water cooled furnace walls provide adequate heat absorption to maintain a target bed temperature of ~871°C (1,600°F). The hot combustion products rise to the top of the boiler and pass through internal cyclones, then superheater, RH, and economizer sections that comprise the backpass. The gases then pass through the regenerative air preheater and flow to the fabric filter, ID fan, and stack or CDR system.

SO_2 Removal

When limestone is added to the fluidized bed, it undergoes calcination and then reacts with the SO_2 in the flue gas to form calcium sulfate. SO_2 reductions of 90 to 95 percent are typical. The coal-fired CFB produces low levels of NOx by combusting the coal in the circulating bed, where temperatures are maintained at approximately 871°C (1,600°F). This low temperature minimizes the formation of NOx, while allowing the oxidation of carbon and the capture of sulfur by calcium to proceed to completion. Further NOx reduction is achieved with SNCR ammonia injection. Addition of dry limestone to the bed, in appropriate particle sizes, provides the calcium carbonate for sulfur capture.

Ash Removal

Solids are collected in multi-cyclone hoppers and recycled to the furnace. Excess solids are purged via the bed solids drain (with cooling) or the baghouse, and sent to the plant ash handling system.

Air Preheaters

Each steam generator is furnished with two vertical-shaft, tri-sector, regenerative type air preheaters with an assumed total air leakage of 5.5 percent. These units are driven by electric motors through gear reducers.

3.3.2 NO_x Control System

The plant is designed to achieve the environmental target of 0.07 lb NOx/MMBtu. The coal-fired CFB produces low levels of NOx by combusting the coal in the circulating bed, where temperatures are maintained at approximately 871°C (1,600°F). This low temperature along with OFA minimizes the formation of NOx to approximately 0.13 lb NOx/MMBtu. Further NOx reduction is achieved with SNCR ammonia injection, which achieves the emission limit of 0.07 lb/MMBtu.

SNCR uses aqueous ammonia to reduce NOx to N_2 and H_2O. The SNCR system consists of ammonia storage and injection. The SNCR system is designed for 46 percent reduction with 2 ppmv ammonia slip

The SNCR capital costs are included with the boiler costs. The aqueous ammonia storage and injection system consists of the unloading facilities, bulk storage tank, vaporizers, dilution air skid, and injection grid.

3.3.3 Mercury Removal

Mercury removal is based on a coal Hg content of 0.081 ppm (dry) for PRB coal and 0.116 ppm (dry) for NDL. The basis for the coal Hg concentration was discussed in Section 2.3. The combination of pollution control technologies used in the CFB plants, in-bed limestone injection, SNCR, and fabric filters, result in an assumed 57 percent co-benefit mercury removal for both coal types [12]. This level of co-benefit capture is sufficient to meet the mercury emissions targets, however since it is currently standard practice to also include carbon injection, carbon injection was also included.

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4. PC CASES

This section contains an evaluation of SC plant designs (Cases S12A, S12B, L12A, and L12B) and USC PC plants (Cases S13A, S13B, L13A, and L13B). All the designs have a nominal net output of 550 megawatts electric (MWe). All four SC plants use a single reheat 24.1 MPa/593°C/593°C (3,500 psig/1,100°F/1,100°F) cycle. All four USC plants use a single reheat 27.6 MPa/649°C/649°C (4,000 psi/1,200°F/1,200°F) cycle. Cases S12A and S12B are very similar in terms of process, equipment, scope, and arrangement, except that Case S12B employs CO_2 absorption/regeneration and compression/transport systems. Cases L12A and L12B differ from Cases S12A and S12B only through the use of a different coal type (NDL instead of PRB). The same is true for the USC cases. Cases S13A and S13B are very similar in terms of process, equipment, scope, and arrangement, except that Case S13B employs CO_2 absorption/regeneration and compression/transport systems. Cases L13A and L13B differ from Cases S13A and S13B only through the use of a different coal type (NDL instead of PRB).

Section 4.1 covers the four non-carbon capture cases and Section 4.2 covers the four CO_2 capture cases coal. The sections are organized analogously as follows:

- Process and System Description provides an overview of the technology operation as applied to Cases S12A/L12A and S13A/L13A in Section 4.1.1 and S12B/L12B and S13B/L13B in Section 4.2.1.
- Key Assumptions is a summary of study and modeling assumptions relevant to Cases S12A/L12A and S13A/L13A in Section 4.1.2 and S12B/L12B and S13B/L13B in Section 4.2.2.
- Sparing Philosophy is provided for Cases S12A/L12A and S13A/L13A in Section 4.1.3 and S12B/L12B and S13B/L13B in Section 4.2.3.
- Performance Results provide the main modeling results from Cases S12A/L12A and S13A/L13A in Section 4.1.4 and S12B/L12B and S13B/L13B in Section 4.2.4, including the performance summary, environmental performance, carbon balance, sulfur balance, water balance, mass and energy balance diagrams and mass and energy balance tables.
- Equipment Lists provide an itemized list of major equipment for Cases S12A/L12A and S13A/L13A in Section 4.1.5 and S12B/L12B and S13B/L13B in Section 4.2.5 with account codes that correspond to the cost accounts in the Cost Estimates section.
- Cost Estimates provide a summary of capital and operating costs for Cases S12A/L12A and S13A/L13A in Section 4.1.6 and S12B/L12B and S13B/L13B in Section 4.2.6.

If the information for the CO_2 capture cases is identical to that presented for the non-capture cases, a reference is made to the earlier section rather than repeating the information.

4.1 SC & USC PC NON-CAPTURE CASES (PRB AND LIGNITE)

4.1.1 Process Description

In this section the SC and USC PC processes without CO_2 capture are described. Both the SC and USC process descriptions follow the block flow diagram (BFD) in Exhibit 4-1 and stream numbers reference the same exhibit. The tables in Exhibit 4-2 through Exhibit 4-5 provide process data for the numbered streams in the BFD.

Coal (stream 8) and PA (stream 4) are introduced into the boiler through the wall-fired burners. Additional combustion air, including the OFA, is provided by the FD fans (stream 2). The boiler operates at a slight negative pressure so air leakage is into the boiler, and the infiltration air is accounted for in stream 7.

Flue gas exits the boiler through the SCR reactor (stream 10) and is cooled to 143°C (290°F) in the combustion air preheater (not shown) before passing to the spray-dryer absorbers. The gases from the absorbers are sent to the baghouse to collect the waste products and the fly ash. Activated carbon is injected for additional mercury removal prior to the baghouse. Flue gas exits the baghouse and enters the ID fan suction (stream 15). The clean flue gas passes to the plant stack and is discharged to the atmosphere.

Exhibit 4-1 Cases S12A, L12A, S13A, and L13A Process Flow Diagram

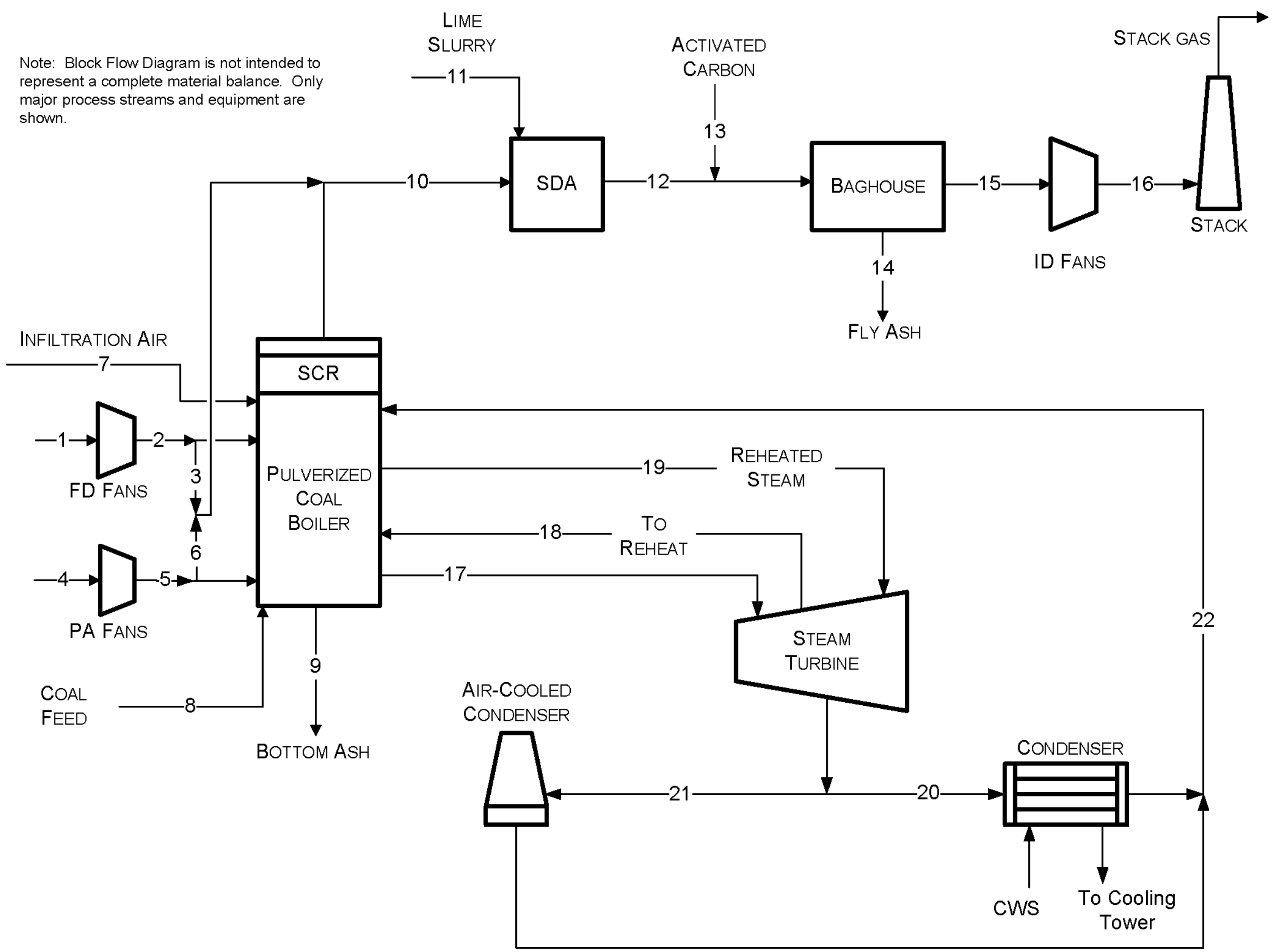

Exhibit 4-2 Case S12A Stream Table

	1	2	3	4	5	6	7	8	9	10	11
V-L Mole Fraction											
Ar	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0000	0.0000	0.0084	0.0000
CO_2	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0000	0.0000	0.1471	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0000	0.0000	0.1153	1.0000
N_2	0.7759	0.7759	0.7759	0.7759	0.7759	0.7759	0.7759	0.0000	0.0000	0.7046	0.0000
O_2	0.2081	0.2081	0.2081	0.2081	0.2081	0.2081	0.2081	0.0000	0.0000	0.0239	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	38,993	38,993	1,473	25,996	25,996	2,102	1,150	0	0	72,928	3,117
V-L Flowrate (kg/hr)	1,126,714	1,126,714	42,548	751,143	751,143	60,734	33,242	0	0	2,146,830	56,162
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	256,752	4,204	16,817	3,910
Temperature (°C)	6	10	10	6	17	17	6	6	143	143	6
Pressure (MPa, abs)	0.09	0.09	0.09	0.09	0.10	0.10	0.09	0.09	0.09	0.09	0.09
Enthalpy (kJ/kg)[A]	15.26	19.77	19.77	15.26	26.74	26.74	15.26	---	---	349.88	200.23
Density (kg/m^3)	1.1	1.1	1.1	1.1	1.2	1.2	1.1	---	---	0.7	1,012.1
V-L Molecular Weight	28.895	28.895	28.895	28.895	28.895	28.895	28.895	---	---	29.438	18.015
V-L Flowrate (lb_{mol}/hr)	85,966	85,966	3,246	57,310	57,310	4,634	2,536	0	0	160,778	6,873
V-L Flowrate (lb/hr)	2,483,979	2,483,979	93,803	1,655,986	1,655,986	133,896	73,287	0	0	4,732,949	123,815
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	566,042	9,269	37,076	8,620
Temperature (°F)	42	50	50	42	63	63	42	42	289	289	42
Pressure (psia)	13.0	13.6	13.6	13.0	14.4	14.4	13.0	13.0	12.7	12.7	13.0
Enthalpy (Btu/lb)[A]	6.6	8.5	8.5	6.6	11.5	11.5	6.6	---	---	150.4	86.1
Density (lb/ft^3)	0.070	0.072	0.072	0.070	0.075	0.075	0.070	---	---	0.047	63.182
	A - Reference conditions are 32.02 F & 0.089 PSIA										

Exhibit 4-2 Case S12A Stream Table (Continued)

	12	13	14	15	16	17	18	19	20	21	22
V-L Mole Fraction											
Ar	0.0081	0.0000	0.0000	0.0081	0.0081	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.1412	0.0000	0.0000	0.1412	0.1412	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.1513	0.0000	0.0000	0.1513	0.1513	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.6764	0.0000	0.0000	0.6764	0.6764	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0229	0.0000	0.0000	0.0229	0.0229	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO_2	0.0001	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	75,964	0	0	75,964	75,964	91,251	75,638	75,638	34,515	34,515	69,030
V-L Flowrate (kg/hr)	2,199,033	0	0	2,199,033	2,199,033	1,643,917	1,362,633	1,362,633	621,796	621,796	1,243,591
Solids Flowrate (kg/hr)	24,686	42	24,728	0	0	0	0	0	0	0	0
Temperature (°C)	82	6	82	82	92	593	354	593	32	32	32
Pressure (MPa, abs)	0.08	0.11	0.08	0.08	0.09	24.23	4.90	4.52	0.005	0.005	1.72
Enthalpy (kJ/kg)[A]	321.63	---	---	323.33	333.95	3,477.66	3,083.97	3,653.25	1,933.01	1,933.01	137.98
Density (kg/m^3)	0.8	---	---	0.8	0.9	69.2	18.7	11.6	0.05	0.05	995.7
V-L Molecular Weight	28.948	---	---	28.948	28.948	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	167,471	0	0	167,471	167,471	201,175	166,752	166,752	76,092	76,092	152,185
V-L Flowrate (lb/hr)	4,848,038	0	0	4,848,038	4,848,038	3,624,217	3,004,091	3,004,091	1,370,825	1,370,825	2,741,650
Solids Flowrate (lb/hr)	54,423	93	54,516	0	0	0	0	0	0	0	0
Temperature (°F)	180	42	180	180	198	1,100	669	1,100	90	90	90
Pressure (psia)	12.3	16.0	12.1	12.1	13.1	3,514.7	710.8	655.8	0.7	0.7	250.0
Enthalpy (Btu/lb)[A]	138.3	---	---	139.0	143.6	1,495.1	1,325.9	1,570.6	831.0	831.0	59.3
Density (lb/ft^3)	0.052	---	---	0.051	0.054	4.319	1.164	0.722	0.003	0.003	62.162

Exhibit 4-3 Case L12A Stream Table

	1	2	3	4	5	6	7	8	9	10	11
V-L Mole Fraction											
Ar	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0000	0.0000	0.0081	0.0000
CO_2	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0000	0.0000	0.1422	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	0.0000	0.0000	0.1502	1.0000
N_2	0.7761	0.7761	0.7761	0.7761	0.7761	0.7761	0.7761	0.0000	0.0000	0.6756	0.0000
O_2	0.2082	0.2082	0.2082	0.2082	0.2082	0.2082	0.2082	0.0000	0.0000	0.0231	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	40,786	40,786	1,540	27,191	27,191	2,199	1,202	0	0	79,580	3,444
V-L Flowrate (kg/hr)	1,178,623	1,178,623	44,508	785,749	785,749	63,532	34,738	0	0	2,308,147	62,046
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	342,852	6,763	27,052	4,485
Temperature (°C)	4	9	9	4	15	15	4	4	143	143	4
Pressure (MPa, abs)	0.10	0.10	0.10	0.10	0.11	0.11	0.10	0.10	0.09	0.09	0.10
Enthalpy (kJ/kg)[A]	13.75	17.98	17.98	13.75	24.54	24.54	13.75	---	---	423.98	18.61
Density (kg/m^3)	1.2	1.2	1.2	1.2	1.3	1.3	1.2	---	---	0.8	1,013.1
V-L Molecular Weight	28.898	28.898	28.898	28.898	28.898	28.898	28.898	---	---	29.004	18.015
V-L Flowrate (lb_{mol}/hr)	89,918	89,918	3,396	59,945	59,945	4,847	2,650	0	0	175,444	7,593
V-L Flowrate (lb/hr)	2,598,420	2,598,420	98,124	1,732,280	1,732,280	140,064	76,584	0	0	5,088,593	136,788
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	755,859	14,910	59,639	9,889
Temperature (°F)	40	48	48	40	59	59	40	40	290	290	40
Pressure (psia)	13.8	14.4	14.4	13.8	15.2	15.2	13.8	13.8	13.5	13.5	13.8
Enthalpy (Btu/lb)[A]	5.9	7.7	7.7	5.9	10.6	10.6	5.9	---	---	182.3	8.0
Density (lb/ft^3)	0.074	0.076	0.076	0.074	0.079	0.079	0.074	---	---	0.049	63.247

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 4-3 Case L12A Stream Table (Continued)

	12	13	14	15	16	17	18	19	20	21	22
V-L Mole Fraction											
Ar	0.0077	0.0000	0.0000	0.0077	0.0077	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.1364	0.0000	0.0000	0.1364	0.1364	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.1853	0.0000	0.0000	0.1853	0.1853	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.6483	0.0000	0.0000	0.6483	0.6483	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0222	0.0000	0.0000	0.0222	0.0222	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO_2	0.0001	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	82,931	0	0	82,931	82,931	91,565	75,901	75,901	34,634	34,634	69,267
V-L Flowrate (kg/hr)	2,365,642	0	0	2,365,642	2,365,642	1,649,575	1,367,371	1,367,371	623,935	623,935	1,247,870
Solids Flowrate (kg/hr)	36,089	65	36,154	0	0	0	0	0	0	0	0
Temperature (°C)	82	6	82	82	91	593	354	593	32	32	32
Pressure (MPa, abs)	0.09	0.11	0.09	0.09	0.10	24.23	4.90	4.52	0.005	0.005	1.72
Enthalpy (kJ/kg)[A]	394.49	---	---	382.06	392.18	3,477.66	3,083.96	3,653.25	134.90	134.90	135.51
Density (kg/m^3)	0.9	---	---	0.9	0.9	69.2	18.7	11.6	0.05	0.05	995.7
V-L Molecular Weight	28.526	---	---	28.526	28.526	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	182,830	0	0	182,830	182,830	201,867	167,332	167,332	76,354	76,354	152,708
V-L Flowrate (lb/hr)	5,215,347	0	0	5,215,347	5,215,347	3,636,690	3,014,536	3,014,536	1,375,542	1,375,542	2,751,083
Solids Flowrate (lb/hr)	79,563	143	79,706	0	0	0	0	0	0	0	0
Temperature (°F)	180	42	180	180	196	1,100	669	1,100	90	90	90
Pressure (psia)	13.1	16.0	12.9	12.9	13.9	3,514.7	710.8	655.8	0.7	0.7	250.0
Enthalpy (Btu/lb)[A]	169.6	---	---	164.3	168.6	1,495.1	1,325.9	1,570.6	58.0	58.0	58.3
Density (lb/ft^3)	0.055	---	---	0.054	0.056	4.319	1.164	0.722	0.003	0.003	62.162

Exhibit 4-4 Case S13A Stream Table

	1	2	3	4	5	6	7	8	9	10	11
V-L Mole Fraction											
Ar	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0000	0.0000	0.0084	0.0000
CO_2	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0000	0.0000	0.1470	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0000	0.0000	0.1153	1.0000
N_2	0.7759	0.7759	0.7759	0.7759	0.7759	0.7759	0.7759	0.0000	0.0000	0.7046	0.0000
O_2	0.2081	0.2081	0.2081	0.2081	0.2081	0.2081	0.2081	0.0000	0.0000	0.0239	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	37,847	37,847	1,429	25,231	25,231	2,040	1,116	0	0	70,782	3,026
V-L Flowrate (kg/hr)	1,093,586	1,093,586	41,297	729,057	729,057	58,948	32,261	0	0	2,083,673	54,509
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	249,170	4,080	16,321	3,758
Temperature (°C)	6	10	10	6	17	17	6	6	143	143	6
Pressure (MPa, abs)	0.09	0.09	0.09	0.09	0.10	0.10	0.09	0.09	0.09	0.09	0.09
Enthalpy (kJ/kg)[A]	15.26	19.77	19.77	15.26	26.74	26.74	15.26	---	---	349.85	197.59
Density (kg/m^3)	1.1	1.1	1.1	1.1	1.2	1.2	1.1	---	---	0.7	1,012.1
V-L Molecular Weight	28.895	28.895	28.895	28.895	28.895	28.895	28.895	---	---	29.438	18.015
V-L Flowrate (lb_{mol}/hr)	83,438	83,438	3,151	55,625	55,625	4,498	2,461	0	0	156,048	6,671
V-L Flowrate (lb/hr)	2,410,945	2,410,945	91,045	1,607,296	1,607,296	129,959	71,123	0	0	4,593,713	120,172
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	549,326	8,995	35,981	8,285
Temperature (°F)	42	50	50	42	63	63	42	42	289	289	42
Pressure (psia)	13.0	13.6	13.6	13.0	14.4	14.4	13.0	13.0	12.7	12.7	13.0
Enthalpy (Btu/lb)[A]	6.6	8.5	8.5	6.6	11.5	11.5	6.6	---	---	150.4	84.9
Density (lb/ft^3)	0.070	0.072	0.072	0.070	0.075	0.075	0.070	---	---	0.047	63.182

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 4-4 Case S13A Stream Table (Continued)

	12	13	14	15	16	17	18	19	20	21	22
V-L Mole Fraction											
Ar	0.0081	0.0000	0.0000	0.0081	0.0081	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.1412	0.0000	0.0000	0.1412	0.1412	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.1513	0.0000	0.0000	0.1513	0.1513	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.6764	0.0000	0.0000	0.6764	0.6764	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0230	0.0000	0.0000	0.0230	0.0230	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO_2	0.0001	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	73,729	0	0	73,729	73,729	94,891	71,267	71,267	28,502	28,502	57,005
V-L Flowrate (kg/hr)	2,134,341	0	0	2,134,341	2,134,341	1,709,484	1,283,899	1,283,899	513,479	513,479	1,026,958
Solids Flowrate (kg/hr)	23,920	41	23,961	0	0	0	0	0	0	0	0
Temperature (°C)	82	6	82	82	92	649	450	649	32	32	32
Pressure (MPa, abs)	0.08	0.11	0.08	0.08	0.09	27.68	8.27	7.78	0.005	0.005	0.86
Enthalpy (kJ/kg)^A	321.75	---	---	323.31	333.93	3,609.84	3,270.42	3,758.29	2,252.88	2,252.88	136.90
Density (kg/m^3)	0.8	---	---	0.8	0.9	72.8	27.2	18.8	0.04	0.04	995.4
V-L Molecular Weight	28.948	---	---	28.948	28.948	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	162,545	0	0	162,545	162,545	209,198	157,117	157,117	62,837	62,837	125,674
V-L Flowrate (lb/hr)	4,705,417	0	0	4,705,417	4,705,417	3,768,766	2,830,513	2,830,513	1,132,027	1,132,027	2,264,054
Solids Flowrate (lb/hr)	52,735	91	52,826	0	0	0	0	0	0	0	0
Temperature (°F)	180	42	180	180	198	1,200	842	1,200	90	90	90
Pressure (psia)	12.3	16.0	12.1	12.1	13.1	4,014.7	1,200.0	1,128.0	0.7	0.7	125.0
Enthalpy (Btu/lb)^A	138.3	---	---	139.0	143.6	1,552.0	1,406.0	1,615.8	968.6	968.6	58.9
Density (lb/ft^3)	0.052	---	---	0.051	0.054	4.542	1.698	1.176	0.002	0.002	62.139

Exhibit 4-5 Case L13A Stream Table

	1	2	3	4	5	6	7	8	9	10	11
V-L Mole Fraction											
Ar	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0000	0.0000	0.0081	0.0000
CO_2	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0000	0.0000	0.1423	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	0.0000	0.0000	0.1504	1.0000
N_2	0.7761	0.7761	0.7761	0.7761	0.7761	0.7761	0.7761	0.0000	0.0000	0.6755	0.0000
O_2	0.2082	0.2082	0.2082	0.2082	0.2082	0.2082	0.2082	0.0000	0.0000	0.0229	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	39,390	39,390	1,491	26,260	26,260	1,805	1,163	0	0	76,873	3,353
V-L Flowrate (kg/hr)	1,138,288	1,138,288	43,091	758,859	758,859	52,163	33,599	0	0	2,229,654	60,399
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	331,614	6,541	26,165	4,304
Temperature (°C)	4	9	9	4	15	15	4	4	144	144	4
Pressure (MPa, abs)	0.10	0.10	0.10	0.10	0.11	0.11	0.10	0.10	0.09	0.09	0.10
Enthalpy (kJ/kg)[A]	13.75	17.98	17.98	13.75	24.54	24.54	13.75	---	---	424.91	201.84
Density (kg/m^3)	1.2	1.2	1.2	1.2	1.3	1.3	1.2	---	---	0.8	1,013.1
V-L Molecular Weight	28.898	28.898	28.898	28.898	28.898	28.898	28.898	---	---	29.004	18.015
V-L Flowrate (lb_{mol}/hr)	86,841	86,841	3,287	57,894	57,894	3,980	2,563	0	0	169,477	7,391
V-L Flowrate (lb/hr)	2,509,496	2,509,496	95,000	1,672,998	1,672,998	115,000	74,074	0	0	4,915,547	133,156
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	731,085	14,421	57,685	9,490
Temperature (°F)	40	48	48	40	59	59	40	40	290	290	40
Pressure (psia)	13.8	14.4	14.4	13.8	15.2	15.2	13.8	13.8	13.5	13.5	13.8
Enthalpy (Btu/lb)[A]	5.9	7.7	7.7	5.9	10.6	10.6	5.9	---	---	182.7	86.8
Density (lb/ft^3)	0.074	0.076	0.076	0.074	0.079	0.079	0.074	---	---	0.049	63.247
	A - Reference conditions are 32.02 F & 0.089 PSIA										

Exhibit 4-5 Case L13A Stream Table (Continued)

	12	13	14	15	16	17	18	19	20	21	22
V-L Mole Fraction											
Ar	0.0077	0.0000	0.0000	0.0077	0.0077	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.1365	0.0000	0.0000	0.1365	0.1365	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.1858	0.0000	0.0000	0.1858	0.1858	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.6480	0.0000	0.0000	0.6480	0.6480	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0219	0.0000	0.0000	0.0219	0.0219	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO_2	0.0001	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	80,136	0	0	80,136	80,136	94,882	71,260	71,260	28,485	28,485	56,970
V-L Flowrate (kg/hr)	2,285,651	0	0	2,285,651	2,285,651	1,709,321	1,283,772	1,283,772	513,166	513,166	1,026,332
Solids Flowrate (kg/hr)	34,872	63	34,935	0	0	0	0	0	0	0	0
Temperature (°C)	82	6	82	82	91	649	450	649	32	32	32
Pressure (MPa, abs)	0.09	0.11	0.09	0.09	0.10	27.68	8.27	7.78	0.005	0.005	0.86
Enthalpy (kJ/kg)[A]	395.46	---	---	382.81	392.93	3,609.84	3,270.42	3,758.29	2,247.71	2,247.71	136.90
Density (kg/m^3)	0.9	---	---	0.9	0.9	72.8	27.2	18.8	0.04	0.04	995.4
V-L Molecular Weight	28.522	---	---	28.522	28.522	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	176,669	0	0	176,669	176,669	209,178	157,102	157,102	62,799	62,799	125,598
V-L Flowrate (lb/hr)	5,038,997	0	0	5,038,997	5,038,997	3,768,408	2,830,232	2,830,232	1,131,338	1,131,338	2,262,675
Solids Flowrate (lb/hr)	76,880	139	77,019	0	0	0	0	0	0	0	0
Temperature (°F)	180	42	180	180	196	1,200	842	1,200	90	90	90
Pressure (psia)	13.1	16.0	12.9	12.9	13.9	4,014.7	1,200.0	1,128.0	0.7	0.7	125.0
Enthalpy (Btu/lb)[A]	170.0	---	---	164.6	168.9	1,552.0	1,406.0	1,615.8	966.3	966.3	58.9
Density (lb/ft^3)	0.055	---	---	0.054	0.056	4.542	1.698	1.176	0.002	0.002	62.139

4.1.2 Key System Assumptions

System assumptions for Cases S12A and L12A, SC PC without CO_2 capture, and Cases S13A and L13A, USC PC without CO_2 capture, are compiled in Exhibit 4-6.

Exhibit 4-6 PC Cases without CO_2 Capture Study Configuration Matrix

	Case S12A w/o CO_2 Capture	Case L12A w/o CO_2 Capture	Case S13A w/o CO_2 Capture	Case L13A w/o CO_2 Capture
Steam Cycle, MPa/°C/°C (psig/°F/°F)	24.1/593/593 (3,500/1,100/1,100)	24.1/593/593 (3,500/1,100/1,100)	27.6/649/649 (4,000/1,200/1,200)	27.6/649/649 (4,000/1,200/1,200)
Coal	Subbituminous	Lignite	Subbituminous	Lignite
Carbon Conversion, %	100	100	100	100
Condenser pressure, mm Hg (in Hg)	36 (1.4)	36 (1.4)	36 (1.4)	36 (1.4)
Combustion Air Preheater Flue Gas Exit Temp, °C (ºF)	143 (290)	143 (290)	143 (290)	143 (290)
Cooling water to condenser, °C (ºF)	9 (48)	8 (47)	9 (48)	8 (47)
Cooling water from condenser, °C (ºF)	20 (68)	19 (67)	20 (68)	19 (67)
FGD Outlet, °C (°F)	82 (180)	82 (180)	82 (180)	82 (180)
SO_2 Control	SDA FGD	SDA FGD	SDA FGD	SDA FGD
FGD Efficiency, % [1]	93	93	93	93
NOx Control	LNB w/OFA and SCR	LNB w/OFA and SCR	LNB w/OFA and SCR	LNB w/OFA and SCR
SCR Efficiency, % [1]	65	65	65	65
Ammonia Slip (end of catalyst life), ppmv	2	2	2	2
Particulate Control	Fabric Filter	Fabric Filter	Fabric Filter	Fabric Filter
Fabric Filter Efficiency, % [1]	99.97	99.97	99.97	99.97
Ash Distribution, Fly/Bottom	80% / 20%	80% / 20%	80% / 20%	80% / 20%
Mercury Control	Co-benefit Capture and Carbon injection	Carbon injection	Co-benefit Capture and Carbon injection	Carbon injection
Mercury removal efficiency, % [1]	90 plus	90	90 plus	90
CO_2 Control	N/A	N/A	N/A	N/A
CO_2 Capture, % [1]	N/A	N/A	N/A	N/A
CO_2 Sequestration	N/A	N/A	N/A	N/A

[1] Equipment removal efficiencies

Balance of Plant – Cases S12A, L12A, S13A, and L13A

The balance of plant assumptions are common to all cases and were presented previously in Section 3.1.6.

4.1.3 Sparing Philosophy

Single trains are used throughout the design with exceptions where equipment capacity requires an additional train. There is no redundancy other than normal sparing of rotating equipment. The plant design consists of the following major subsystems:

- One dry-bottom, wall-fired PC SC or USC boiler (1 x 100 percent)
- Two SCR reactors (2 x 50 percent)
- One lime spray dryer system with two absorbers (1 x 100 percent)
- Two single-stage, in-line, multi-compartment fabric filters (2 x 50 percent)
- One steam turbine (1 x 100 percent)

4.1.4 Cases S12A, L12A, S13A, and L13A Performance Results

The non-capture SC PC plant using PRB coal produces a net output of 550 MWe at a net plant efficiency of 38.7 percent (HHV basis). The same plant configuration using lignite coal produces a net output of 550 MWe at a net plant efficiency of 37.5 percent (HHV basis). The non-capture USC PC plant using PRB coal produces a net output of 550 MWe at a net plant efficiency of 39.9 percent (HHV basis). The same plant configuration using lignite coal produces a net output of 550 MWe at a net plant efficiency of 38.8 percent (HHV basis).

Overall performance for the four plants is summarized in Exhibit 4-7, which includes auxiliary power requirements. The cooling water system, including the CWPs, cooling tower fan, and the air-cooled condenser, account for about 30 percent of the auxiliary load in all cases; and the PA, FD and induced draft fans account for an additional 30 percent in all cases.

In all PC combustion cases boiler efficiencies are 85.8 percent for the PRB coal cases and 83.5 percent for the lignite cases. In each case the boiler heat loss is one percent of the heat input and carbon conversion is 100 percent.

Exhibit 4-7 PC Cases without CO_2 Capture Plant Performance Summary

POWER SUMMARY (Gross Power at Generator Terminals, kWe)	S12A	L12A	S13A	L13A
Steam Turbine Power	**582,700**	**584,700**	**581,500**	**583,200**
AUXILIARY LOAD SUMMARY, kWe				
Coal Handling and Conveying	510	600	500	580
Pulverizers	3,850	5,140	3,740	4,970
Lime Handling & Preparation	170	190	170	180
Ash Handling	850	1,270	830	1,230
PA Fans	2,480	2,440	2,410	2,360
FD Fans	1,460	1,440	1,420	1,390
ID Fans	6,720	6,890	6,520	6,660
SCR	10	20	10	10
Baghouse	120	180	120	170
Spray Dryer FGD	2,230	2,570	2,170	2,490
Steam Turbine Auxiliaries	400	400	400	400
Condensate Pumps	790	790	320	320
CWP	2,400	2,410	2,340	2,340
Ground Water Pumps	250	250	240	240
Cooling Tower Fans	1,570	1,480	1,530	1,430
Air-Cooled Condenser Fans	5,020	4,730	4,880	4,560
Miscellaneous Balance of Plant[1]	2,000	2,000	2,000	2,000
Transformer Loss	1,830	1,840	1,830	1,840
TOTAL AUXILIARIES, kWe	**32,660**	**34,640**	**31,430**	**33,170**
NET POWER, kWe	**550,040**	**550,060**	**550,070**	**550,030**
Plant Capacity Factor, %	85%	85%	85%	85%
Net Plant Efficiency, % (HHV)	38.7%	37.5%	39.9%	38.8%
Net Plant Heat Rate, kJ/kWh (Btu/kWh)	9,298 (8,813)	9,593 (9,093)	9,023 (8,552)	9,279 (8,795)
CONDENSER COOLING DUTY GJ/hr (10^6 Btu/hr)	**2,235 (2,118)**	**2,243 (2,126)**	**2,174 (2,061)**	**2,167 (2,054)**
CONSUMABLES				
As-Received Coal Feed, kg/hr (lb/hr)	256,752 (566,042)	342,852 (755,859)	249,170 (549,326)	331,614 (731,085)
Thermal Input, kWt[2]	1,420,686	1,465,801	1,378,732	1,417,757
Raw Water Withdrawal, m^3/min (gpm)	10.0 (2,649)	10.2 (2,683)	9.8 (2,578)	9.8 (2,597)
Raw Water Consumption, m^3/min (gpm)	7.9 (2,093)	8.0 (2,125)	7.7 (2,035)	7.8 (2,056)

[1] Includes plant control systems, lighting, HVAC and miscellaneous low voltage loads
[2] Thermal input based on as-received HHV of coal

Environmental Performance

The environmental targets for emissions of Hg, NOx, SO_2, and PM were presented in Section 2.3. A summary of the plant air emissions for Cases S12A, L12A, S13A, and L13A is presented in Exhibit 4-8.

Exhibit 4-8 PC Cases without CO_2 Capture Air Emissions

	kg/GJ ($lb/10^6$ Btu)				Tonne/year (ton/year) 85% capacity factor				kg/MWh (lb/MWh)			
	S12A	L12A	S13A	L13A	S12A	L12A	S13A	L13A	S12A	L12A	S13A	L13A
SO_2	0.051 (0.119)	0.057 (0.132)	0.051 (0.119)	0.057 (0.132)	1,945 (2,144)	2,236 (2,465)	1,888 (2,081)	2,163 (2,384)	0.448 (0.99)	0.514 (1.13)	0.436 (0.96)	0.498 (1.10)
NO_X	0.030 (0.070)	0.030 (0.070)	0.030 (0.070)	0.030 (0.070)	1,146 (1,263)	1,182 (1,303)	1,112 (1,226)	1,144 (1,261)	0.264 (0.582)	0.272 (0.599)	0.257 (0.567)	0.263 (0.581)
Particulates	0.006 (0.0130)	0.006 (0.0130)	0.006 (0.0130)	0.006 (0.0130)	213 (235)	220 (242)	207 (228)	212 (234)	0.049 (0.108)	0.050 (0.111)	0.048 (0.105)	0.049 (0.108)
Hg	2.57E-7 (5.97E-7)	4.82E-7 (1.12E-6)	2.57E-7 (5.97E-7)	4.82E-7 (1.12E-6)	0.010 (0.011)	0.019 (0.021)	0.009 (0.010)	0.018 (0.020)	2.25E-6 (4.96E-6)	4.35E-6 (9.59E-6)	2.19E-6 (4.83E-6)	4.22E-6 (9.29E-6)
CO_2	92.3 (214.7)	94.4 (219.5)	92.3 (214.7)	94.4 (219.5)	3,514,375 (3,873,936)	3,707,311 (4,086,611)	3,410,593 (3,759,535)	3,585,786 (3,952,653)	810 (1,786)	852 (1,877)	788 (1,737)	826 (1,820)
CO_2 [1]									858 (1,892)	905 (1,996)	833 (1,836)	876 (1,930)

[1] CO_2 emissions based on net power instead of gross power

SO_2 emissions are controlled using a lime spray dryer FGD system that achieves a removal efficiency of 93 percent. The waste is collected in the baghouse. A portion of the waste is stored in a recycle storage silo, which is then used to mix with lime slurry to increase the reagent utilization.

NOx emissions are controlled to about 0.2 lb/MMBtu through the use of LNBs and OFA. An SCR unit then further reduces the NOx concentration by 65 percent to 0.07 lb/MMBtu.

Particulate emissions are controlled using a pulse jet fabric filter, which operates at an efficiency of 99.97 percent.

Co-benefit capture and activated carbon injection result in greater than 90 percent reduction of mercury emissions for the PRB coal. For the lignite coal, no co-benefit capture is assumed, and carbon injection results in a total Hg capture of 90 percent.

CO_2 emissions represent the uncontrolled discharge from the process.

The carbon balances for the four non-capture PC cases are shown in Exhibit 4-9 and Exhibit 4-10. The carbon input to the plant consists of carbon in the air in addition to carbon in the coal. 100 percent carbon conversion is assumed since carbon conversion for low rank PC plants is typically about 99.9 percent.

Carbon in the air is not neglected here since the model accounts for air components throughout. Carbon leaves the plant as CO_2 in the stack gas. The activated carbon injected for mercury removal is captured in the baghouse and removed with the ash.

Exhibit 4-9 Cases S12A and L12A Carbon Balance

Carbon In, kg/hr (lb/hr)			Carbon Out, kg/hr (lb/hr)		
	S12A	**L12A**		**S12A**	**L12A**
Coal	128,551 (283,407)	135,611 (298,970)	**Ash**	42 (93)	65 (143)
Air (CO_2)	260 (574)	273 (601)	**Stack Gas**	128,812 (283,981)	135,883 (299,571)
Activated Carbon	42 (93)	65 (143)			
Total	**128,854 (284,074)**	**135,948 (299,715)**	**Total**	**128,854 (284,074)**	**135,948 (299,715)**

Exhibit 4-10 Cases S13A and L13A Carbon Balance

Carbon In, kg/hr (lb/hr)			Carbon Out, kg/hr (lb/hr)		
	S13A	**L13A**		**S13A**	**L13A**
Coal	124,755 (275,037)	131,166 (289,171)	**Ash**	41 (91)	63 (139)
Air (CO_2)	253 (557)	263 (580)	**Stack Gas**	125,008 (275,595)	131,429 (289,751)
Activated Carbon	41 (91)	63 (139)			
Total	**125,049 (275,685)**	**131,492 (289,890)**	**Total**	**125,049 (275,685)**	**131,492 (289,890)**

Exhibit 4-11 and Exhibit 4-12 show the sulfur balances for the four non-capture PC cases. Sulfur input comes solely from the sulfur in the coal. Sulfur output is the sulfur combined with lime in the ash, and the sulfur emitted in the stack gas.

Exhibit 4-11 Cases S12A and L12A Sulfur Balance

Sulfur In, kg/hr (lb/hr)			Sulfur Out, kg/hr (lb/hr)		
	S12A	**L12A**		**S12A**	**L12A**
Coal	1,868 (4,118)	2,148 (4,735)	**Ash**	1,737 (3,829)	1,997 (4,403)
			Stack Gas	131 (288)	150 (331)
Total	**1,868 (4,118)**	**2,148 (4,735)**	**Total**	**1,868 (4,118)**	**2,148 (4,735)**

Exhibit 4-12 Cases S13A and L13A Sulfur Balance

Sulfur In, kg/hr (lb/hr)			Sulfur Out, kg/hr (lb/hr)		
	S13A	**L13A**		**S13A**	**L13A**
Coal	1,813 (3,996)	2,077 (4,580)	**Ash**	1,686 (3,716)	1,932 (4,259)
			Stack Gas	127 (280)	145 (321)
Total	**1,813 (3,996)**	**2,077 (4,580)**	**Total**	**1,813 (3,996)**	**2,077 (4,580)**

Exhibit 4-13, Exhibit 4-14, Exhibit 4-15, and Exhibit 4-16 show the overall water balances for the plants. Raw water withdrawal is obtained from groundwater (50 percent) and from municipal sources (50 percent). Water demand represents the total amount of water required for a particular process. Some water is recovered within the process and that water is re-used as internal recycle. Raw water withdrawal is the difference between water demand and internal recycle. Some water is discharged from the process to a permitted outfall. The difference between the withdrawal and discharge is the consumption.

Exhibit 4-13 Case S12A Water Balance

Water Use	Water Demand, m^3/min (gpm)	Internal Recycle, m^3/min (gpm)	Raw Water Withdrawal, m^3/min (gpm)	Process Water Discharge, m^3/min (gpm)	Raw Water Consumption, m^3/min (gpm)
FGD Makeup	0.94 (248)	0 (0)	0.94 (248)	0 (0)	0.94 (248)
BFW Makeup	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cooling Tower Makeup	9.4 (2,474)	0.27 (72)	9.1 (2,402)	2.1 (556)	6.98 (1,845)
Total	**10.3 (2,722)**	**0.27 (72)**	**10.0 (2,649)**	**2.1 (556)**	**7.92 (2,093)**

Exhibit 4-14 Case L12A Water Balance

Water Use	Water Demand, m^3/min (gpm)	Internal Recycle, m^3/min (gpm)	Raw Water Withdrawal, m^3/min (gpm)	Process Water Discharge, m^3/min (gpm)	Raw Water Consumption, m^3/min (gpm)
FGD Makeup	1.04 (274)	0 (0)	1.04 (274)	0 (0)	1.04 (274)
BFW Makeup	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cooling Tower Makeup	9.4 (2,482)	0.28 (73)	9.1 (2,409)	2.11 (558)	7.01 (1,851)
Total	**10.4 (2,755)**	**0.28 (73)**	**10.2 (2,683)**	**2.11 (558)**	**8.04 (2,125)**

Exhibit 4-15 Case S13A Water Balance

Water Use	Water Demand, m^3/min (gpm)	Internal Recycle, m^3/min (gpm)	Raw Water Withdrawal, m^3/min (gpm)	Process Water Discharge, m^3/min (gpm)	Raw Water Consumption, m^3/min (gpm)
FGD Makeup	0.91 (240)	0 (0)	0.91 (240)	0 (0)	0.91 (240)
BFW Makeup	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cooling Tower Makeup	9.1 (2,413)	0.29 (75)	8.8 (2,337)	2.05 (543)	6.79 (1,795)
Total	**10.0 (2,653)**	**0.29 (75)**	**9.8 (2,578)**	**2.05 (543)**	**7.70 (2,035)**

Exhibit 4-16 Case L13A Water Balance

Water Use	Water Demand, m^3/min (gpm)	Internal Recycle, m^3/min (gpm)	Raw Water Withdrawal, m^3/min (gpm)	Process Water Discharge, m^3/min (gpm)	Raw Water Consumption, m^3/min (gpm)
FGD Makeup	1.01 (266)	0 (0)	1.01 (266)	0 (0)	1.01 (266)
BFW Makeup	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cooling Tower Makeup	9.1 (2,406)	0.29 (75)	8.8 (2,330)	2.05 (541)	6.77 (1,789)
Total	**10.1 (2,672)**	**0.29 (75)**	**9.8 (2,597)**	**2.05 (541)**	**7.78 (2,056)**

Heat and Mass Balance Diagrams

Heat and mass balance diagrams are shown for the following subsystems in Exhibit 4-17 through Exhibit 4-24:

- Boiler and flue gas cleanup
- Steam and FW

Overall plant energy balances are provided in tabular form in Exhibit 4-25 and Exhibit 4-26 for the four non-capture cases. The power out is the steam turbine power after generator losses.

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Exhibit 4-17 Case S12A Boiler and Gas Cleanup System Heat and Mass Balance Diagram

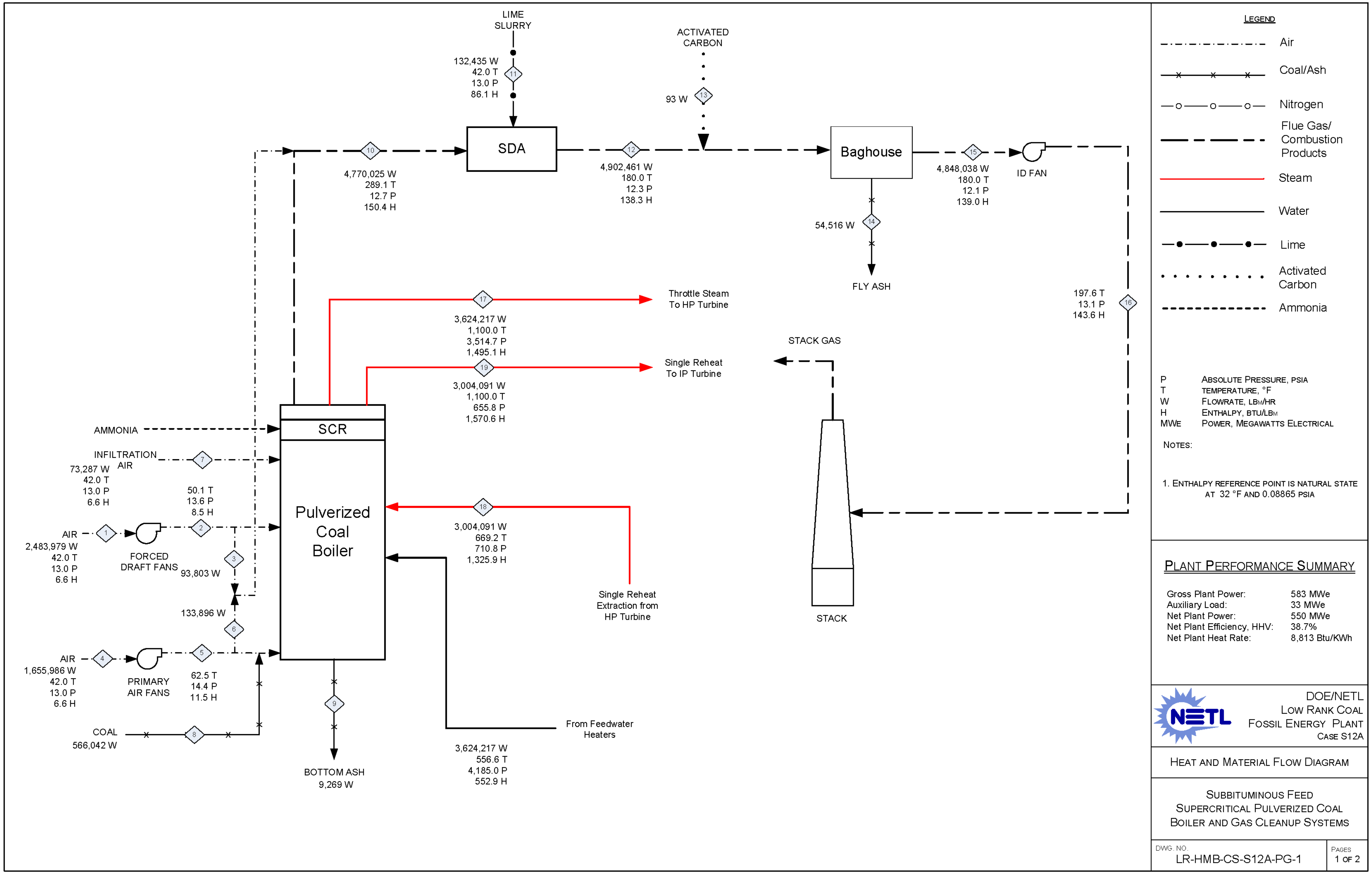

Exhibit 4-18 Case S12A Power Block System Heat and Mass Balance Diagram

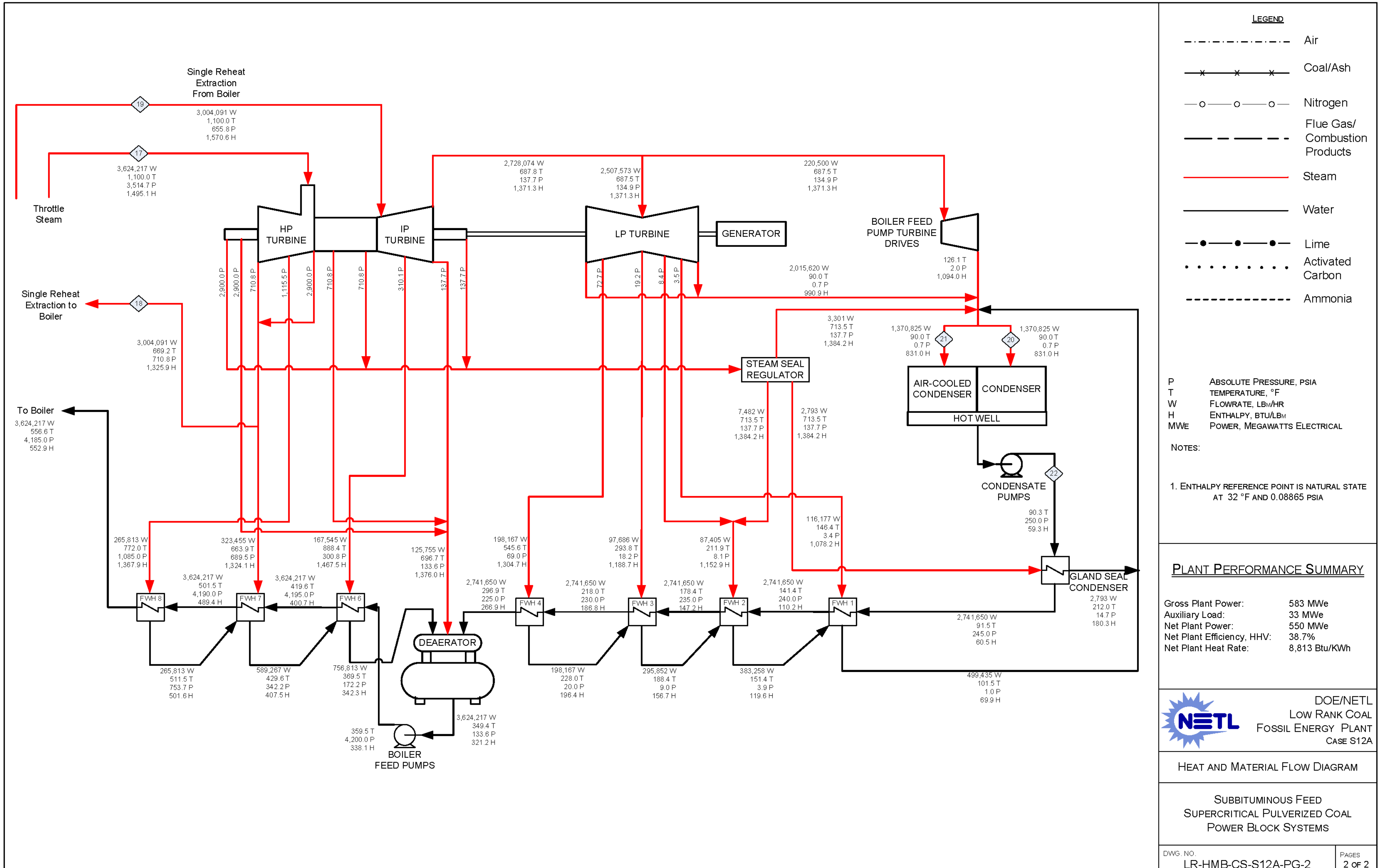

Exhibit 4-19 Case L12A Boiler and Gas Cleanup System Heat and Mass Balance Diagram

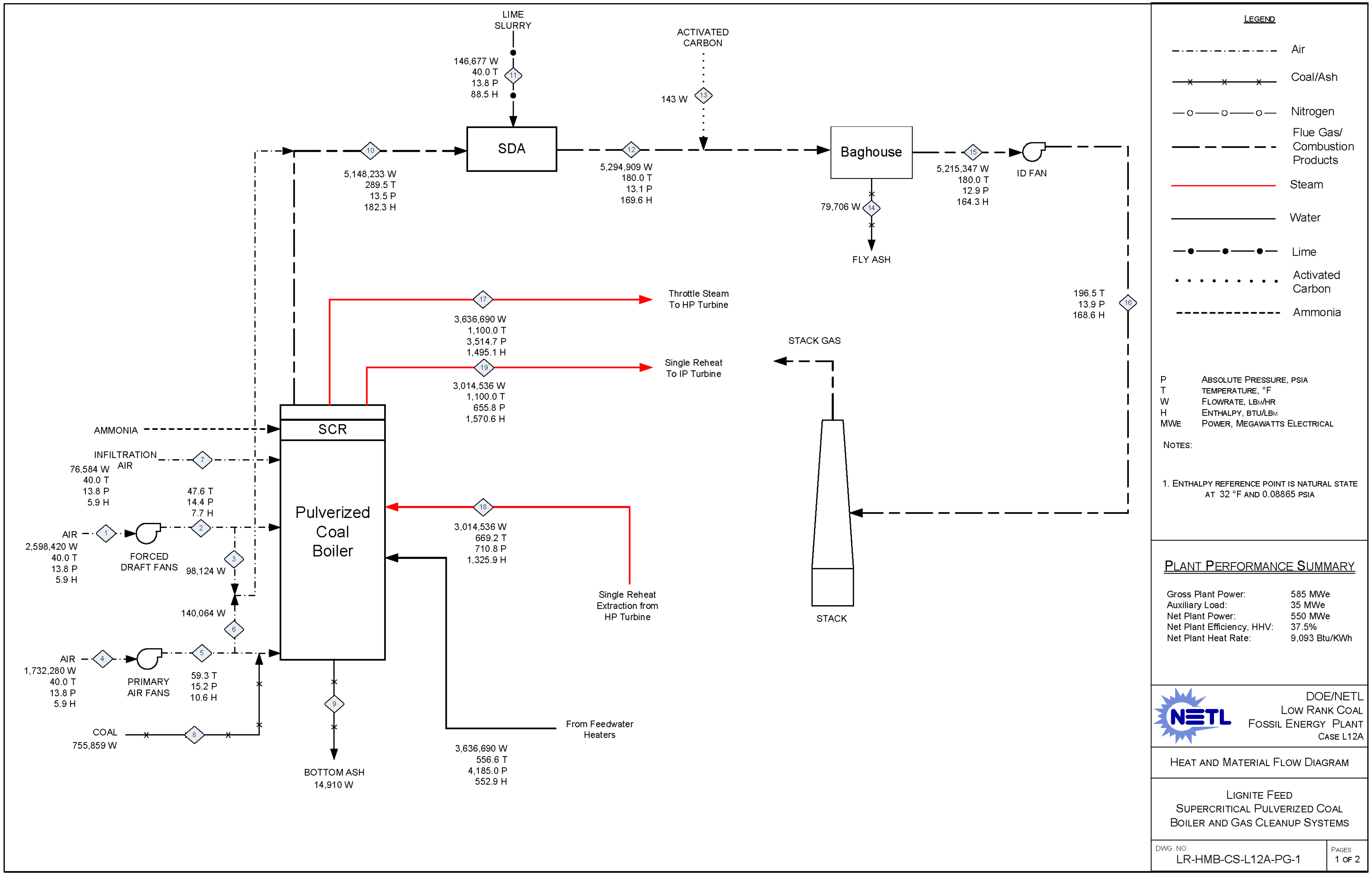

Exhibit 4-20 Case L12A Power Block System Heat and Mass Balance Diagram

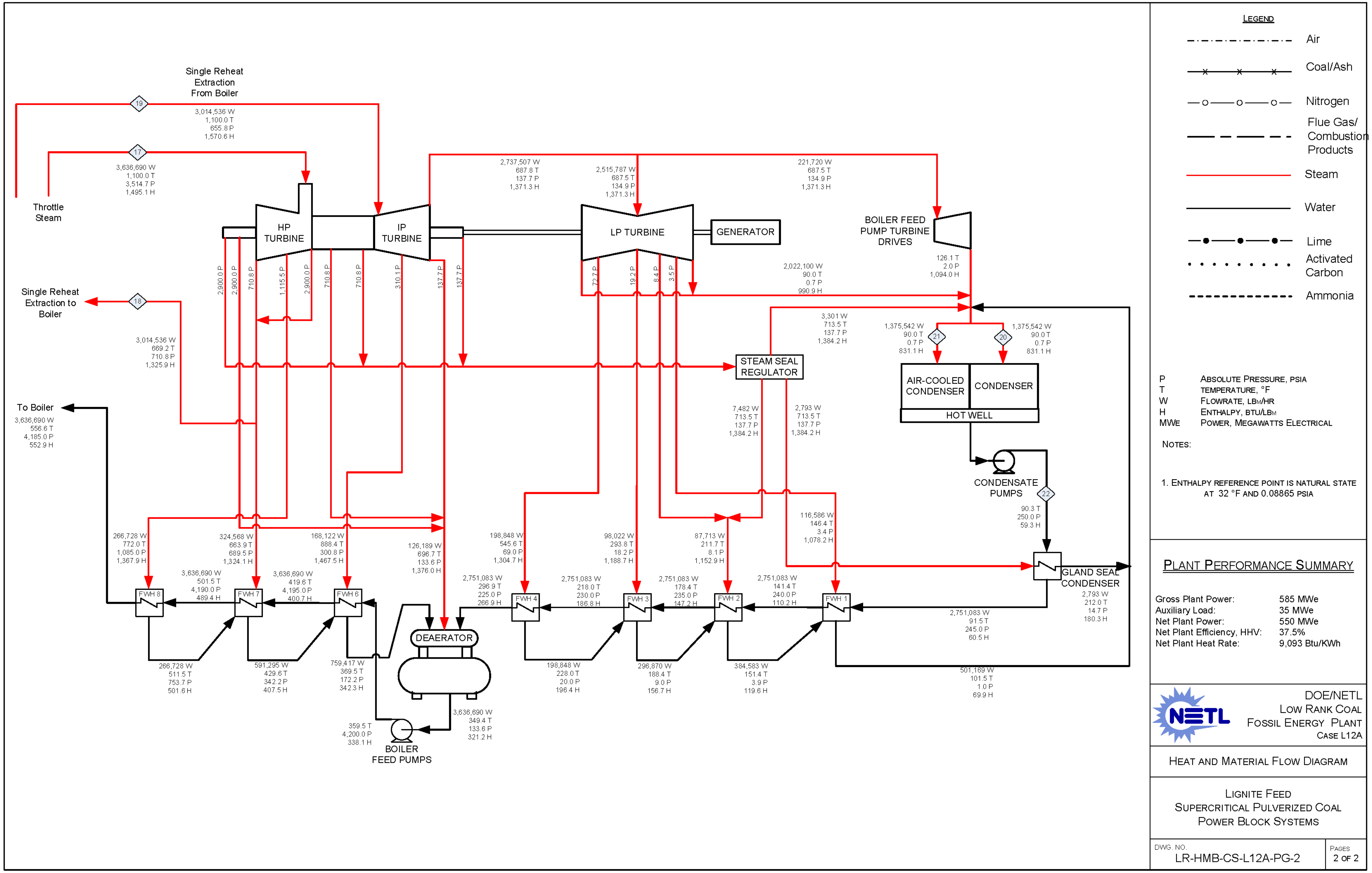

Exhibit 4-21 Case S13A Boiler and Gas Cleanup System Heat and Mass Balance Diagram

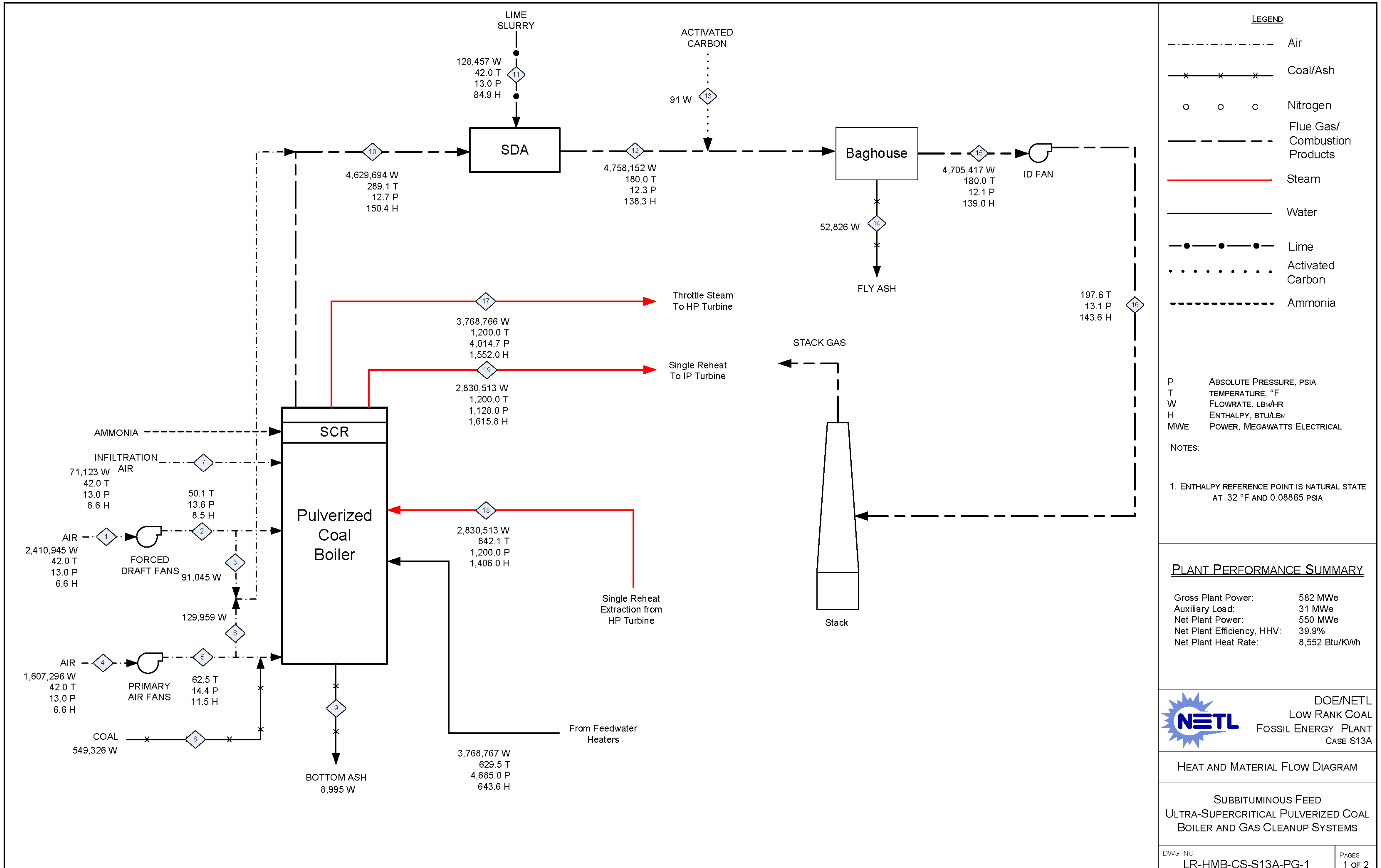

Exhibit 4-22 Case S13A Power Block System Heat and Mass Balance Diagram

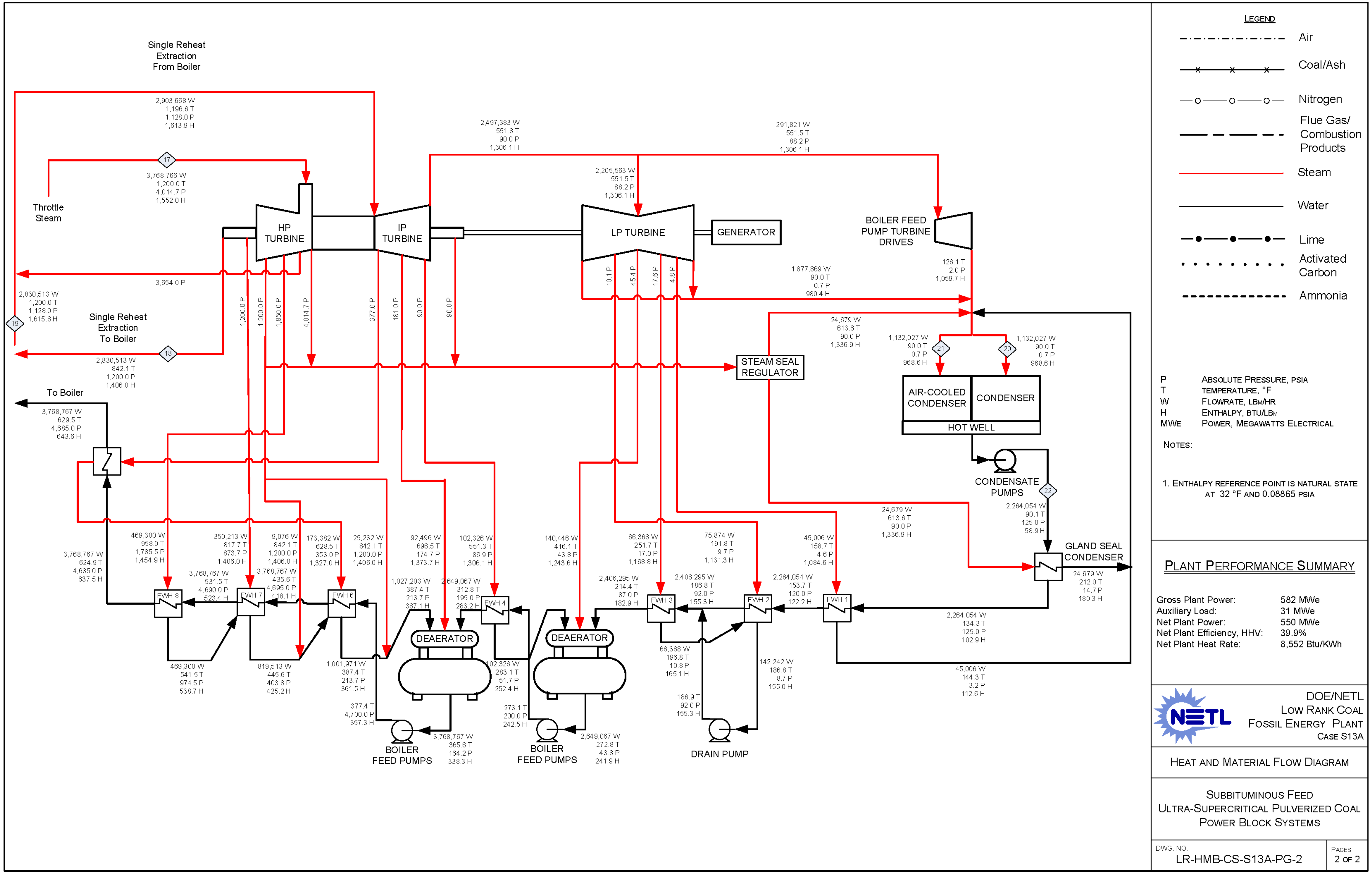

Exhibit 4-23 Case L13A Boiler and Gas Cleanup System Heat and Mass Balance Diagram

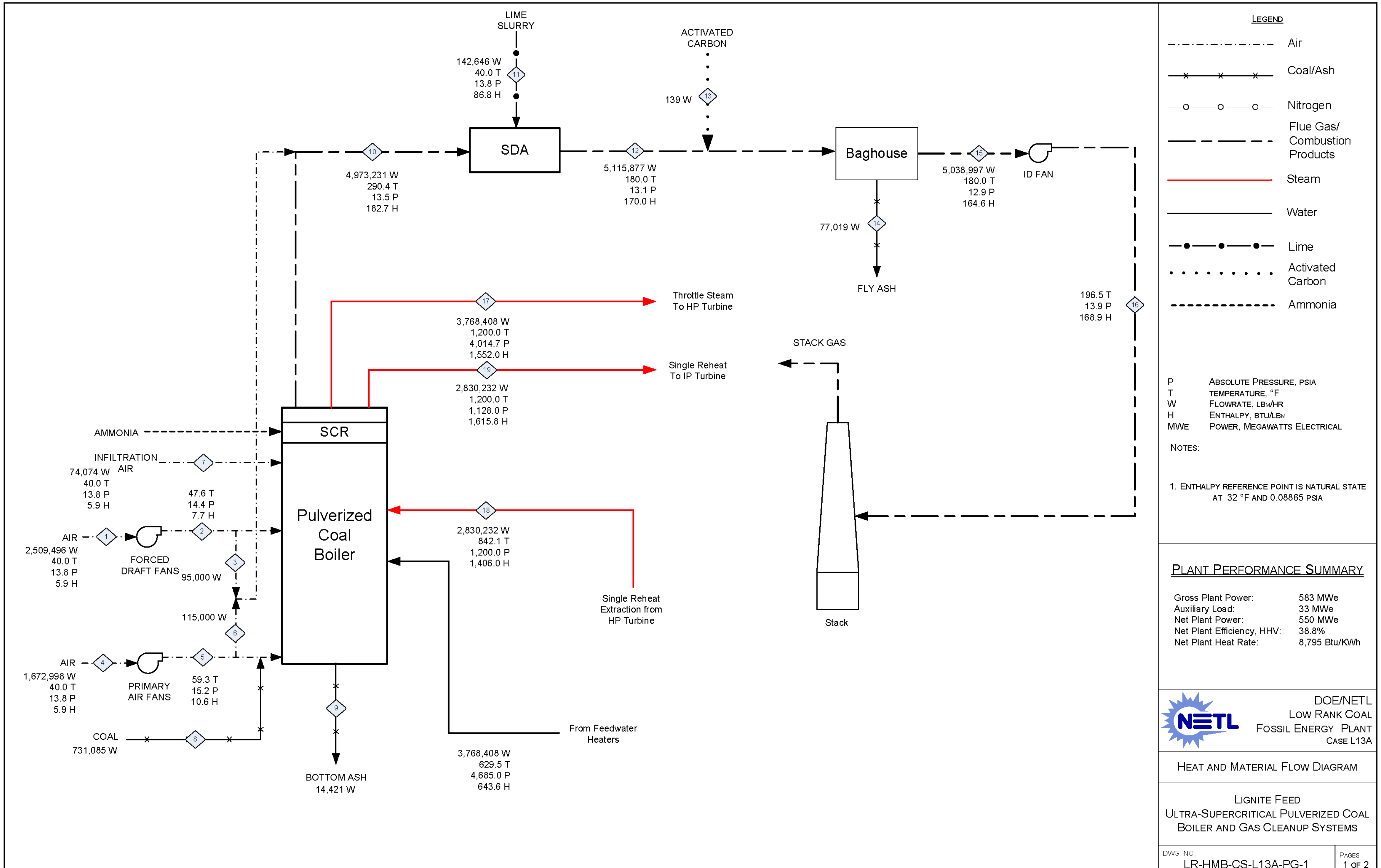

Exhibit 4-24 Case L13A Power Block System Heat and Mass Balance Diagram

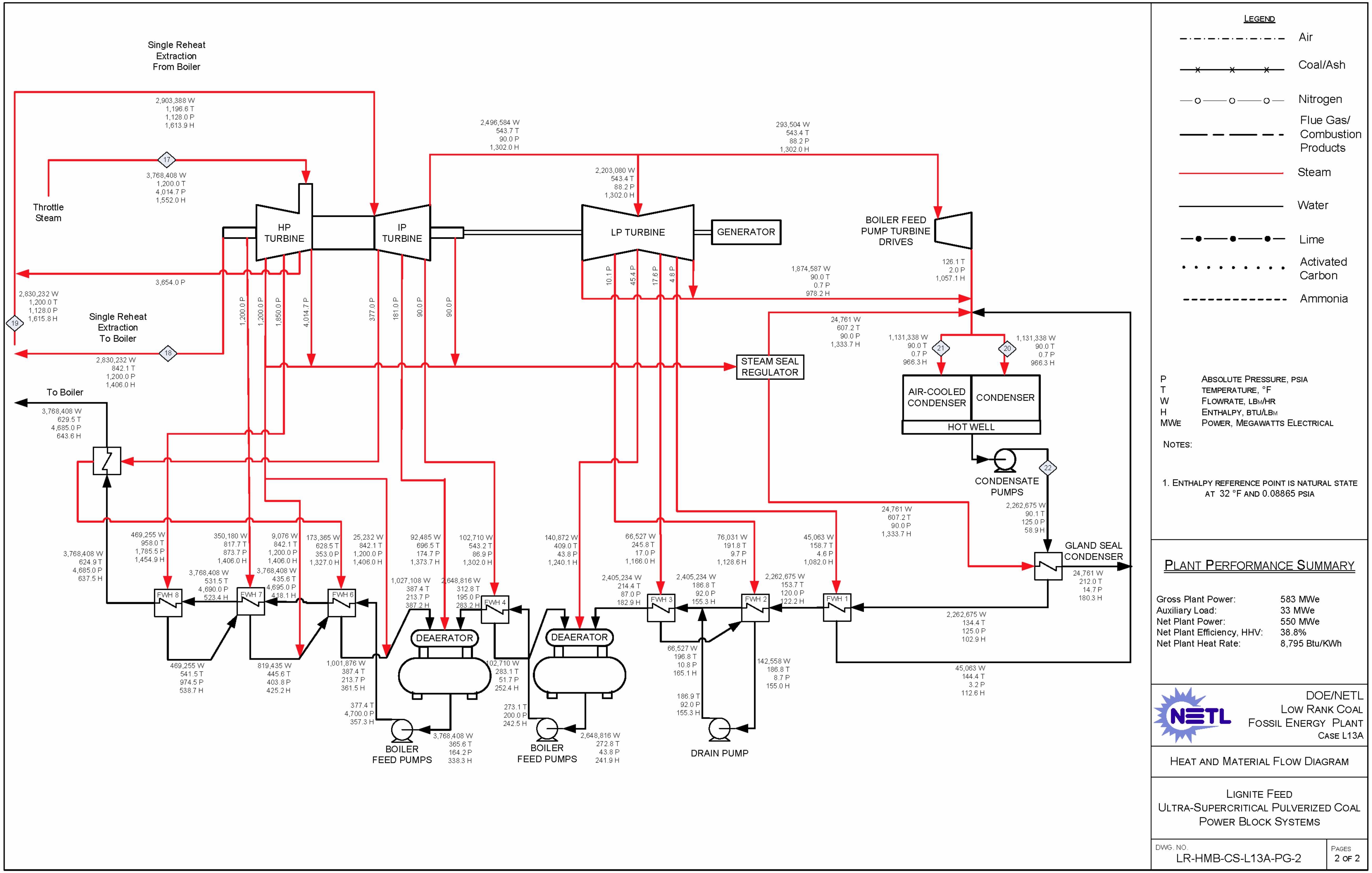

Exhibit 4-25 Cases S12A and L12A Energy Balance (0°C [32°F] Reference)

	HHV		Sensible + Latent		Power		Total	
	S12A	L12A	S12A	L12A	S12A	L12A	S12A	L12A
Heat In, GJ/hr (MMBtu/hr)								
Coal	5,114 (4,848)	5,277 (5,002)	2.6 (2.5)	3.1 (2.9)			5,117 (4,850)	5,280 (5,004)
Combustion Air			29.2 (27.6)	27.5 (26.1)			29.2 (27.6)	27.5 (26.0)
Raw Water Makeup			14.4 (13.6)	11.6 (11.0)			14.4 (13.6)	11.6 (11.0)
Lime			0.02 (0.02)	0.01 (0.01)			0.02 (0.02)	0.01 (0.01)
Auxiliary Power					118 (111)	125 (118)	118 (111)	125 (118)
Totals	**5,114 (4,848)**	**5,277 (5,002)**	**46.2 (43.8)**	**42.2 (40.0)**	**118 (111)**	**125 (118)**	**5,278 (5,003)**	**5,444 (5,160)**
Heat Out, GJ/hr (MMBtu/hr)								
Bottom Ash			0.5 (0.4)	0.8 (0.7)			0.5 (0.4)	0.8 (0.7)
Fly Ash + FGD Ash			1.6 (1.6)	2.4 (2.3)			1.6 (1.6)	2.4 (2.3)
Flue Gas			734 (696)	928 (879)			734 (696)	928 (879)
Condenser			2,235 (2,118)	2,243 (2,126)			2,235 (2,118)	2,243 (2,126)
Cooling Tower Blowdown			11.7 (11.1)	11.4 (10.8)			11.7 (11.1)	11.4 (10.8)
Process Losses*			197 (187)	154 (146)			197 (187)	154 (146)
Power					2,098 (1,988)	2,105 (1,995)	2,098 (1,988)	2,105 (1,995)
Totals	**0 (0)**	**0 (0)**	**3,180 (3,015)**	**3,339 (3,165)**	**2,098 (1,988)**	**2,105 (1,995)**	**5,278 (5,003)**	**5,444 (5,160)**

* Process losses including steam turbine, combustion reactions, and gas cooling are estimated to match the heat input to the plant.

Exhibit 4-26 Cases S13A and L13A Energy Balance (0°C [32°F] Reference)

	HHV		Sensible + Latent		Power		Total	
	S13A	L13A	S13A	L13A	S13A	L13A	S13A	L13A
Heat In, GJ/hr (MMBtu/hr)								
Coal	4,963 (4,704)	5,104 (4,838)	2.6 (2.4)	3.0 (2.8)			4,966 (4,707)	5,107 (4,840)
Combustion Air			28.3 (26.8)	26.6 (25.2)			28.3 (26.8)	26.5 (25.2)
Raw Water Makeup			14.0 (13.3)	11.3 (10.7)			14.0 (13.3)	11.3 (10.7)
Lime			0.02 (0.01)	0.01 (0.01)			0.02 (0.01)	0.01 (0.01)
Auxiliary Power					113 (107)	119 (113)	113 (107)	119 (113)
Totals	**4,963 (4,704)**	**5,104 (4,838)**	**44.9 (42.5)**	**40.8 (38.7)**	**113 (107)**	**119 (113)**	**5,121 (4,854)**	**5,264 (4,989)**
Heat Out, GJ/hr (MMBtu/hr)								
Bottom Ash			0.5 (0.4)	0.7 (0.7)			0.5 (0.4)	0.7 (0.7)
Fly Ash + FGD Ash			1.6 (1.5)	2.3 (2.2)			1.6 (1.5)	2.3 (2.2)
Flue Gas			713 (676)	898 (851)			713 (676)	898 (851)
Condenser			2,174 (2,061)	2,167 (2,054)			2,174 (2,061)	2,167 (2,054)
Cooling Tower Blowdown			11.4 (10.8)	11.1 (10.5)			11.4 (10.8)	11.1 (10.5)
Process Losses			128 (121)	85 (80)			128 (121)	85 (80)
Power					2,093 (1,984)	2,100 (1,990)	2,093 (1,984)	2,100 (1,990)
Totals	**0 (0)**	**0 (0)**	**3,028 (2,870)**	**3,165 (2,999)**	**2,093 (1,984)**	**2,100 (1,990)**	**5,121 (4,854)**	**5,264 (4,989)**

* Process losses including steam turbine, combustion reactions, and gas cooling are estimated to match the heat input to the plant.

4.1.5 PC Cases without CO_2 Capture Equipment Lists

Major equipment items for the SC PC and USC PC Cases with no CO_2 capture using PRB or lignite coal are shown in the following tables. The equipment lists are not meant to be comprehensive, but rather representative. The accounts used in the equipment list correspond to the account numbers used in the cost estimates in Section 4.1.6. In general, the design conditions include a 10 percent contingency for flows and heat duties and a 21 percent contingency for heads on pumps and fans.

ACCOUNT 1 FUEL AND SORBENT HANDLING

Equipment No.	Description	Type	Operating Qty (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
1	Bottom Trestle Dumper and Receiving Hoppers	N/A	2(0)	181 tonne (200 ton)	181 tonne (200 ton)	181 tonne (200 ton)	181 tonne (200 ton)
2	Feeder	Belt	2(0)	572 tonne/hr (630 tph)	572 tonne/hr (630 tph)	572 tonne/hr (630 tph)	572 tonne/hr (630 tph)
3	Conveyor No. 1	Belt	1(0)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)
4	Transfer Tower No. 1	Enclosed	1(0)	N/A	N/A	N/A	N/A
5	Conveyor No. 2	Belt	1(0)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)
6	As-Received Coal Sampling System	Two-stage	1(0)	N/A	N/A	N/A	N/A
7	Stacker/Reclaimer	Traveling, linear	1(0)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)
8	Reclaim Hopper	N/A	2(1)	54 tonne (60 ton)	73 tonne (80 ton)	54 tonne (60 ton)	73 tonne (80 ton)
9	Feeder	Vibratory	2(1)	209 tonne/hr (230 tph)	281 tonne/hr (310 tph)	209 tonne/hr (230 tph)	272 tonne/hr (300 tph)
10	Conveyor No. 3	Belt w/ tripper	1(0)	426 tonne/hr (470 tph)	562 tonne/hr (620 tph)	408 tonne/hr (450 tph)	544 tonne/hr (600 tph)
11	Crusher Tower	N/A	1(0)	N/A	N/A	N/A	N/A
12	Coal Surge Bin w/ Vent Filter	Dual outlet	2(0)	209 tonne (230 ton)	281 tonne (310 ton)	209 tonne (230 ton)	272 tonne (300 ton)
13	Crusher	Impactor reduction	2(0)	8cm x 0 - 3cm x 0 (3” x 0 - 1-1/4” x 0)	8cm x 0 - 3cm x 0 (3” x 0 - 1-1/4” x 0)	8cm x 0 - 3cm x 0 (3” x 0 - 1-1/4” x 0)	8cm x 0 - 3cm x 0 (3” x 0 - 1-1/4” x 0)
14	As-Fired Coal Sampling System	Swing hammer	1(0)	N/A	N/A	N/A	N/A
15	Conveyor No. 4	Belt w/tripper	1(0)	426 tonne/hr (470 tph)	562 tonne/hr (620 tph)	408 tonne/hr (450 tph)	544 tonne/hr (600 tph)
16	Transfer Tower No. 2	Enclosed	1(0)	N/A	N/A	N/A	N/A

Equipment No.	Description	Type	Operating Qty (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
17	Conveyor No. 5	Belt w/ tripper	1(0)	426 tonne/hr (470 tph)	562 tonne/hr (620 tph)	408 tonne/hr (450 tph)	544 tonne/hr (600 tph)
18	Coal Silo w/ Vent Filter and Slide Gates	Field erected	6(0)	454 tonne (500 ton)	635 tonne (700 ton)	454 tonne (500 ton)	635 tonne (700 ton)
19	Lime Truck Unloading System	N/A	1(0)	18 tonne/hr (20 tph)	18 tonne/hr (20 tph)	18 tonne/hr (20 tph)	18 tonne/hr (20 tph)
20	Lime Bulk Storage Silo w/Vent Filter	Field erected	3(0)	454 tonne (500 ton)	544 tonne (600 ton)	454 tonne (500 ton)	544 tonne (600 ton)
21	Lime Live Storage Transport	Pneumatic	1(0)	6 tonne/hr (7 tph)	7 tonne/hr (8 tph)	6 tonne/hr (7 tph)	7 tonne/hr (8 tph)
22	Limestone Day Bin	w/ actuator	2(0)	54 tonne (60 ton)	64 tonne (70 ton)	45 tonne (50 ton)	54 tonne (60 ton)
23	Activated Carbon Storage Silo and Feeder System with Vent Filter	Shop assembled	1(0)	Silo - 36 tonne (40 ton) Feeder - 45 kg/hr (100 lb/hr)	Silo - 54 tonne (60 ton) Feeder - 73 kg/hr (160 lb/hr)	Silo - 36 tonne (40 ton) Feeder - 45 kg/hr (100 lb/hr)	Silo - 45 tonne (50 ton) Feeder - 68 kg/hr (150 lb/hr)

ACCOUNT 2 COAL AND SORBENT PREPARATION AND FEED

Equipment No.	Description	Type	Operating Qty (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
1	Coal Feeder	Gravimetric	6(0)	45 tonne/hr (50 tph)	64 tonne/hr (70 tph)	45 tonne/hr (50 tph)	64 tonne/hr (70 tph)
2	Coal Pulverizer	Ball type or equivalent	6(0)	45 tonne/hr (50 tph)	64 tonne/hr (70 tph)	45 tonne/hr (50 tph)	64 tonne/hr (70 tph)
3	Lime Slaker	N/A	1(1)	5 tonne/hr (6 tph)	6 tonne/hr (7 tph)	5 tonne/hr (6 tph)	6 tonne/hr (7 tph)
4	Lime Slurry Tank	Field Erected	1(1)	276,337 liters (73,000 gal)	314,192 liters (83,000 gal)	264,981 liters (70,000 gal)	302,835 liters (80,000 gal)
5	Lime Slurry Feed Pumps	Horizontal centrifugal	1(1)	303 lpm @ 9m H_2O (80 gpm @ 30 ft H_2O)	341 lpm @ 9m H_2O (90 gpm @ 30 ft H_2O)	265 lpm @ 9m H_2O (70 gpm @ 30 ft H_2O)	303 lpm @ 9m H_2O (80 gpm @ 30 ft H_2O)

ACCOUNT 3 FEEDWATER AND MISCELLANEOUS SYSTEMS AND EQUIPMENT

Equipment No.	Description	Type	Operating Qty (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
1	Demineralized Water Storage Tank	Vertical, cylindrical, outdoor	2(0)	1,086,413 liters (287,000 gal)	1,090,199 liters (288,000 gal)	1,131,838 liters (299,000 gal)	1,128,053 liters (298,000 gal)
2	Condensate Pumps	Vertical canned	1(1)	23,091 lpm @ 213 m H_2O (6,100 gpm @ 700 ft H_2O)	23,470 lpm @ 213 m H_2O (6,200 gpm @ 700 ft H_2O)	19,306 lpm @ 91 m H_2O (5,100 gpm @ 300 ft H_2O)	19,306 lpm @ 91 m H_2O (5,100 gpm @ 300 ft H_2O)
3	Deaerator and Storage Tank	Horizontal spray type	2 (0) (USC) 1 (0) (SC)	1,809,834 kg/hr (3,990,000 lb/hr), 5 min. tank	1,816,184 kg/hr (4,004,000 lb/hr), 5 min. tank	1,881,501 kg/hr (4,148,000 lb/hr), 5 min. Tank	1,880,140 kg/hr (4,145,000 lb/hr), 5 min. tank
4	Boiler Feed Pump/Turbine	Barrel type, multi-stage, centrifugal	2 (2) (USC) 1 (1) (SC)	30,283 lpm @ 3,444 m H_2O (8,000 gpm @ 11,300 ft H_2O)	30,662 lpm @ 3,444 m H_2O (8,100 gpm @ 11,300 ft H_2O)	31,419 lpm @ 3,871 m H_2O (8,300 gpm @ 12,700 ft H_2O)	31,419 lpm @ 3,871 m H_2O (8,300 gpm @ 12,700 ft H_2O)
5	Startup Boiler Feed Pump, Electric Motor Driven	Barrel type, multi-stage, centrifugal	1(0)	9,085 lpm @ 3,444 m H_2O (2,400 gpm @ 11,300 ft H_2O)	9,085 lpm @ 3,444 m H_2O (2,400 gpm @ 11,300 ft H_2O)	9,464 lpm @ 3,871 m H_2O (2,500 gpm @ 12,700 ft H_2O)	9,464 lpm @ 3,871 m H_2O (2,500 gpm @ 12,700 ft H_2O)
6	LP Feedwater Heater 1A/1B	Horizontal U-tube	2(0)	693,996 kg/hr (1,530,000 lb/hr)	693,996 kg/hr (1,530,000 lb/hr)	571,526 kg/hr (1,260,000 lb/hr)	571,526 kg/hr (1,260,000 lb/hr)
7	LP Feedwater Heater 2A/2B	Horizontal U-tube	2(0)	693,996 kg/hr (1,530,000 lb/hr)	693,996 kg/hr (1,530,000 lb/hr)	571,526 kg/hr (1,260,000 lb/hr)	571,526 kg/hr (1,260,000 lb/hr)
8	LP Feedwater Heater 3A/3B	Horizontal U-tube	2(0)	693,996 kg/hr (1,530,000 lb/hr)	693,996 kg/hr (1,530,000 lb/hr)	571,526 kg/hr (1,260,000 lb/hr)	571,526 kg/hr (1,260,000 lb/hr)
9	LP Feedwater Heater 4A/4B	Horizontal U-tube	2(0)	693,996 kg/hr (1,530,000 lb/hr)	693,996 kg/hr (1,530,000 lb/hr)	571,526 kg/hr (1,260,000 lb/hr)	571,526 kg/hr (1,260,000 lb/hr)
10	HP Feedwater Heater 6	Horizontal U-tube	1(0)	1,809,834 kg/hr (3,990,000 lb/hr)	1,814,369 kg/hr (4,000,000 lb/hr)	1,882,408 kg/hr (4,150,000 lb/hr)	1,882,408 kg/hr (4,150,000 lb/hr)
11	HP Feedwater Heater 7	Horizontal U-tube	1(0)	1,809,834 kg/hr (3,990,000 lb/hr)	1,814,369 kg/hr (4,000,000 lb/hr)	1,882,408 kg/hr (4,150,000 lb/hr)	1,882,408 kg/hr (4,150,000 lb/hr)
12	HP Feedwater heater 8	Horizontal U-tube	1(0)	1,809,834 kg/hr (3,990,000 lb/hr)	1,814,369 kg/hr (4,000,000 lb/hr)	1,882,408 kg/hr (4,150,000 lb/hr)	1,882,408 kg/hr (4,150,000 lb/hr)

Equipment No.	Description	Type	Operating Qty (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
13	Auxiliary Boiler	Shop fabricated, water tube	1(0)	18,144 kg/hr, 2.8 MPa, 343°C (40,000 lb/hr, 400 psig, 650°F)	18,144 kg/hr, 2.8 MPa, 343°C (40,000 lb/hr, 400 psig, 650°F)	18,144 kg/hr, 2.8 MPa, 343°C (40,000 lb/hr, 400 psig, 650°F)	18,144 kg/hr, 2.8 MPa, 343°C (40,000 lb/hr, 400 psig, 650°F)
14	Fuel Oil System	No. 2 fuel oil for light off	1(0)	1,135,624 liter (300,000 gal)	1,135,624 liter (300,000 gal)	1,135,624 liter (300,000 gal)	1,135,624 liter (300,000 gal)
15	Service Air Compressors	Flooded Screw	2(1)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)
16	Instrument Air Dryers	Duplex, regenerative	2(1)	28 m^3/min (1,000 scfm)	28 m^3/min (1,000 scfm)	28 m^3/min (1,000 scfm)	28 m^3/min (1,000 scfm)
17	Closed Cycle Cooling Heat Exchangers	Shell and tube	2(0)	53 GJ/hr (50 MMBtu/hr) each	53 GJ/hr (50 MMBtu/hr) each	53 GJ/hr (50 MMBtu/hr) each	53 GJ/hr (50 MMBtu/hr) each
18	Closed Cycle Cooling Water Pumps	Horizontal centrifugal	2(1)	20,820 lpm @ 30 m H_2O (5,500 gpm @ 100 ft H_2O)	20,820 lpm @ 30 m H_2O (5,500 gpm @ 100 ft H_2O)	20,820 lpm @ 30 m H_2O (5,500 gpm @ 100 ft H_2O)	20,820 lpm @ 30 m H_2O (5,500 gpm @ 100 ft H_2O)
19	Engine-Driven Fire Pump	Vertical turbine, diesel engine	1(1)	3,785 lpm @ 88 m H_2O (1,000 gpm @ 290 ft H_2O)	3,785 lpm @ 88 m H_2O (1,000 gpm @ 290 ft H_2O)	3,785 lpm @ 88 m H_2O (1,000 gpm @ 290 ft H_2O)	3,785 lpm @ 88 m H_2O (1,000 gpm @ 290 ft H_2O)
20	Fire Service Booster Pump	Two-stage horizontal centrifugal	1(1)	2,650 lpm @ 64 m H_2O (700 gpm @ 210 ft H_2O)	2,650 lpm @ 64 m H_2O (700 gpm @ 210 ft H_2O)	2,650 lpm @ 64 m H_2O (700 gpm @ 210 ft H_2O)	2,650 lpm @ 64 m H_2O (700 gpm @ 210 ft H_2O)
21	Raw Water Pumps	Stainless steel, single suction	2(1)	2,650 lpm @ 43 m H_2O (700 gpm @ 140 ft H_2O)	2,650 lpm @ 43 m H_2O (700 gpm @ 140 ft H_2O)	2,574 lpm @ 43 m H_2O (680 gpm @ 140 ft H_2O)	2,574 lpm @ 43 m H_2O (680 gpm @ 140 ft H_2O)
22	Ground Water Pumps	Stainless steel, single suction	2(1)	2,650 lpm @ 268 m H_2O (700 gpm @ 880 ft H_2O)	2,650 lpm @ 268 m H_2O (700 gpm @ 880 ft H_2O)	2,574 lpm @ 268 m H_2O (680 gpm @ 880 ft H_2O)	2,574 lpm @ 268 m H_2O (680 gpm @ 880 ft H_2O)
23	Filtered Water Pumps	Stainless steel, single suction	2(1)	303 lpm @ 49 m H_2O (80 gpm @ 160 ft H_2O)	303 lpm @ 49 m H_2O (80 gpm @ 160 ft H_2O)	303 lpm @ 49 m H_2O (80 gpm @ 160 ft H_2O)	303 lpm @ 49 m H_2O (80 gpm @ 160 ft H_2O)

Equipment No.	Description	Type	Operating Qty (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
24	Filtered Water Tank	Vertical, cylindrical	1(0)	299,048 liter (79,000 gal)	299,048 liter (79,000 gal)	299,048 liter (79,000 gal)	299,048 liter (79,000 gal)
25	Makeup Water Demineralizer	Multi-media filter, cartridge filter, RO membrane assembly, electrodeionization unit	1(1)	606 lpm (160 gpm)	606 lpm (160 gpm)	644 lpm (170 gpm)	644 lpm (170 gpm)
26	Liquid Waste Treatment System	--	1(0)	10 years, 24-hour storm	10 years, 24-hour storm	10 years, 24-hour storm	10 years, 24-hour storm

ACCOUNT 4 BOILER AND ACCESSORIES

Equipment No.	Description	Type	Operating Qty (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
1	Boiler	Once-thru, wall-fired, low NOx burners, overfire air	1(0)	Supercritical, 1,809,834 kg/hr steam @ 25.5 MPa/602°C/602°C (3,990,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)	Supercritical, 1,814,369 kg/hr steam @ 25.5 MPa/602°C/602°C (4,000,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)	Ultra-supercritical, 1,882,408 kg/hr steam @ 29.0 MPa/657°C/657°C (4,150,000 lb/hr steam @ 4,200 psig/1,215°F/1,215°F)	Ultra-supercritical, 1,882,408 kg/hr steam @ 29.0 MPa/657°C/657°C (4,150,000 lb/hr steam @ 4,200 psig/1,215°F/1,215°F)
2	Primary Air Fan	Centrifugal	2(0)	413,676 kg/hr, 6,162 m^3/min @ 123 cm WG (912,000 lb/hr, 217,600 acfm @ 48 in. WG)	432,727 kg/hr, 6,046 m^3/min @ 123 cm WG (954,000 lb/hr, 213,500 acfm @ 48 in. WG)	400,976 kg/hr, 5,978 m^3/min @ 123 cm WG (884,000 lb/hr, 211,100 acfm @ 48 in. WG)	417,759 kg/hr, 5,836 m^3/min @ 123 cm WG (921,000 lb/hr, 206,100 acfm @ 48 in. WG)
3	Forced Draft Fan	Centrifugal	2(0)	620,061 kg/hr, 9,243 m^3/min @ 47 cm WG (1,367,000 lb/hr, 326,400 acfm @ 19 in. WG)	648,637 kg/hr, 9,070 m^3/min @ 47 cm WG (1,430,000 lb/hr, 320,300 acfm @ 19 in. WG)	601,917 kg/hr, 8,968 m^3/min @ 47 cm WG (1,327,000 lb/hr, 316,700 acfm @ 19 in. WG)	626,411 kg/hr, 8,756 m^3/min @ 47 cm WG (1,381,000 lb/hr, 309,200 acfm @ 19 in. WG)

Equipment No.	Description	Type	Operating Qty (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
4	Induced Draft Fan	Centrifugal	2(0)	1,210,638 kg/hr, 24,653 m^3/min @ 82 cm WG (2,669,000 lb/hr, 870,600 acfm @ 32 in. WG)	1,302,264 kg/hr, 25,239 m^3/min @ 82 cm WG (2,871,000 lb/hr, 891,300 acfm @ 32 in. WG)	1,174,351 kg/hr, 23,919 m^3/min @ 82 cm WG (2,589,000 lb/hr, 844,700 acfm @ 32 in. WG)	1,257,812 kg/hr, 24,378 m^3/min @ 82 cm WG (2,773,000 lb/hr, 860,900 acfm @ 32 in. WG)
5	SCR Reactor Vessel	Space for spare layer	2(0)	2,422,183 kg/hr (5,340,000 lb/hr)	2,603,620 kg/hr (5,740,000 lb/hr)	2,349,608 kg/hr (5,180,000 lb/hr)	2,517,438 kg/hr (5,550,000 lb/hr)
6	SCR Catalyst	--	3(0)	--	--	--	--
7	Dilution Air Blower	Centrifugal	2(1)	40 m^3/min @ 108 cm WG (1,400 acfm @ 42 in. WG)	42 m^3/min @ 108 cm WG (1,500 acfm @ 42 in. WG)	40 m^3/min @ 108 cm WG (1,400 acfm @ 42 in. WG)	40 m^3/min @ 108 cm WG (1,400 acfm @ 42 in. WG)
8	Ammonia Storage	Horizontal tank	5(0)	45,425 liter (12,000 gal)	45,425 liter (12,000 gal)	41,640 liter (11,000 gal)	45,425 liter (12,000 gal)
9	Ammonia Feed Pump	Centrifugal	2(1)	9 lpm @ 91 m H_2O (2 gpm @ 300 ft H_2O)	9 lpm @ 91 m H_2O (2 gpm @ 300 ft H_2O)	8 lpm @ 91 m H_2O (2 gpm @ 300 ft H_2O)	9 lpm @ 91 m H_2O (2 gpm @ 300 ft H_2O)

ACCOUNT 5 FLUE GAS CLEANUP

Equipment No.	Description	Type	Operating Qty (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
1	Fabric Filter	Single stage, high-ratio with pulse-jet online cleaning system, air-to-cloth ratio - 3.5 ft/min	2(0)	1,210,638 kg/hr (2,669,000 lb/hr) 99.9% efficiency	1,302,264 kg/hr (2,871,000 lb/hr) 99.9% efficiency	1,174,351 kg/hr (2,589,000 lb/hr) 99.9% efficiency	1,257,812 kg/hr (2,773,000 lb/hr) 99.9% efficiency
2	Spray Dryer	Co-current open spray	2(0)	26,420 m^3/min (933,000 acfm)	27,128 m^3/min (958,000 acfm)	25,627 m^3/min (905,000 acfm)	26,221 m^3/min (926,000 acfm)
3	Atomizer	Rotary	2(1)	151 lpm @ 64 m H_2O (40 gpm @ 210 ft H_2O)	189 lpm @ 64 m H_2O (50 gpm @ 210 ft H_2O)	151 lpm @ 64 m H_2O (40 gpm @ 210 ft H_2O)	189 lpm @ 64 m H_2O (50 gpm @ 210 ft H_2O)

Equipment No.	Description	Type	Operating Qty (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
4	Spray Dryer Solids Conveying	---	2(0)	---	---	---	---
5	Carbon Injectors	---	1(0)	45 kg/hr (100 lb/hr)	73 kg/hr (160 lb/hr)	45 kg/hr (100 lb/hr)	68 kg/hr (150 lb/hr)

ACCOUNT 6 COMBUSTION TURBINE/ACCESSORIES

N/A

ACCOUNT 7 HRSG, DUCTING & STACK

Equipment No.	Description	Type	Operating Qty (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
1	Stack	Reinforced concrete with FRP liner	1(0)	152 m (500 ft) high x 6.4 m (21 ft) diameter	152 m (500 ft) high x 6.5 m (21 ft) diameter	152 m (500 ft) high x 6.3 m (21 ft) diameter	152 m (500 ft) high x 6.4 m (21 ft) diameter

ACCOUNT 8 STEAM TURBINE GENERATOR AND AUXILIARIES

Equipment No.	Description	Type	Operating Qty (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
1	Steam Turbine	Commercially available advanced steam turbine	1(0)	613 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)	615 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)	612 MW 27.6 MPa/649°C/649°C (4000 psig/ 1200°F/1200°F)	614 MW 27.6 MPa/649°C/649°C (4000 psig/ 1200°F/1200°F)
2	Steam Turbine Generator	Hydrogen cooled, static excitation	1(0)	680 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	680 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	680 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	680 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase

Equipment No.	Description	Type	Operating Qty (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
3	Surface Condenser	Single pass, divided waterbox including vacuum pumps	1(0)	1,220 GJ/hr (1,160 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 9°C (48°F), Water temperature rise 11°C (20°F)	1,230 GJ/hr (1,170 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 8°C (47°F), Water temperature rise 11°C (20°F)	1,190 GJ/hr (1,130 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 9°C (48°F), Water temperature rise 11°C (20°F)	1,190 GJ/hr (1,130 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 8°C (47°F), Water temperature rise 11°C (20°F)
4	Air-cooled Condenser	---	1(0)	1,220 GJ/hr (1,160 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 6°C (42°F)	1,230 GJ/hr (1,170 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 4°C (40°F)	1,190 GJ/hr (1,130 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 6°C (42°F)	1,190 GJ/hr (1,130 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 4°C (40°F)

ACCOUNT 9 COOLING WATER SYSTEM

Equipment No.	Description	Type	Operating Qty (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
1	Circulating Water Pumps	Vertical, wet pit	2(1)	242,300 lpm @ 30 m (64,000 gpm @ 100 ft)	242,300 lpm @ 30 m (64,000 gpm @ 100 ft)	234,700 lpm @ 30 m (62,000 gpm @ 100 ft)	234,700 lpm @ 30 m (62,000 gpm @ 100 ft)
2	Cooling Tower	Evaporative, mechanical draft, multi-cell	1(0)	3°C (37°F) wet bulb / 9°C (48°F) CWT / 20°C (68°F) HWT / 1,340 GJ/hr (1,270 MMBtu/hr) heat duty	2°C (36°F) wet bulb / 8°C (47°F) CWT / 19°C (67°F) HWT / 1,350 GJ/hr (1,280 MMBtu/hr) heat duty	3°C (37°F) wet bulb / 9°C (48°F) CWT / 20°C (68°F) HWT / 1,308 GJ/hr (1,240 MMBtu/hr) heat duty	3°C (37°F) wet bulb / 9°C (48°F) CWT / 20°C (68°F) HWT / 1,308 GJ/hr (1,240 MMBtu/hr) heat duty

ACCOUNT 10 ASH/SPENT SORBENT RECOVERY AND HANDLING

Equipment No.	Description	Type	Operating Qty. (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
1	Economizer Hopper (part of boiler scope of supply)	--	4(0)	--	--	--	--
2	Bottom Ash Hopper (part of boiler scope of supply)	--	2(0)	--	--	--	--
3	Clinker Grinder	--	1(1)	4.5 tonne/hr (5 tph)	7.3 tonne/hr (8 tph)	4.5 tonne/hr (5 tph)	7.3 tonne/hr (8 tph)
4	Pyrites Hopper (part of pulverizer scope of supply included with boiler)	--	6(0)	--	--	--	--
5	Hydroejectors	--	12(0)	--	--	--	--
6	Economizer /Pyrites Transfer Tank	--	1(0)	--	--	--	--
7	Ash Sluice Pumps	Vertical, wet pit	1(1)	189 lpm @ 17 m H_2O (50 gpm @ 56 ft H_2O)	303 lpm @ 17 m H_2O (80 gpm @ 56 ft H_2O)	189 lpm @ 17 m H_2O (50 gpm @ 56 ft H_2O)	303 lpm @ 17 m H_2O (80 gpm @ 56 ft H_2O)
8	Ash Seal Water Pumps	Vertical, wet pit	1(1)	7,571 lpm @ 9 m H_2O (2,000 gpm @ 28 ft H_2O)	7,571 lpm @ 9 m H_2O (2,000 gpm @ 28 ft H_2O)	7,571 lpm @ 9 m H_2O (2,000 gpm @ 28 ft H_2O)	7,571 lpm @ 9 m H_2O (2,000 gpm @ 28 ft H_2O)
9	Hydrobins	--	1(1)	189 lpm (50 gpm)	303 lpm (80 gpm)	189 lpm (50 gpm)	303 lpm (80 gpm)
10	Baghouse Hopper (part of baghouse scope of supply)	--	24(0)	--	--	--	--
11	Air Heater Hopper (part of boiler scope of supply)	--	10(0)	--	--	--	--
12	Air Blower	--	1(1)	25 m^3/min @ 0.2 MPa (880 scfm @ 24 psi)	36 m^3/min @ 0.2 MPa (1,280 scfm @ 24 psi)	24 m^3/min @ 0.2 MPa (850 scfm @ 24 psi)	35 m^3/min @ 0.2 MPa (1,240 scfm @ 24 psi)

Equipment No.	Description	Type	Operating Qty. (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
13	Fly Ash Silo	Reinforced concrete	2(0)	1,630 tonne (1,800 ton)	2,360 tonne (2,600 ton)	1,540 tonne (1,700 ton)	2,270 tonne (2,500 ton)
14	Slide Gate Valves	--	2(0)	--	--	--	--
15	Unloader	--	1(0)	--	--	--	--
16	Telescoping Unloading Chute	--	1(0)	154 tonne/hr (170 tph)	227 tonne/hr (250 tph)	145 tonne/hr (160 tph)	218 tonne/hr (240 tph)
17	Recycle Waste Storage Silo	Reinforced concrete	2(0)	272 tonne (300 ton)	363 tonne (400 ton)	272 tonne (300 ton)	272 tonne (300 ton)
18	Recycle Waste Conveyor	--	1(0)	36 tonne/hr (40 tph)	36 tonne/hr (40 tph)	36 tonne/hr (40 tph)	36 tonne/hr (40 tph)
19	Recycle Slurry Mixer	--	1(1)	984 lpm (260 gpm)	1,060 lpm (280 gpm)	946 lpm (250 gpm)	1,060 lpm (280 gpm)
20	Recycle Waste Slurry Tank	--	1(0)	60,570 liters (16,000 gal)	64,350 liters (17,000 gal)	56,780 liters (15,000 gal)	64,350 liters (17,000 gal)
21	Recycle Waste Pump	--	1(1)	984 lpm (260 gpm)	1,060 lpm (280 gpm)	946 lpm (250 gpm)	1,060 lpm (280 gpm)

ACCOUNT 11 ACCESSORY ELECTRIC PLANT

Equipment No.	Description	Type	Operating Qty. (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
1	STG Transformer	Oil-filled	1(0)	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz
2	Auxiliary Transformer	Oil-filled	1(1)	24 kV/4.16 kV, 34 MVA, 3-ph, 60 Hz	24 kV/4.16 kV, 36 MVA, 3-ph, 60 Hz	24 kV/4.16 kV, 33 MVA, 3-ph, 60 Hz	24 kV/4.16 kV, 35 MVA, 3-ph, 60 Hz
3	Low Voltage Transformer	Dry ventilated	1(1)	4.16 kV/480 V, 5 MVA, 3-ph, 60 Hz	4.16 kV/480 V, 5 MVA, 3-ph, 60 Hz	4.16 kV/480 V, 5 MVA, 3-ph, 60 Hz	4.16 kV/480 V, 5 MVA, 3-ph, 60 Hz
4	STG Isolated Phase Bus Duct and Tap Bus	Aluminum, self-cooled	1(0)	24 kV, 3-ph, 60 Hz	24 kV, 3-ph, 60 Hz	24 kV, 3-ph, 60 Hz	24 kV, 3-ph, 60 Hz

Equipment No.	Description	Type	Operating Qty. (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
5	Medium Voltage Switchgear	Metal clad	1(1)	4.16 kV, 3-ph, 60 Hz	4.16 kV, 3-ph, 60 Hz	4.16 kV, 3-ph, 60 Hz	4.16 kV, 3-ph, 60 Hz
6	Low Voltage Switchgear	Metal enclosed	1(1)	480 V, 3-ph, 60 Hz	480 V, 3-ph, 60 Hz	480 V, 3-ph, 60 Hz	480 V, 3-ph, 60 Hz
7	Emergency Diesel Generator	Sized for emergency shutdown	1(0)	750 kW, 480 V, 3-ph, 60 Hz	750 kW, 480 V, 3-ph, 60 Hz	750 kW, 480 V, 3-ph, 60 Hz	750 kW, 480 V, 3-ph, 60 Hz

ACCOUNT 12 INSTRUMENTATION AND CONTROL

Equipment No.	Description	Type	Operating Qty. (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
1	DCS - Main Control	Monitor/keyboard, Operator printer, Engineering printer	1(0)	Operator stations/printers and engineering stations/printers	Operator stations/printers and engineering stations/printers	Operator stations/printers and engineering stations/printers	Operator stations/printers and engineering stations/printers
2	DCS - Processor	Microprocessor with redundant input/output	1(0)	N/A	N/A	N/A	N/A
3	DCS - Data Highway	Fiber optic	1(0)	Fully redundant, 25% spare	Fully redundant, 25% spare	Fully redundant, 25% spare	Fully redundant, 25% spare

4.1.6 PC Cases without CO_2 Capture – Cost Estimating

Costs Results

The cost estimating methodology was described previously in Section 2.6. The TPC summary organized by cost account, detailed breakdown of capital costs, owner's costs, and initial and annual O&M costs for the SC PC PRB case (S12A) are shown in Exhibit 4-27, Exhibit 4-28, Exhibit 4-29, and Exhibit 4-30 respectively. The same data for the SC PC lignite cases (L12A) are shown in Exhibit 4-31, Exhibit 4-32, Exhibit 4-33, and Exhibit 4-34; the USC PC PRB case (S13A) are shown in Exhibit 4-35, Exhibit 4-36, Exhibit 4-37, and Exhibit 4-38, and the USC PC Lignite case (L13A) are shown in Exhibit 4-39, Exhibit 4-40, Exhibit 4-41, and Exhibit 4-42.

The estimated TOC of the SC PC plant with no CO_2 capture using PRB coal is $2,293/kW and using lignite coal is $2,489/kW. Project and process contingencies represent 8.9 and 0 percent respectively in both cases. The COE is 57.8 mills/kWh for the PRB case and 62.2 mills/kWh for the lignite case. The estimated TOC of the USC PC plant with no CO_2 capture using PRB coal is $2,405/kW and using lignite coal is $2,628/kW. Project and process contingencies represent 8.9 and 1.4 percent respectively in both cases. The COE is 62.2 mills/kWh for the PRB case and 67.3 mills/kWh for the lignite case.

Exhibit 4-27 Case S12A TPC Summary

Client: USDOE/NETL **Report Date:** 2009-Oct-19

Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case S12A - 1x550 MWnet SuperCritical PC

Plant Size: 550.0 MW,net **Estimate Type:** Conceptual **Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING	$17,008	$5,162	$11,264	$0	$0	**$33,434**	$3,010	$0	$5,467	**$41,910**	$76
2	COAL & SORBENT PREP & FEED	$8,508	$683	$2,375	$0	$0	**$11,567**	$1,017	$0	$1,888	**$14,471**	$26
3	FEEDWATER & MISC. BOP SYSTEMS	$39,303	$0	$18,715	$0	$0	**$58,017**	$5,290	$0	$10,094	**$73,401**	$133
4	PC BOILER											
4.1	PC Boiler & Accessories	$187,066	$0	$91,635	$0	$0	**$278,701**	$27,096	$0	$30,580	**$336,377**	$612
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.3	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.4-4.9	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 4	**$187,066**	**$0**	**$91,635**	**$0**	**$0**	**$278,701**	**$27,096**	**$0**	**$30,580**	**$336,377**	**$612**
5	FLUE GAS CLEANUP	$100,170	$0	$35,511	$0	$0	**$135,681**	$12,991	$0	$14,867	**$163,540**	$297
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
6.2-6.9	Combustion Turbine Other	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 6	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
7.2-7.9	HRSG Accessories, Ductwork and Stack	$20,718	$1,191	$14,069	$0	$0	**$35,979**	$3,303	$0	$5,129	**$44,411**	$81
	SUBTOTAL 7	**$20,718**	**$1,191**	**$14,069**	**$0**	**$0**	**$35,979**	**$3,303**	**$0**	**$5,129**	**$44,411**	**$81**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$51,735	$0	$6,882	$0	$0	**$58,617**	$5,618	$0	$6,423	**$70,658**	$128
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$58,443	$1,092	$20,603	$0	$0	**$80,138**	$7,565	$0	$15,344	**$103,046**	$187
	SUBTOTAL 8	**$110,177**	**$1,092**	**$27,485**	**$0**	**$0**	**$138,754**	**$13,182**	**$0**	**$21,767**	**$173,704**	**$316**
9	COOLING WATER SYSTEM	$7,708	$4,202	$7,496	$0	$0	**$19,407**	$1,827	$0	$2,913	**$24,146**	$44
10	ASH/SPENT SORBENT HANDLING SYS	$5,738	$182	$7,672	$0	$0	**$13,593**	$1,307	$0	$1,533	**$16,434**	$30
11	ACCESSORY ELECTRIC PLANT	$17,818	$6,364	$18,555	$0	$0	**$42,738**	$3,769	$0	$5,753	**$52,259**	$95
12	INSTRUMENTATION & CONTROL	$8,731	$0	$8,853	$0	$0	**$17,584**	$1,594	$0	$2,356	**$21,534**	$39
13	IMPROVEMENTS TO SITE	$2,975	$1,710	$5,995	$0	$0	**$10,680**	$1,054	$0	$2,347	**$14,080**	$26
14	BUILDINGS & STRUCTURES	$0	$23,371	$22,120	$0	$0	**$45,491**	$4,103	$0	$7,439	**$57,033**	$104
	TOTAL COST	**$525,921**	**$43,959**	**$271,745**	**$0**	**$0**	**$841,625**	**$79,543**	**$0**	**$112,132**	**$1,033,301**	**$1,879**

Exhibit 4-28 Case S12A Total Plant Cost Details

Client:	USDOE/NETL
Project:	Low Rank (Western) Coal Baseline Study
	TOTAL PLANT COST SUMMARY
Case:	Case S12A - 1x550 MWnet SuperCritical PC
Plant Size:	550.0 MW,net
Estimate Type:	Conceptual
Report Date:	2009-Oct-19
Cost Base (June)	2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING											
1.1	Coal Receive & Unload	$4,119	$0	$1,881	$0	$0	$6,000	$536	$0	$980	$7,516	$14
1.2	Coal Stackout & Reclaim	$5,323	$0	$1,206	$0	$0	$6,529	$571	$0	$1,065	$8,165	$15
1.3	Coal Conveyors	$4,949	$0	$1,193	$0	$0	$6,142	$538	$0	$1,002	$7,682	$14
1.4	Other Coal Handling	$1,295	$0	$276	$0	$0	$1,571	$137	$0	$256	$1,964	$4
1.5	Sorbent Receive & Unload	$50	$0	$15	$0	$0	$65	$6	$0	$11	$82	$0
1.6	Sorbent Stackout & Reclaim	$810	$0	$148	$0	$0	$958	$83	$0	$156	$1,198	$2
1.7	Sorbent Conveyors	$289	$63	$71	$0	$0	$422	$37	$0	$69	$528	$1
1.8	Other Sorbent Handling	$175	$41	$92	$0	$0	$307	$27	$0	$50	$384	$1
1.9	Coal & Sorbent Hnd.Foundations	$0	$5,058	$6,381	$0	$0	$11,440	$1,074	$0	$1,877	$14,391	$26
	SUBTOTAL 1.	**$17,008**	**$5,162**	**$11,264**	**$0**	**$0**	**$33,434**	**$3,010**	**$0**	**$5,467**	**$41,910**	**$76**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$2,390	$0	$466	$0	$0	$2,855	$249	$0	$466	$3,570	$6
2.2	Coal Conveyor to Storage	$6,119	$0	$1,336	$0	$0	$7,454	$652	$0	$1,216	$9,322	$17
2.3	Coal Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.4	Misc.Coal Prep & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.5	Sorbent Prep Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.6	Sorbent Storage & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.7	Sorbent Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.8	Booster Air Supply System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.9	Coal & Sorbent Feed Foundation	$0	$683	$574	$0	$0	$1,257	$117	$0	$206	$1,580	$3
	SUBTOTAL 2.	**$8,508**	**$683**	**$2,375**	**$0**	**$0**	**$11,567**	**$1,017**	**$0**	**$1,888**	**$14,471**	**$26**
3	FEEDWATER & MISC. BOP SYSTEMS											
3.1	FeedwaterSystem	$18,479	$0	$5,969	$0	$0	$24,448	$2,136	$0	$3,988	$30,572	$56
3.2	Water Makeup & Pretreating	$2,739	$0	$882	$0	$0	$3,620	$342	$0	$792	$4,755	$9
3.3	Other Feedwater Subsystems	$5,657	$0	$2,391	$0	$0	$8,048	$721	$0	$1,315	$10,084	$18
3.4	Service Water Systems	$537	$0	$292	$0	$0	$829	$78	$0	$181	$1,088	$2
3.5	Other Boiler Plant Systems	$7,063	$0	$6,973	$0	$0	$14,037	$1,333	$0	$2,305	$17,675	$32
3.6	FO Supply Sys & Nat Gas	$256	$0	$320	$0	$0	$575	$54	$0	$94	$724	$1
3.7	Waste Treatment Equipment	$1,857	$0	$1,058	$0	$0	$2,915	$284	$0	$640	$3,839	$7
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	$2,715	$0	$829	$0	$0	$3,545	$341	$0	$777	$4,663	$8
	SUBTOTAL 3.	**$39,303**	**$0**	**$18,715**	**$0**	**$0**	**$58,017**	**$5,290**	**$0**	**$10,094**	**$73,401**	**$133**

Exhibit 4-28 Case S12A Total Plant Cost Details (Continued)

Client:	USDOE/NETL			**Report Date:**	2009-Oct-19
Project:	Low Rank (Western) Coal Baseline Study				
	TOTAL PLANT COST SUMMARY				
Case:	Case S12A - 1x550 MWnet SuperCritical PC				
Plant Size:	550.0 MW,net	**Estimate Type:**	Conceptual	**Cost Base (June)**	2007 ($x1000)

Acct		Equipment	Material	Labor		Sales	Bare Erected	Eng'g CM	Contingencies		TOTAL PLANT COST	
No.	Item/Description	Cost	Cost	Direct	Indirect	Tax	Cost $	H.O.& Fee	Process	Project	$	$/kW
4	PC BOILER											
4.1	PC Boiler & Accessories	$187,066	$0	$91,635	$0	$0	$278,701	$27,096	$0	$30,580	$336,377	$612
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.3	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.4	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.5	Primary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.6	Secondary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.8	Major Component Rigging	$0	w/4.1	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.9	Boiler Foundations	$0	w/14.1	w/14.1	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 4.	**$187,066**	**$0**	**$91,635**	**$0**	**$0**	**$278,701**	**$27,096**	**$0**	**$30,580**	**$336,377**	**$612**
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$80,019	$0	$21,798	$0	$0	$101,816	$9,725	$0	$11,154	$122,696	$223
5.2	Other FGD	$1,033	$0	$670	$0	$0	$1,703	$164	$0	$187	$2,054	$4
5.3	Bag House & Accessories	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.4	Other Particulate Removal Materials	$19,118	$0	$13,044	$0	$0	$32,162	$3,102	$0	$3,526	$38,790	$71
5.5	Gypsum Dewatering System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.6	Mercury Removal System	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.9	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 5.	**$100,170**	**$0**	**$35,511**	**$0**	**$0**	**$135,681**	**$12,991**	**$0**	**$14,867**	**$163,540**	**$297**
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
6.2	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.3	Compressed Air Piping	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.9	Combustion Turbine Foundations	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
7.2	HRSG Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7.3	Ductwork	$10,332	$0	$6,638	$0	$0	$16,970	$1,480	$0	$2,767	$21,217	$39
7.4	Stack	$10,386	$0	$6,078	$0	$0	$16,464	$1,585	$0	$1,805	$19,854	$36
7.9	Duct & Stack Foundations	$0	$1,191	$1,354	$0	$0	$2,545	$238	$0	$557	$3,340	$6
	SUBTOTAL 7.	**$20,718**	**$1,191**	**$14,069**	**$0**	**$0**	**$35,979**	**$3,303**	**$0**	**$5,129**	**$44,411**	**$81**

Exhibit 4-28 Case S12A Total Plant Cost Details (Continued)

	Client:	USDOE/NETL								Report Date:	2009-Oct-19		
	Project:	Low Rank (Western) Coal Baseline Study											
		TOTAL PLANT COST SUMMARY											
	Case:	Case S12A - 1x550 MWnet SuperCritical PC											
	Plant Size:	550.0 MW,net		Estimate Type:		Conceptual				Cost Base (June)	2007	($x1000)	
Acct		Equipment	Material	Labor		Sales	Bare Erected	Eng'g CM	Contingencies		TOTAL PLANT COST		
No.	Item/Description	Cost	Cost	Direct	Indirect	Tax	Cost $	H.O.& Fee	Process	Project	$	$/kW	
8	STEAM TURBINE GENERATOR												
8.1	Steam TG & Accessories	$51,735	$0	$6,882	$0	$0	$58,617	$5,618	$0	$6,423	$70,658	$128	
8.2	Turbine Plant Auxiliaries	$348	$0	$746	$0	$0	$1,094	$107	$0	$120	$1,321	$2	
8.3a	Condenser & Auxiliaries	$4,035	$0	$2,295	$0	$0	$6,330	$609	$0	$694	$7,633	$14	
8.3b	Air Cooled Condenser	$36,976	$0	$7,413	$0	$0	$44,389	$4,439	$0	$9,766	$58,593	$107	
8.4	Steam Piping	$17,083	$0	$8,423	$0	$0	$25,507	$2,143	$0	$4,147	$31,797	$58	
8.9	TG Foundations	$0	$1,092	$1,726	$0	$0	$2,818	$267	$0	$617	$3,702	$7	
	SUBTOTAL 8.	**$110,177**	**$1,092**	**$27,485**	**$0**	**$0**	**$138,754**	**$13,182**	**$0**	**$21,767**	**$173,704**	**$316**	
9	COOLING WATER SYSTEM												
9.1	Cooling Towers	$5,639	$0	$1,756	$0	$0	$7,395	$707	$0	$810	$8,912	$16	
9.2	Circulating Water Pumps	$1,181	$0	$59	$0	$0	$1,240	$104	$0	$134	$1,479	$3	
9.3	Circ.Water System Auxiliaries	$333	$0	$44	$0	$0	$378	$36	$0	$41	$455	$1	
9.4	Circ.Water Piping	$0	$2,644	$2,562	$0	$0	$5,206	$487	$0	$854	$6,547	$12	
9.5	Make-up Water System	$290	$0	$388	$0	$0	$678	$65	$0	$111	$854	$2	
9.6	Component Cooling Water Sys	$264	$0	$210	$0	$0	$474	$45	$0	$78	$597	$1	
9.9	Circ.Water System Foundations& Structures	$0	$1,559	$2,477	$0	$0	$4,036	$382	$0	$883	$5,301	$10	
	SUBTOTAL 9.	**$7,708**	**$4,202**	**$7,496**	**$0**	**$0**	**$19,407**	**$1,827**	**$0**	**$2,913**	**$24,146**	**$44**	
10	ASH/SPENT SORBENT HANDLING SYS												
10.1	Ash Coolers	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0	
10.2	Cyclone Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0	
10.3	HGCU Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0	
10.4	High Temperature Ash Piping	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0	
10.5	Other Ash Recovery Equipment	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0	
10.6	Ash Storage Silos	$768	$0	$2,366	$0	$0	$3,134	$308	$0	$344	$3,786	$7	
10.7	Ash Transport & Feed Equipment	$4,971	$0	$5,092	$0	$0	$10,062	$962	$0	$1,102	$12,127	$22	
10.8	Misc. Ash Handling Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
10.9	Ash/Spent Sorbent Foundation	$0	$182	$215	$0	$0	$397	$37	$0	$87	$522	$1	
	SUBTOTAL 10.	**$5,738**	**$182**	**$7,672**	**$0**	**$0**	**$13,593**	**$1,307**	**$0**	**$1,533**	**$16,434**	**$30**	

Exhibit 4-28 Case S12A Total Plant Cost Details (Continued)

Client: USDOE/NETL — Report Date: 2009-Oct-19
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case S12A - 1x550 MWnet SuperCritical PC
Plant Size: 550.0 MW,net — Estimate Type: Conceptual — Cost Base (June) 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT											
11.1	Generator Equipment	$1,602	$0	$260	$0	$0	$1,862	$173	$0	$153	$2,187	$4
11.2	Station Service Equipment	$2,908	$0	$956	$0	$0	$3,864	$361	$0	$317	$4,542	$8
11.3	Switchgear & Motor Control	$3,344	$0	$568	$0	$0	$3,912	$363	$0	$427	$4,702	$9
11.4	Conduit & Cable Tray	$0	$2,096	$7,249	$0	$0	$9,345	$905	$0	$1,537	$11,787	$21
11.5	Wire & Cable	$0	$3,956	$7,636	$0	$0	$11,592	$977	$0	$1,885	$14,454	$26
11.6	Protective Equipment	$270	$0	$920	$0	$0	$1,190	$116	$0	$131	$1,437	$3
11.7	Standby Equipment	$1,279	$0	$29	$0	$0	$1,308	$120	$0	$143	$1,571	$3
11.8	Main Power Transformers	$8,414	$0	$172	$0	$0	$8,587	$652	$0	$924	$10,162	$18
11.9	Electrical Foundations	$0	$312	$765	$0	$0	$1,077	$103	$0	$236	$1,416	$3
	SUBTOTAL 11.	**$17,818**	**$6,364**	**$18,555**	**$0**	**$0**	**$42,738**	**$3,769**	**$0**	**$5,753**	**$52,259**	**$95**
12	INSTRUMENTATION & CONTROL											
12.1	PC Control Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.2	Combustion Turbine Control	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
12.3	Steam Turbine Control	w/8.1	$0	w/8.1	$0	$0	$0	$0	$0	$0	$0	$0
12.4	Other Major Component Control	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.5	Signal Processing Equipment	W/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.6	Control Boards,Panels & Racks	$450	$0	$269	$0	$0	$719	$68	$0	$118	$905	$2
12.7	Distributed Control System Equipment	$4,538	$0	$793	$0	$0	$5,332	$494	$0	$583	$6,409	$12
12.8	Instrument Wiring & Tubing	$2,460	$0	$4,880	$0	$0	$7,341	$626	$0	$1,195	$9,161	$17
12.9	Other I & C Equipment	$1,282	$0	$2,910	$0	$0	$4,193	$407	$0	$460	$5,059	$9
	SUBTOTAL 12.	**$8,731**	**$0**	**$8,853**	**$0**	**$0**	**$17,584**	**$1,594**	**$0**	**$2,356**	**$21,534**	**$39**
13	IMPROVEMENTS TO SITE											
13.1	Site Preparation	$0	$50	$1,000	$0	$0	$1,050	$104	$0	$231	$1,385	$3
13.2	Site Improvements	$0	$1,660	$2,062	$0	$0	$3,722	$367	$0	$818	$4,906	$9
13.3	Site Facilities	$2,975	$0	$2,934	$0	$0	$5,908	$582	$0	$1,298	$7,789	$14
	SUBTOTAL 13.	**$2,975**	**$1,710**	**$5,995**	**$0**	**$0**	**$10,680**	**$1,054**	**$0**	**$2,347**	**$14,080**	**$26**
14	BUILDINGS & STRUCTURES											
14.1	Boiler Building	$0	$9,125	$8,024	$0	$0	$17,149	$1,541	$0	$2,804	$21,494	$39
14.2	Turbine Building	$0	$11,851	$11,045	$0	$0	$22,896	$2,064	$0	$3,744	$28,704	$52
14.3	Administration Building	$0	$587	$621	$0	$0	$1,208	$110	$0	$198	$1,515	$3
14.4	Circulation Water Pumphouse	$0	$168	$134	$0	$0	$302	$27	$0	$49	$378	$1
14.5	Water Treatment Buildings	$0	$347	$317	$0	$0	$664	$60	$0	$109	$832	$2
14.6	Machine Shop	$0	$393	$264	$0	$0	$657	$58	$0	$107	$822	$1
14.7	Warehouse	$0	$266	$267	$0	$0	$533	$48	$0	$87	$668	$1
14.8	Other Buildings & Structures	$0	$217	$185	$0	$0	$403	$36	$0	$66	$504	$1
14.9	Waste Treating Building & Str.	$0	$416	$1,263	$0	$0	$1,680	$159	$0	$276	$2,115	$4
	SUBTOTAL 14.	**$0**	**$23,371**	**$22,120**	**$0**	**$0**	**$45,491**	**$4,103**	**$0**	**$7,439**	**$57,033**	**$104**
	TOTAL COST	**$525,921**	**$43,959**	**$271,745**	**$0**	**$0**	**$841,625**	**$79,543**	**$0**	**$112,132**	**$1,033,301**	**$1,879**

Exhibit 4-29 Case S12A Owner's Costs

Owner's Costs	$x1000	$/kW
Preproduction Costs		
6 Months Fixed O&M	$8,089	$15
1 Month Variable O&M	$2,042	$4
25% of 1 Months Fuel Cost at 100% CF	$786	$1
2% of TPC	$20,666	$38
Total	**$31,582**	**$57**
Inventory Capital		
60 day supply of fuel and consumables at 100% CF	$7,331	$13
0.5% of TPC (spare parts)	$5,167	$9
Total	**$12,498**	**$23**
Initial Cost for Catalyst and Chemicals	**$0**	**$0**
Land	**$900**	**$2**
Other Owner's Costs	**$154,995**	**$282**
Financing Costs	**$27,899**	**$51**
Total Owner's Costs	**$227,874**	**$414**
Total Overnight Cost (TOC)	**$1,261,175**	**$2,293**
TASC Multiplier	1.134	
Total As-Spent Cost (TASC)	**$1,430,172**	**$2,600**

Exhibit 4-30 Case S12A Initial and Annual O&M Costs

INITIAL & ANNUAL O&M EXPENSES						Cost Base (June)	2007
Case S12A - 1x550 MWnet SuperCritical PC						Heat Rate-net(Btu/kWh):	8,813
						MWe-net:	550
						Capacity Factor: (%):	85
OPERATING & MAINTENANCE LABOR							
Operating Labor							
Operating Labor Rate(base):	34.65	$/hour					
Operating Labor Burden:	30.00	% of base					
Labor O-H Charge Rate:	25.00	% of labor					
			Total				
Skilled Operator	2.0		2.0				
Operator	9.0		9.0				
Foreman	1.0		1.0				
Lab Tech's, etc.	2.0		2.0				
TOTAL-O.J.'s	14.0		14.0				
						Annual Cost $	Annual Unit Cost $/kW-net
Annual Operating Labor Cost						$5,524,319	$10.044
Maintenance Labor Cost						$7,417,788	$13.486
Administrative & Support Labor						$3,235,527	$5.882
Property Taxes and Insurance						$20,666,014	$37.573
TOTAL FIXED OPERATING COSTS						**$36,843,648**	**$66.985**
VARIABLE OPERATING COSTS							
							$/kWh-net
Maintenance Material Cost						**$11,126,682**	**$0.00272**
Consumables	Consumption Initial	Consumption /Day	Unit Cost	Initial Cost			
Water(/1000 gallons)	0	1,954	1.08		**$0**	**$655,769**	**$0.00016**
Chemicals							
MU & WT Chem.(lb)	0	9,459	0.17		$0	$507,895	$0.00012
Lime (ton)	0	104	75.00		$0	$2,423,115	$0.00059
Carbon (Mercury Removal) (lb)	0	2,232	1.05		$0	$727,220	$0.00018
MEA Solvent (ton)	0	0	2,249.89		$0	$0	$0.00000
NaOH (tons)	0	0	433.68		$0	$0	$0.00000
H2SO4 (tons)	0	0	138.78		$0	$0	$0.00000
Corrosion Inhibitor	0	0	0.00		$0	$0	$0.00000
Activated Carbon(lb)	0	0	1.05		$0	$0	$0.00000
Ammonia (19% NH3) ton	0	23	129.80		$0	$909,959	$0.00022
Subtotal Chemicals					**$0**	**$4,568,188**	**$0.00112**
Other							
Supplemental Fuel(MBtu)	0	0	0.00		$0	$0	$0.00000
SCR Catalyst(m3)	w/equip.	0.34	5,775.94		$0	$616,966	$0.00015
Emission Penalties	0	0	0.00		$0	$0	$0.00000
Subtotal Other					**$0**	**$616,966**	**$0.00015**
Waste Disposal							
Flyash (ton)	0	655	16.23		$0	$3,296,184	$0.00080
Bottom Ash(ton)	0	111	16.23		$0	$560,448	$0.00014
Subtotal-Waste Disposal					**$0**	**$3,856,632**	**$0.00094**
By-products & Emissions							
Gypsum (tons)	0	0	0.00		$0	$0	$0.00000
Subtotal By-Products					**$0**	**$0**	**$0.00000**
TOTAL VARIABLE OPERATING COSTS					**$0**	**$20,824,238**	**$0.00508**
Fuel(ton)	0	6,799	15.22		**$0**	**$32,105,871**	**$0.00784**

Exhibit 4-31 Case L12A Total Plant Cost Summary

Client:	USDOE/NETL	Report Date: 2009-Oct-19
Project:	Low Rank (Western) Coal Baseline Study	
	TOTAL PLANT COST SUMMARY	
Case:	Case L12A - 1x550 MWnet SuperCritical PC	
Plant Size:	550.1 MW,net Estimate Type: Conceptual	Cost Base (Jun) 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING	$20,203	$6,164	$13,439	$0	$0	**$39,807**	$3,584	$0	$6,509	**$49,900**	$91
2	COAL & SORBENT PREP & FEED	$10,297	$827	$2,874	$0	$0	**$13,998**	$1,231	$0	$2,284	**$17,514**	$32
3	FEEDWATER & MISC. BOP SYSTEMS	$40,266	$0	$19,601	$0	$0	**$59,867**	$5,465	$0	$10,401	**$75,733**	$138
4	PC BOILER											
4.1	PC Boiler & Accessories	$224,872	$0	$101,809	$0	$0	**$326,681**	$31,743	$0	$35,842	**$394,267**	$717
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.3	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.4-4.9	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 4	**$224,872**	**$0**	**$101,809**	**$0**	**$0**	**$326,681**	**$31,743**	**$0**	**$35,842**	**$394,267**	**$717**
5	FLUE GAS CLEANUP	$105,938	$0	$37,556	$0	$0	**$143,493**	$13,739	$0	$15,723	**$172,956**	$314
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
6.2-6.9	Combustion Turbine Other	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 6	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
7.2-7.9	HRSG Accessories, Ductwork and Stack	$20,874	$1,200	$14,175	$0	$0	**$36,249**	$3,328	$0	$5,168	**$44,745**	$81
	SUBTOTAL 7	**$20,874**	**$1,200**	**$14,175**	**$0**	**$0**	**$36,249**	**$3,328**	**$0**	**$5,168**	**$44,745**	**$81**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$51,845	$0	$6,898	$0	$0	**$58,742**	$5,630	$0	$6,437	**$70,809**	$129
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$58,720	$1,095	$20,674	$0	$0	**$80,489**	$7,599	$0	$15,415	**$103,503**	$188
	SUBTOTAL 8	**$110,565**	**$1,095**	**$27,572**	**$0**	**$0**	**$139,232**	**$13,229**	**$0**	**$21,852**	**$174,313**	**$317**
9	COOLING WATER SYSTEM	$7,741	$4,210	$7,520	$0	$0	**$19,471**	$1,833	$0	$2,922	**$24,227**	$44
10	ASH/SPENT SORBENT HANDLING SYS	$7,142	$227	$9,549	$0	$0	**$16,919**	$1,627	$0	$1,909	**$20,454**	$37
11	ACCESSORY ELECTRIC PLANT	$18,063	$6,512	$18,990	$0	$0	**$43,565**	$3,843	$0	$5,869	**$53,277**	$97
12	INSTRUMENTATION & CONTROL	$8,700	$0	$8,822	$0	$0	**$17,523**	$1,589	$0	$2,347	**$21,459**	$39
13	IMPROVEMENTS TO SITE	$2,980	$1,713	$6,005	$0	$0	**$10,697**	$1,055	$0	$2,351	**$14,103**	$26
14	BUILDINGS & STRUCTURES	$0	$24,413	$23,039	$0	$0	**$47,453**	$4,280	$0	$7,760	**$59,492**	$108
	TOTAL COST	**$577,642**	**$46,362**	**$290,951**	**$0**	**$0**	**$914,955**	**$86,546**	**$0**	**$120,937**	**$1,122,438**	**$2,041**

Exhibit 4-32 Case L12A Total Plant Cost Details

Client:	USDOE/NETL					Report Date:	2009-Oct-19	
Project:	Low Rank (Western) Coal Baseline Study							
	TOTAL PLANT COST SUMMARY							
Case:	Case L12A - 1x550 MWnet SuperCritical PC							
Plant Size:	550.1	MW,net	Estimate Type:	Conceptual		Cost Base (Jun)	2007	($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING											
1.1	Coal Receive & Unload	$4,927	$0	$2,250	$0	$0	$7,178	$641	$0	$1,173	$8,992	$16
1.2	Coal Stackout & Reclaim	$6,368	$0	$1,443	$0	$0	$7,810	$683	$0	$1,274	$9,768	$18
1.3	Coal Conveyors	$5,920	$0	$1,428	$0	$0	$7,348	$644	$0	$1,199	$9,190	$17
1.4	Other Coal Handling	$1,549	$0	$330	$0	$0	$1,879	$164	$0	$307	$2,350	$4
1.5	Sorbent Receive & Unload	$55	$0	$16	$0	$0	$71	$6	$0	$12	$89	$0
1.6	Sorbent Stackout & Reclaim	$881	$0	$161	$0	$0	$1,042	$91	$0	$170	$1,303	$2
1.7	Sorbent Conveyors	$314	$68	$77	$0	$0	$459	$40	$0	$75	$574	$1
1.8	Other Sorbent Handling	$190	$45	$100	$0	$0	$334	$30	$0	$55	$418	$1
1.9	Coal & Sorbent Hnd.Foundations	$0	$6,051	$7,634	$0	$0	$13,685	$1,285	$0	$2,246	$17,216	$31
	SUBTOTAL 1.	**$20,203**	**$6,164**	**$13,439**	**$0**	**$0**	**$39,807**	**$3,584**	**$0**	**$6,509**	**$49,900**	**$91**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$2,892	$0	$564	$0	$0	$3,456	$301	$0	$564	$4,321	$8
2.2	Coal Conveyor to Storage	$7,405	$0	$1,616	$0	$0	$9,021	$789	$0	$1,471	$11,281	$21
2.3	Coal Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.4	Misc.Coal Prep & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.5	Sorbent Prep Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.6	Sorbent Storage & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.7	Sorbent Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.8	Booster Air Supply System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.9	Coal & Sorbent Feed Foundation	$0	$827	$694	$0	$0	$1,521	$141	$0	$249	$1,912	$3
	SUBTOTAL 2.	**$10,297**	**$827**	**$2,874**	**$0**	**$0**	**$13,998**	**$1,231**	**$0**	**$2,284**	**$17,514**	**$32**
3	FEEDWATER & MISC. BOP SYSTEMS											
3.1	FeedwaterSystem	$18,522	$0	$5,983	$0	$0	$24,505	$2,141	$0	$3,997	$30,643	$56
3.2	Water Makeup & Pretreating	$2,763	$0	$889	$0	$0	$3,652	$345	$0	$800	$4,797	$9
3.3	Other Feedwater Subsystems	$5,670	$0	$2,396	$0	$0	$8,067	$723	$0	$1,318	$10,108	$18
3.4	Service Water Systems	$542	$0	$295	$0	$0	$836	$79	$0	$183	$1,098	$2
3.5	Other Boiler Plant Systems	$7,919	$0	$7,818	$0	$0	$15,737	$1,495	$0	$2,585	$19,817	$36
3.6	FO Supply Sys & Nat Gas	$256	$0	$320	$0	$0	$577	$54	$0	$95	$726	$1
3.7	Waste Treatment Equipment	$1,873	$0	$1,068	$0	$0	$2,941	$286	$0	$645	$3,873	$7
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	$2,721	$0	$831	$0	$0	$3,552	$342	$0	$779	$4,672	$8
	SUBTOTAL 3.	**$40,266**	**$0**	**$19,601**	**$0**	**$0**	**$59,867**	**$5,465**	**$0**	**$10,401**	**$75,733**	**$138**

Exhibit 4-32 Case L12A Total Plant Cost Details (Continued)

Client:	USDOE/NETL
Project:	Low Rank (Western) Coal Baseline Study
Report Date:	2009-Oct-19
Case:	Case L12A - 1x550 MWnet SuperCritical PC
Plant Size:	550.1 MW,net
Estimate Type:	Conceptual
Cost Base (Jun)	2007 ($x1000)

TOTAL PLANT COST SUMMARY

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
4	PC BOILER											
4.1	PC Boiler & Accessories	$224,872	$0	$101,809	$0	$0	$326,681	$31,743	$0	$35,842	$394,267	$717
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.3	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.4	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.5	Primary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.6	Secondary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.8	Major Component Rigging	$0	w/4.1	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.9	Boiler Foundations	$0	w/14.1	w/14.1	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 4.	**$224,872**	**$0**	**$101,809**	**$0**	**$0**	**$326,681**	**$31,743**	**$0**	**$35,842**	**$394,267**	**$717**
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$84,626	$0	$23,053	$0	$0	$107,679	$10,285	$0	$11,796	$129,760	$236
5.2	Other FGD	$1,093	$0	$708	$0	$0	$1,801	$174	$0	$197	$2,172	$4
5.3	Bag House & Accessories	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.4	Other Particulate Removal Materials	$20,219	$0	$13,795	$0	$0	$34,014	$3,281	$0	$3,729	$41,024	$75
5.5	Gypsum Dewatering System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.6	Mercury Removal System	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.9	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 5.	**$105,938**	**$0**	**$37,556**	**$0**	**$0**	**$143,493**	**$13,739**	**$0**	**$15,723**	**$172,956**	**$314**
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
6.2	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.3	Compressed Air Piping	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.9	Combustion Turbine Foundations	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
7.2	HRSG Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7.3	Ductwork	$10,410	$0	$6,688	$0	$0	$17,098	$1,491	$0	$2,788	$21,377	$39
7.4	Stack	$10,464	$0	$6,123	$0	$0	$16,588	$1,597	$0	$1,818	$20,003	$36
7.9	Duct & Stack Foundations	$0	$1,200	$1,364	$0	$0	$2,564	$240	$0	$561	$3,365	$6
	SUBTOTAL 7.	**$20,874**	**$1,200**	**$14,175**	**$0**	**$0**	**$36,249**	**$3,328**	**$0**	**$5,168**	**$44,745**	**$81**

Exhibit 4-32 Case L12A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 2009-Oct-19
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case L12A - 1x550 MWnet SuperCritical PC
Plant Size: 550.1 MW,net **Estimate Type:** Conceptual **Cost Base (Jun)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$51,845	$0	$6,898	$0	$0	$58,742	$5,630	$0	$6,437	$70,809	$129
8.2	Turbine Plant Auxiliaries	$349	$0	$748	$0	$0	$1,097	$107	$0	$120	$1,324	$2
8.3a	Condenser & Auxiliaries	$4,059	$0	$2,301	$0	$0	$6,360	$612	$0	$697	$7,669	$14
8.3b	Air Cooled Condenser	$37,199	$0	$7,457	$0	$0	$44,656	$4,466	$0	$9,824	$58,946	$107
8.4	Steam Piping	$17,113	$0	$8,438	$0	$0	$25,552	$2,147	$0	$4,155	$31,853	$58
8.9	TG Foundations	$0	$1,095	$1,730	$0	$0	$2,825	$267	$0	$619	$3,711	$7
	SUBTOTAL 8.	**$110,565**	**$1,095**	**$27,572**	**$0**	**$0**	**$139,232**	**$13,229**	**$0**	**$21,852**	**$174,313**	**$317**
9	COOLING WATER SYSTEM											
9.1	Cooling Towers	$5,670	$0	$1,766	$0	$0	$7,436	$711	$0	$815	$8,961	$16
9.2	Circulating Water Pumps	$1,181	$0	$59	$0	$0	$1,240	$104	$0	$134	$1,479	$3
9.3	Circ.Water System Auxiliaries	$333	$0	$44	$0	$0	$378	$36	$0	$41	$455	$1
9.4	Circ.Water Piping	$0	$2,644	$2,562	$0	$0	$5,206	$487	$0	$854	$6,547	$12
9.5	Make-up Water System	$292	$0	$391	$0	$0	$683	$65	$0	$112	$861	$2
9.6	Component Cooling Water Sys	$264	$0	$210	$0	$0	$474	$45	$0	$78	$597	$1
9.9	Circ.Water System Foundations& Structures	$0	$1,566	$2,488	$0	$0	$4,055	$384	$0	$888	$5,326	$10
	SUBTOTAL 9.	**$7,741**	**$4,210**	**$7,520**	**$0**	**$0**	**$19,471**	**$1,833**	**$0**	**$2,922**	**$24,227**	**$44**
10	ASH/SPENT SORBENT HANDLING SYS											
10.1	Ash Coolers	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.2	Cyclone Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.3	HGCU Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.4	High Temperature Ash Piping	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.5	Other Ash Recovery Equipment	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.6	Ash Storage Silos	$956	$0	$2,945	$0	$0	$3,900	$383	$0	$428	$4,712	$9
10.7	Ash Transport & Feed Equipment	$6,187	$0	$6,337	$0	$0	$12,524	$1,197	$0	$1,372	$15,093	$27
10.8	Misc. Ash Handling Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.9	Ash/Spent Sorbent Foundation	$0	$227	$267	$0	$0	$495	$46	$0	$108	$649	$1
	SUBTOTAL 10.	**$7,142**	**$227**	**$9,549**	**$0**	**$0**	**$16,919**	**$1,627**	**$0**	**$1,909**	**$20,454**	**$37**

Exhibit 4-32 Case L12A Total Plant Cost Details (Continued)

Client:	USDOE/NETL				Report Date:	2009-Oct-19
Project:	Low Rank (Western) Coal Baseline Study					
	TOTAL PLANT COST SUMMARY					
Case:	Case L12A - 1x550 MWnet SuperCritical PC					
Plant Size:	550.1 MW,net	Estimate Type:	Conceptual	Cost Base (Jun)	2007	($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT											
11.1	Generator Equipment	$1,605	$0	$261	$0	$0	$1,866	$173	$0	$153	$2,192	$4
11.2	Station Service Equipment	$2,979	$0	$979	$0	$0	$3,958	$370	$0	$325	$4,653	$8
11.3	Switchgear & Motor Control	$3,425	$0	$582	$0	$0	$4,007	$371	$0	$438	$4,817	$9
11.4	Conduit & Cable Tray	$0	$2,147	$7,425	$0	$0	$9,572	$927	$0	$1,575	$12,074	$22
11.5	Wire & Cable	$0	$4,052	$7,822	$0	$0	$11,874	$1,000	$0	$1,931	$14,805	$27
11.6	Protective Equipment	$280	$0	$952	$0	$0	$1,232	$120	$0	$135	$1,488	$3
11.7	Standby Equipment	$1,281	$0	$29	$0	$0	$1,311	$120	$0	$143	$1,574	$3
11.8	Main Power Transformers	$8,493	$0	$173	$0	$0	$8,665	$658	$0	$932	$10,255	$19
11.9	Electrical Foundations	$0	$313	$767	$0	$0	$1,080	$103	$0	$237	$1,420	$3
	SUBTOTAL 11.	**$18,063**	**$6,512**	**$18,990**	**$0**	**$0**	**$43,565**	**$3,843**	**$0**	**$5,869**	**$53,277**	**$97**
12	INSTRUMENTATION & CONTROL											
12.1	PC Control Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.2	Combustion Turbine Control	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
12.3	Steam Turbine Control	w/8.1	$0	w/8.1	$0	$0	$0	$0	$0	$0	$0	$0
12.4	Other Major Component Control	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.5	Signal Processing Equipment	W/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.6	Control Boards,Panels & Racks	$448	$0	$268	$0	$0	$716	$68	$0	$118	$902	$2
12.7	Distributed Control System Equipment	$4,523	$0	$790	$0	$0	$5,313	$493	$0	$581	$6,386	$12
12.8	Instrument Wiring & Tubing	$2,452	$0	$4,863	$0	$0	$7,315	$623	$0	$1,191	$9,129	$17
12.9	Other I & C Equipment	$1,278	$0	$2,900	$0	$0	$4,178	$405	$0	$458	$5,041	$9
	SUBTOTAL 12.	**$8,700**	**$0**	**$8,822**	**$0**	**$0**	**$17,523**	**$1,589**	**$0**	**$2,347**	**$21,459**	**$39**
13	IMPROVEMENTS TO SITE											
13.1	Site Preparation	$0	$50	$1,002	$0	$0	$1,052	$104	$0	$231	$1,387	$3
13.2	Site Improvements	$0	$1,663	$2,065	$0	$0	$3,728	$368	$0	$819	$4,914	$9
13.3	Site Facilities	$2,980	$0	$2,938	$0	$0	$5,918	$583	$0	$1,300	$7,801	$14
	SUBTOTAL 13.	**$2,980**	**$1,713**	**$6,005**	**$0**	**$0**	**$10,697**	**$1,055**	**$0**	**$2,351**	**$14,103**	**$26**
14	BUILDINGS & STRUCTURES											
14.1	Boiler Building	$0	$10,137	$8,915	$0	$0	$19,052	$1,712	$0	$3,115	$23,879	$43
14.2	Turbine Building	$0	$11,875	$11,068	$0	$0	$22,943	$2,068	$0	$3,752	$28,763	$52
14.3	Administration Building	$0	$588	$622	$0	$0	$1,209	$110	$0	$198	$1,517	$3
14.4	Circulation Water Pumphouse	$0	$168	$134	$0	$0	$302	$27	$0	$49	$379	$1
14.5	Water Treatment Buildings	$0	$350	$320	$0	$0	$670	$60	$0	$110	$840	$2
14.6	Machine Shop	$0	$393	$264	$0	$0	$657	$58	$0	$107	$823	$1
14.7	Warehouse	$0	$266	$267	$0	$0	$534	$48	$0	$87	$669	$1
14.8	Other Buildings & Structures	$0	$218	$185	$0	$0	$403	$36	$0	$66	$505	$1
14.9	Waste Treating Building & Str.	$0	$417	$1,265	$0	$0	$1,682	$160	$0	$276	$2,118	$4
	SUBTOTAL 14.	**$0**	**$24,413**	**$23,039**	**$0**	**$0**	**$47,453**	**$4,280**	**$0**	**$7,760**	**$59,492**	**$108**
	TOTAL COST	**$577,642**	**$46,362**	**$290,951**	**$0**	**$0**	**$914,955**	**$86,546**	**$0**	**$120,937**	**$1,122,438**	**$2,041**

Exhibit 4-33 Case L12A Owner's Costs

Owner's Costs	$x1000	$/kW
Preproduction Costs		
6 Months Fixed O&M	$8,612	$16
1 Month Variable O&M	$2,430	$4
25% of 1 Months Fuel Cost at 100% CF	$753	$1
2% of TPC	$22,449	$41
Total	**$34,243**	**$62**
Inventory Capital		
60 day supply of fuel and consumables at 100% CF	$7,234	$13
0.5% of TPC (spare parts)	$5,612	$10
Total	**$12,847**	**$23**
Initial Cost for Catalyst and Chemicals	**$0**	**$0**
Land	**$900**	**$2**
Other Owner's Costs	**$168,366**	**$306**
Financing Costs	**$30,306**	**$55**
Total Owner's Costs	**$246,661**	**$448**
Total Overnight Cost (TOC)	**$1,369,100**	**$2,489**
TASC Multiplier	1.134	
Total As-Spent Cost (TASC)	**$1,552,559**	**$2,823**

Exhibit 4-34 Case L12A Initial and Annual O&M Costs

INITIAL & ANNUAL O&M EXPENSES					Cost Base (Jun)	2007
Case L12A - 1x550 MWnet SuperCritical PC					Heat Rate-net(Btu/kWh):	9,093
					MWe-net:	550
					Capacity Factor: (%):	85
OPERATING & MAINTENANCE LABOR						
Operating Labor						
Operating Labor Rate(base):	34.65	$/hour				
Operating Labor Burden:	30.00	% of base				
Labor O-H Charge Rate:	25.00	% of labor				
			Total			
Skilled Operator	2.0		2.0			
Operator	9.0		9.0			
Foreman	1.0		1.0			
Lab Tech's, etc.	2.0		2.0			
TOTAL-O.J.'s	14.0		14.0			
					Annual Cost $	Annual Unit Cost $/kW-net
Annual Operating Labor Cost					$5,524,319	$10.043
Maintenance Labor Cost					$8,254,296	$15.006
Administrative & Support Labor					$3,444,654	$6.262
Property Taxes and Insurance					$22,448,766	$40.812
TOTAL FIXED OPERATING COSTS					**$39,672,035**	**$72.124**
VARIABLE OPERATING COSTS						
						$/kWh-net
Maintenance Material Cost					**$12,381,445**	**$0.00302**
Consumables	Consumption Initial	Consumption /Day	Unit Cost	Initial Cost		
Water(/1000 gallons)	0	1,979	1.08	**$0**	**$663,985**	**$0.00016**
Chemicals						
MU & WT Chem.(lb)	0	9,577	0.17	$0	$514,258	$0.00013
Lime (ton)	0	119	75.00	$0	$2,763,490	$0.00067
Carbon (Mercury Removal) (lb)	0	3,456	1.05	$0	$1,126,018	$0.00027
MEA Solvent (ton)	0	0	2,249.89	$0	$0	$0.00000
NaOH (tons)	0	0	433.68	$0	$0	$0.00000
H2SO4 (tons)	0	0	138.78	$0	$0	$0.00000
Corrosion Inhibitor	0	0	0.00	$0	$0	$0.00000
Activated Carbon(lb)	0	0	1.05	$0	$0	$0.00000
Ammonia (19% NH3) ton	0	23	129.80	$0	$938,470	$0.00023
Subtotal Chemicals				**$0**	**$5,342,236**	**$0.00130**
Other						
Supplemental Fuel(MBtu)	0	0	0.00	$0	$0	$0.00000
SCR Catalyst(m3)	w/equip.	0.38	5,775.94	$0	$674,244	$0.00016
Emission Penalties	0	0	0.00	$0	$0	$0.00000
Subtotal Other				**$0**	**$674,244**	**$0.00016**
Waste Disposal						
Flyash (ton)	0	957	16.23	$0	$4,819,205	$0.00118
Bottom Ash(ton)	0	179	16.23	$0	$901,502	$0.00022
Subtotal-Waste Disposal				**$0**	**$5,720,706**	**$0.00140**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	$0.00000
Subtotal By-Products				**$0**	**$0**	**$0.00000**
TOTAL VARIABLE OPERATING COSTS				**$0**	**$24,782,616**	**$0.00605**
Fuel(ton)	0	9,078	10.92	**$0**	**$30,757,131**	**$0.00751**

Exhibit 4-35 Case S13A Total Plant Cost Summary

Client:	USDOE/NETL	Report Date:	2009-Oct-19
Project:	Low Rank (Western) Coal Baseline Study		

TOTAL PLANT COST SUMMARY

Case:	Case S13A - 1x550 MWnet USC PC				
Plant Size:	550.1 MW,net	Estimate Type:	Conceptual	Cost Base (June) 2007	($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING	$16,671	$5,062	$11,046	$0	$0	**$32,779**	$2,951	$0	$5,360	**$41,090**	$75
2	COAL & SORBENT PREP & FEED	$8,336	$670	$2,327	$0	$0	**$11,332**	$996	$0	$1,849	**$14,178**	$26
3	FEEDWATER & MISC. BOP SYSTEMS	$42,307	$0	$20,070	$0	$0	**$62,377**	$5,679	$0	$10,799	**$78,855**	$143
4	PC BOILER											
4.1	PC Boiler & Accessories	$200,535	$0	$98,233	$0	$0	**$298,768**	$29,047	$14,938	$34,275	**$377,029**	$685
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.3	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.4-4.9	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 4	**$200,535**	**$0**	**$98,233**	**$0**	**$0**	**$298,768**	**$29,047**	**$14,938**	**$34,275**	**$377,029**	**$685**
5	FLUE GAS CLEANUP	$97,938	$0	$34,720	$0	$0	**$132,658**	$12,702	$0	$14,536	**$159,896**	$291
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
6.2-6.9	Combustion Turbine Other	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 6	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
7.2-7.9	HRSG Accessories, Ductwork and Stack	$20,284	$1,166	$13,774	$0	$0	**$35,224**	$3,234	$0	$5,021	**$43,479**	$79
	SUBTOTAL 7	**$20,284**	**$1,166**	**$13,774**	**$0**	**$0**	**$35,224**	**$3,234**	**$0**	**$5,021**	**$43,479**	**$79**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$52,622	$0	$6,835	$0	$0	**$59,457**	$5,698	$2,973	$6,813	**$74,940**	$136
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$62,415	$1,091	$22,787	$0	$0	**$86,293**	$8,068	$0	$16,302	**$110,663**	$201
	SUBTOTAL 8	**$115,037**	**$1,091**	**$29,622**	**$0**	**$0**	**$145,750**	**$13,766**	**$2,973**	**$23,115**	**$185,603**	**$337**
9	COOLING WATER SYSTEM	$7,568	$4,130	$7,364	$0	$0	**$19,062**	$1,794	$0	$2,862	**$23,718**	$43
10	ASH/SPENT SORBENT HANDLING SYS	$5,638	$179	$7,539	$0	$0	**$13,356**	$1,284	$0	$1,507	**$16,147**	$29
11	ACCESSORY ELECTRIC PLANT	$18,541	$6,271	$18,280	$0	$0	**$43,092**	$3,788	$0	$5,774	**$52,654**	$96
12	INSTRUMENTATION & CONTROL	$8,765	$0	$8,888	$0	$0	**$17,654**	$1,601	$0	$2,365	**$21,619**	$39
13	IMPROVEMENTS TO SITE	$2,972	$1,708	$5,989	$0	$0	**$10,669**	$1,053	$0	$2,344	**$14,067**	$26
14	BUILDINGS & STRUCTURES	$0	$23,099	$21,871	$0	$0	**$44,970**	$4,057	$0	$7,354	**$56,381**	$103
	TOTAL COST	**$544,592**	**$43,377**	**$279,722**	**$0**	**$0**	**$867,692**	**$81,951**	**$17,911**	**$117,162**	**$1,084,716**	**$1,972**

Exhibit 4-36 Case S13A Total Plant Cost Details

Client: USDOE/NETL **Report Date:** 2009-Oct-19
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case S13A - 1x550 MWnet USC PC
Plant Size: 550.1 MW,net **Estimate Type:** Conceptual **Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING											
1.1	Coal Receive & Unload	$4,040	$0	$1,845	$0	$0	$5,885	$526	$0	$962	$7,373	$13
1.2	Coal Stackout & Reclaim	$5,221	$0	$1,183	$0	$0	$6,404	$560	$0	$1,045	$8,009	$15
1.3	Coal Conveyors	$4,854	$0	$1,171	$0	$0	$6,025	$528	$0	$983	$7,536	$14
1.4	Other Coal Handling	$1,270	$0	$271	$0	$0	$1,541	$135	$0	$251	$1,927	$4
1.5	Sorbent Receive & Unload	$49	$0	$15	$0	$0	$63	$6	$0	$10	$79	$0
1.6	Sorbent Stackout & Reclaim	$786	$0	$144	$0	$0	$931	$81	$0	$152	$1,163	$2
1.7	Sorbent Conveyors	$281	$61	$69	$0	$0	$410	$35	$0	$67	$512	$1
1.8	Other Sorbent Handling	$169	$40	$89	$0	$0	$298	$26	$0	$49	$373	$1
1.9	Coal & Sorbent Hnd.Foundations	$0	$4,962	$6,260	$0	$0	$11,221	$1,054	$0	$1,841	$14,117	$26
	SUBTOTAL 1.	**$16,671**	**$5,062**	**$11,046**	**$0**	**$0**	**$32,779**	**$2,951**	**$0**	**$5,360**	**$41,090**	**$75**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$2,341	$0	$456	$0	$0	$2,798	$244	$0	$456	$3,498	$6
2.2	Coal Conveyor to Storage	$5,995	$0	$1,308	$0	$0	$7,303	$638	$0	$1,191	$9,133	$17
2.3	Coal Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.4	Misc.Coal Prep & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.5	Sorbent Prep Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.6	Sorbent Storage & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.7	Sorbent Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.8	Booster Air Supply System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.9	Coal & Sorbent Feed Foundation	$0	$670	$562	$0	$0	$1,232	$114	$0	$202	$1,548	$3
	SUBTOTAL 2.	**$8,336**	**$670**	**$2,327**	**$0**	**$0**	**$11,332**	**$996**	**$0**	**$1,849**	**$14,178**	**$26**
3	FEEDWATER & MISC. BOP SYSTEMS											
3.1	FeedwaterSystem	$20,466	$0	$6,611	$0	$0	$27,077	$2,366	$0	$4,416	$33,860	$62
3.2	Water Makeup & Pretreating	$2,690	$0	$866	$0	$0	$3,556	$336	$0	$779	$4,671	$8
3.3	Other Feedwater Subsystems	$6,266	$0	$2,648	$0	$0	$8,914	$798	$0	$1,457	$11,169	$20
3.4	Service Water Systems	$527	$0	$287	$0	$0	$814	$77	$0	$178	$1,069	$2
3.5	Other Boiler Plant Systems	$7,566	$0	$7,470	$0	$0	$15,037	$1,428	$0	$2,470	$18,935	$34
3.6	FO Supply Sys & Nat Gas	$255	$0	$319	$0	$0	$575	$54	$0	$94	$723	$1
3.7	Waste Treatment Equipment	$1,824	$0	$1,040	$0	$0	$2,864	$279	$0	$628	$3,771	$7
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	$2,712	$0	$828	$0	$0	$3,540	$340	$0	$776	$4,657	$8
	SUBTOTAL 3.	**$42,307**	**$0**	**$20,070**	**$0**	**$0**	**$62,377**	**$5,679**	**$0**	**$10,799**	**$78,855**	**$143**
4	PC BOILER											
4.1	PC Boiler & Accessories	$200,535	$0	$98,233	$0	$0	$298,768	$29,047	$14,938	$34,275	$377,029	$685
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.3	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.4	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.5	Primary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.6	Secondary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.8	Major Component Rigging	$0	w/4.1	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.9	Boiler Foundations	$0	w/14.1	w/14.1	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 4.	**$200,535**	**$0**	**$98,233**	**$0**	**$0**	**$298,768**	**$29,047**	**$14,938**	**$34,275**	**$377,029**	**$685**

Exhibit 4-36 Case S13A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 2009-Oct-19
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case S13A - 1x550 MWnet USC PC
Plant Size: 550.1 MW,net **Estimate Type:** Conceptual **Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$78,236	$0	$21,312	$0	$0	$99,548	$9,509	$0	$10,906	$119,962	$218
5.2	Other FGD	$1,010	$0	$655	$0	$0	$1,665	$160	$0	$183	$2,008	$4
5.3	Bag House & Accessories	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.4	Other Particulate Removal Materials	$18,692	$0	$12,753	$0	$0	$31,445	$3,033	$0	$3,448	$37,926	$69
5.5	Gypsum Dewatering System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.6	Mercury Removal System	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.9	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 5.	**$97,938**	**$0**	**$34,720**	**$0**	**$0**	**$132,658**	**$12,702**	**$0**	**$14,536**	**$159,896**	**$291**
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
6.2	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.3	Compressed Air Piping	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.9	Combustion Turbine Foundations	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
7.2	HRSG Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7.3	Ductwork	$10,115	$0	$6,499	$0	$0	$16,614	$1,449	$0	$2,709	$20,772	$38
7.4	Stack	$10,168	$0	$5,950	$0	$0	$16,118	$1,552	$0	$1,767	$19,437	$35
7.9	Duct & Stack Foundations	$0	$1,166	$1,325	$0	$0	$2,492	$233	$0	$545	$3,270	$6
	SUBTOTAL 7.	**$20,284**	**$1,166**	**$13,774**	**$0**	**$0**	**$35,224**	**$3,234**	**$0**	**$5,021**	**$43,479**	**$79**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$52,622	$0	$6,835	$0	$0	$59,457	$5,698	$2,973	$6,813	$74,940	$136
8.2	Turbine Plant Auxiliaries	$348	$0	$745	$0	$0	$1,092	$107	$0	$120	$1,319	$2
8.3a	Condenser & Auxiliaries	$3,961	$0	$2,291	$0	$0	$6,253	$602	$0	$685	$7,540	$14
8.3b	Air Cooled Condenser	$36,304	$0	$7,278	$0	$0	$43,582	$4,358	$0	$9,588	$57,528	$105
8.4	Steam Piping	$21,802	$0	$10,750	$0	$0	$32,552	$2,735	$0	$5,293	$40,580	$74
8.9	TG Foundations	$0	$1,091	$1,723	$0	$0	$2,814	$266	$0	$616	$3,696	$7
	SUBTOTAL 8.	**$115,037**	**$1,091**	**$29,622**	**$0**	**$0**	**$145,750**	**$13,766**	**$2,973**	**$23,115**	**$185,603**	**$337**
9	COOLING WATER SYSTEM											
9.1	Cooling Towers	$5,545	$0	$1,727	$0	$0	$7,272	$695	$0	$797	$8,764	$16
9.2	Circulating Water Pumps	$1,155	$0	$57	$0	$0	$1,213	$102	$0	$131	$1,446	$3
9.3	Circ.Water System Auxiliaries	$327	$0	$44	$0	$0	$371	$35	$0	$41	$447	$1
9.4	Circ.Water Piping	$0	$2,594	$2,514	$0	$0	$5,107	$478	$0	$838	$6,423	$12
9.5	Make-up Water System	$281	$0	$375	$0	$0	$656	$63	$0	$108	$826	$2
9.6	Component Cooling Water Sys	$259	$0	$206	$0	$0	$465	$44	$0	$76	$586	$1
9.9	Circ.Water System Foundations& Structures	$0	$1,537	$2,441	$0	$0	$3,978	$376	$0	$871	$5,225	$9
	SUBTOTAL 9.	**$7,568**	**$4,130**	**$7,364**	**$0**	**$0**	**$19,062**	**$1,794**	**$0**	**$2,862**	**$23,718**	**$43**

Exhibit 4-36 Case S13A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 2009-Oct-19
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case S13A - 1x550 MWnet USC PC
Plant Size: 550.1 MW,net **Estimate Type:** Conceptual **Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
10	ASH/SPENT SORBENT HANDLING SYS											
10.1	Ash Coolers	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.2	Cyclone Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.3	HGCU Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.4	High Temperature Ash Piping	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.5	Other Ash Recovery Equipment	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.6	Ash Storage Silos	$754	$0	$2,325	$0	$0	$3,079	$302	$0	$338	$3,719	$7
10.7	Ash Transport & Feed Equipment	$4,884	$0	$5,003	$0	$0	$9,887	$945	$0	$1,083	$11,915	$22
10.8	Misc. Ash Handling Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.9	Ash/Spent Sorbent Foundation	$0	$179	$211	$0	$0	$390	$37	$0	$85	$512	$1
	SUBTOTAL 10.	**$5,638**	**$179**	**$7,539**	**$0**	**$0**	**$13,356**	**$1,284**	**$0**	**$1,507**	**$16,147**	**$29**
11	ACCESSORY ELECTRIC PLANT											
11.1	Generator Equipment	$1,600	$0	$260	$0	$0	$1,860	$172	$0	$152	$2,185	$4
11.2	Station Service Equipment	$2,864	$0	$941	$0	$0	$3,805	$356	$0	$312	$4,472	$8
11.3	Switchgear & Motor Control	$3,292	$0	$560	$0	$0	$3,852	$357	$0	$421	$4,630	$8
11.4	Conduit & Cable Tray	$0	$2,064	$7,137	$0	$0	$9,202	$891	$0	$1,514	$11,606	$21
11.5	Wire & Cable	$0	$3,895	$7,519	$0	$0	$11,414	$962	$0	$1,856	$14,232	$26
11.6	Protective Equipment	$264	$0	$898	$0	$0	$1,162	$113	$0	$128	$1,403	$3
11.7	Standby Equipment	$1,278	$0	$29	$0	$0	$1,307	$120	$0	$143	$1,570	$3
11.8	Main Power Transformers	$9,243	$0	$172	$0	$0	$9,415	$714	$0	$1,013	$11,142	$20
11.9	Electrical Foundations	$0	$312	$764	$0	$0	$1,076	$103	$0	$236	$1,414	$3
	SUBTOTAL 11.	**$18,541**	**$6,271**	**$18,280**	**$0**	**$0**	**$43,092**	**$3,788**	**$0**	**$5,774**	**$52,654**	**$96**
12	INSTRUMENTATION & CONTROL											
12.1	PC Control Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.2	Combustion Turbine Control	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
12.3	Steam Turbine Control	w/8.1	$0	w/8.1	$0	$0	$0	$0	$0	$0	$0	$0
12.4	Other Major Component Control	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.5	Signal Processing Equipment	W/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.6	Control Boards,Panels & Racks	$451	$0	$270	$0	$0	$722	$68	$0	$118	$908	$2
12.7	Distributed Control System Equipment	$4,556	$0	$796	$0	$0	$5,353	$496	$0	$585	$6,434	$12
12.8	Instrument Wiring & Tubing	$2,470	$0	$4,900	$0	$0	$7,370	$628	$0	$1,200	$9,198	$17
12.9	Other I & C Equipment	$1,288	$0	$2,922	$0	$0	$4,209	$408	$0	$462	$5,079	$9
	SUBTOTAL 12.	**$8,765**	**$0**	**$8,888**	**$0**	**$0**	**$17,654**	**$1,601**	**$0**	**$2,365**	**$21,619**	**$39**

Exhibit 4-36 Case S13A Total Plant Cost Details (Continued)

	Client:	USDOE/NETL							**Report Date:**	2009-Oct-19		
	Project:	Low Rank (Western) Coal Baseline Study										
		TOTAL PLANT COST SUMMARY										
	Case:	Case S13A - 1x550 MWnet USC PC										
	Plant Size:	550.1 MW,net		**Estimate Type:**		Conceptual			**Cost Base (June)**	2007	($x1000)	

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
13	IMPROVEMENTS TO SITE											
13.1	Site Preparation	$0	$50	$999	$0	$0	$1,049	$104	$0	$231	$1,384	$3
13.2	Site Improvements	$0	$1,658	$2,060	$0	$0	$3,718	$367	$0	$817	$4,902	$9
13.3	Site Facilities	$2,972	$0	$2,931	$0	$0	$5,903	$582	$0	$1,297	$7,781	$14
	SUBTOTAL 13.	**$2,972**	**$1,708**	**$5,989**	**$0**	**$0**	**$10,669**	**$1,053**	**$0**	**$2,344**	**$14,067**	**$26**
14	BUILDINGS & STRUCTURES											
14.1	Boiler Building	$0	$9,031	$7,942	$0	$0	$16,974	$1,526	$0	$2,775	$21,274	$39
14.2	Turbine Building	$0	$11,680	$10,886	$0	$0	$22,566	$2,034	$0	$3,690	$28,289	$51
14.3	Administration Building	$0	$587	$620	$0	$0	$1,207	$109	$0	$198	$1,514	$3
14.4	Circulation Water Pumphouse	$0	$168	$134	$0	$0	$302	$27	$0	$49	$378	$1
14.5	Water Treatment Buildings	$0	$341	$311	$0	$0	$652	$59	$0	$107	$818	$1
14.6	Machine Shop	$0	$392	$264	$0	$0	$656	$58	$0	$107	$821	$1
14.7	Warehouse	$0	$266	$267	$0	$0	$533	$48	$0	$87	$668	$1
14.8	Other Buildings & Structures	$0	$217	$185	$0	$0	$402	$36	$0	$66	$504	$1
14.9	Waste Treating Building & Str.	$0	$416	$1,263	$0	$0	$1,679	$159	$0	$276	$2,114	$4
	SUBTOTAL 14.	**$0**	**$23,099**	**$21,871**	**$0**	**$0**	**$44,970**	**$4,057**	**$0**	**$7,354**	**$56,381**	**$103**
	TOTAL COST	**$544,592**	**$43,377**	**$279,722**	**$0**	**$0**	**$867,692**	**$81,951**	**$17,911**	**$117,162**	**$1,084,716**	**$1,972**

Exhibit 4-37 Case S13A Owner's Costs

Owner's Costs	$x1000	$/kW
Preproduction Costs		
6 Months Fixed O&M	$8,258	$15
1 Month Variable O&M	$2,050	$4
25% of 1 Months Fuel Cost at 100% CF	$763	$1
2% of TPC	$21,694	$39
Total	**$32,765**	**$60**
Inventory Capital		
60 day supply of fuel and consumables at 100% CF	$7,109	$13
0.5% of TPC (spare parts)	$5,424	$10
Total	**$12,533**	**$23**
Initial Cost for Catalyst and Chemicals	**$0**	**$0**
Land	**$900**	**$2**
Other Owner's Costs	**$162,707**	**$296**
Financing Costs	**$29,287**	**$53**
Total Owner's Costs	**$238,193**	**$433**
Total Overnight Cost (TOC)	**$1,322,909**	**$2,405**
TASC Multiplier	1.140	
Total As-Spent Cost (TASC)	**$1,508,117**	**$2,742**

Exhibit 4-38 Case S13A Initial and Annual O&M Costs

INITIAL & ANNUAL O&M EXPENSES						Cost Base (June):	2007
Case S13A - 1x550 MWnet USC PC						Heat Rate-net (Btu/kWh):	8,552
						MWe-net:	550
						Capacity Factor (%):	85
OPERATING & MAINTENANCE LABOR							
Operating Labor							
Operating Labor Rate(base):	34.65	$/hour					
Operating Labor Burden:	30.00	% of base					
Labor O-H Charge Rate:	25.00	% of labor					
			Total				
Skilled Operator	2.0		2.0				
Operator	9.0		9.0				
Foreman	1.0		1.0				
Lab Tech's, etc.	2.0		2.0				
TOTAL-O.J.'s	14.0		14.0				
						Annual Cost $	Annual Unit Cost $/kW-net
Annual Operating Labor Cost						$5,524,319	$10.043
Maintenance Labor Cost						$7,688,764	$13.978
Administrative & Support Labor						$3,303,271	$6.005
Property Taxes and Insurance						$21,694,323	$39.441
TOTAL FIXED OPERATING COSTS						**$38,210,677**	**$69.468**
VARIABLE OPERATING COSTS							
							$/kWh-net
Maintenance Material Cost						**$11,533,147**	**$0.00282**
Consumables	Consumption Initial	 /Day	Unit Cost	Initial Cost			
Water(/1000 gallons)	0	1,906	1.08	**$0**		**$639,581**	**$0.00016**
Chemicals							
MU & WT Chem.(lb)	0	9,225	0.17	$0		$495,357	$0.00012
Lime (ton)	0	99	75.00	$0		$2,314,496	$0.00057
Carbon (Mercury Removal) (lb)	0	2,184	1.05	$0		$711,581	$0.00017
MEA Solvent (ton)	0	0	2,249.89	$0		$0	$0.00000
NaOH (tons)	0	0	433.68	$0		$0	$0.00000
H2SO4 (tons)	0	0	138.78	$0		$0	$0.00000
Corrosion Inhibitor	0	0	0.00	$0		$0	$0.00000
Activated Carbon(lb)	0	0	1.05	$0		$0	$0.00000
Ammonia (19% NH3) ton	0	22	129.80	$0		$881,930	$0.00022
Subtotal Chemicals				**$0**		**$4,403,364**	**$0.00108**
Other							
Supplemental Fuel(MBtu)	0	0	0.00	$0		$0	$0.00000
SCR Catalyst(m3)	w/equip.	0.33	5,775.94	$0		$598,965	$0.00015
Emission Penalties	0	0	0.00	$0		$0	$0.00000
Subtotal Other				**$0**		**$598,965**	**$0.00015**
Waste Disposal							
Flyash (ton)	0	634	16.23	$0		$3,192,587	$0.00078
Bottom Ash(ton)	0	108	16.23	$0		$543,656	$0.00013
Subtotal-Waste Disposal				**$0**		**$3,736,243**	**$0.00091**
By-products & Emissions							
Gypsum (tons)	0	0	0.00	$0		$0	$0.00000
Subtotal By-Products				**$0**		**$0**	**$0.00000**
TOTAL VARIABLE OPERATING COSTS				**$0**		**$20,911,298**	**$0.00511**
Fuel(ton)	0	6,591	15.22	**$0**		**$31,124,393**	**$0.00760**

Exhibit 4-39 Case L13A Total Plant Cost Summary

Client:	USDOE/NETL
Project:	Low Rank (Western) Coal Baseline Study
Report Date:	19-Oct-09
Case:	Case L13A - 1x550 MWnet USC PC
Plant Size:	550.0 MW,net
Estimate Type:	Conceptual
Cost Base (June)	2007 ($x1000)

TOTAL PLANT COST SUMMARY

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING	$19,772	$6,034	$13,155	$0	$0	**$38,961**	$3,508	$0	$6,370	**$48,840**	$89
2	COAL & SORBENT PREP & FEED	$10,067	$809	$2,810	$0	$0	**$13,686**	$1,203	$0	$2,233	**$17,122**	$31
3	FEEDWATER & MISC. BOP SYSTEMS	$43,234	$0	$20,968	$0	$0	**$64,202**	$5,852	$0	$11,101	**$81,155**	$148
4	PC BOILER											
4.1	PC Boiler & Accessories	$242,279	$0	$109,690	$0	$0	**$351,969**	$34,201	$17,598	$40,377	**$444,145**	$808
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.3	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.4-4.9	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 4	**$242,279**	**$0**	**$109,690**	**$0**	**$0**	**$351,969**	**$34,201**	**$17,598**	**$40,377**	**$444,145**	**$808**
5	FLUE GAS CLEANUP	$106,208	$0	$37,651	$0	$0	**$143,860**	$13,774	$0	$15,763	**$173,397**	$315
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
6.2-6.9	Combustion Turbine Other	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 6	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
7.2-7.9	HRSG Accessories, Ductwork and Stack	$20,603	$1,185	$13,991	$0	$0	**$35,778**	$3,285	$0	$5,100	**$44,163**	$80
	SUBTOTAL 7	**$20,603**	**$1,185**	**$13,991**	**$0**	**$0**	**$35,778**	**$3,285**	**$0**	**$5,100**	**$44,163**	**$80**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$53,046	$0	$6,890	$0	$0	**$59,936**	$5,744	$2,997	$6,868	**$75,544**	$137
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$62,564	$1,093	$22,869	$0	$0	**$86,525**	$8,088	$0	$16,340	**$110,953**	$202
	SUBTOTAL 8	**$115,610**	**$1,093**	**$29,759**	**$0**	**$0**	**$146,461**	**$13,831**	**$2,997**	**$23,208**	**$186,497**	**$339**
9	COOLING WATER SYSTEM	$7,574	$4,130	$7,373	$0	$0	**$19,077**	$1,796	$0	$2,864	**$23,737**	$43
10	ASH/SPENT SORBENT HANDLING SYS	$7,007	$223	$9,369	$0	$0	**$16,599**	$1,596	$0	$1,873	**$20,067**	$36
11	ACCESSORY ELECTRIC PLANT	$17,868	$6,380	$18,579	$0	$0	**$42,827**	$3,776	$0	$5,765	**$52,368**	$95
12	INSTRUMENTATION & CONTROL	$8,736	$0	$8,858	$0	$0	**$17,594**	$1,595	$0	$2,357	**$21,546**	$39
13	IMPROVEMENTS TO SITE	$2,975	$1,710	$5,996	$0	$0	**$10,682**	$1,054	$0	$2,347	**$14,083**	$26
14	BUILDINGS & STRUCTURES	$0	$24,117	$22,768	$0	$0	**$46,884**	$4,229	$0	$7,667	**$58,780**	$107
	TOTAL COST	**$601,934**	**$45,680**	**$300,965**	**$0**	**$0**	**$948,580**	**$89,700**	**$20,595**	**$127,026**	**$1,185,901**	**$2,156**

Exhibit 4-40 Case L13A Total Plant Cost Details

	Client:	USDOE/NETL								Report Date:	19-Oct-09		
	Project:	Low Rank (Western) Coal Baseline Study											
		TOTAL PLANT COST SUMMARY											
	Case:	Case L13A - 1x550 MWnet USC PC											
	Plant Size:	550.0 MW,net		Estimate Type:		Conceptual				Cost Base (June)	2007	($x1000)	

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING											
1.1	Coal Receive & Unload	$4,824	$0	$2,203	$0	$0	$7,027	$628	$0	$1,148	$8,803	$16
1.2	Coal Stackout & Reclaim	$6,234	$0	$1,412	$0	$0	$7,646	$669	$0	$1,247	$9,562	$17
1.3	Coal Conveyors	$5,796	$0	$1,398	$0	$0	$7,193	$630	$0	$1,174	$8,997	$16
1.4	Other Coal Handling	$1,516	$0	$323	$0	$0	$1,840	$161	$0	$300	$2,300	$4
1.5	Sorbent Receive & Unload	$53	$0	$16	$0	$0	$69	$6	$0	$11	$87	$0
1.6	Sorbent Stackout & Reclaim	$858	$0	$157	$0	$0	$1,015	$88	$0	$166	$1,269	$2
1.7	Sorbent Conveyors	$306	$66	$75	$0	$0	$448	$39	$0	$73	$559	$1
1.8	Other Sorbent Handling	$185	$43	$97	$0	$0	$325	$29	$0	$53	$407	$1
1.9	Coal & Sorbent Hnd.Foundations	$0	$5,924	$7,473	$0	$0	$13,398	$1,258	$0	$2,198	$16,854	$31
	SUBTOTAL 1.	**$19,772**	**$6,034**	**$13,155**	**$0**	**$0**	**$38,961**	**$3,508**	**$0**	**$6,370**	**$48,840**	**$89**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$2,827	$0	$551	$0	$0	$3,378	$295	$0	$551	$4,224	$8
2.2	Coal Conveyor to Storage	$7,239	$0	$1,580	$0	$0	$8,820	$771	$0	$1,439	$11,029	$20
2.3	Coal Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.4	Misc.Coal Prep & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.5	Sorbent Prep Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.6	Sorbent Storage & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.7	Sorbent Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.8	Booster Air Supply System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.9	Coal & Sorbent Feed Foundation	$0	$809	$679	$0	$0	$1,487	$138	$0	$244	$1,869	$3
	SUBTOTAL 2.	**$10,067**	**$809**	**$2,810**	**$0**	**$0**	**$13,686**	**$1,203**	**$0**	**$2,233**	**$17,122**	**$31**
3	FEEDWATER & MISC. BOP SYSTEMS											
3.1	FeedwaterSystem	$20,466	$0	$6,611	$0	$0	$27,077	$2,366	$0	$4,416	$33,860	$62
3.2	Water Makeup & Pretreating	$2,705	$0	$871	$0	$0	$3,575	$338	$0	$783	$4,696	$9
3.3	Other Feedwater Subsystems	$6,266	$0	$2,648	$0	$0	$8,914	$798	$0	$1,457	$11,169	$20
3.4	Service Water Systems	$530	$0	$288	$0	$0	$819	$77	$0	$179	$1,075	$2
3.5	Other Boiler Plant Systems	$8,463	$0	$8,355	$0	$0	$16,818	$1,597	$0	$2,762	$21,177	$39
3.6	FO Supply Sys & Nat Gas	$256	$0	$320	$0	$0	$576	$54	$0	$94	$724	$1
3.7	Waste Treatment Equipment	$1,834	$0	$1,045	$0	$0	$2,879	$280	$0	$632	$3,791	$7
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	$2,716	$0	$830	$0	$0	$3,545	$341	$0	$777	$4,664	$8
	SUBTOTAL 3.	**$43,234**	**$0**	**$20,968**	**$0**	**$0**	**$64,202**	**$5,852**	**$0**	**$11,101**	**$81,155**	**$148**
4	PC BOILER											
4.1	PC Boiler & Accessories	$242,279	$0	$109,690	$0	$0	$351,969	$34,201	$17,598	$40,377	$444,145	$808
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.3	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.4	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.5	Primary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.6	Secondary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.8	Major Component Rigging	$0	w/4.1	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.9	Boiler Foundations	$0	w/14.1	w/14.1	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 4.	**$242,279**	**$0**	**$109,690**	**$0**	**$0**	**$351,969**	**$34,201**	**$17,598**	**$40,377**	**$444,145**	**$808**

Exhibit 4-40 Case L13A Total Plant Cost Details (Continued)

Client:	USDOE/NETL	**Report Date:**	19-Oct-09
Project:	Low Rank (Western) Coal Baseline Study		
	TOTAL PLANT COST SUMMARY		
Case:	Case L13A - 1x550 MWnet USC PC		
Plant Size:	550.0 MW,net	**Estimate Type:** Conceptual	**Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$84,842	$0	$23,111	$0	$0	$107,954	$10,311	$0	$11,827	$130,092	$237
5.2	Other FGD	$1,095	$0	$710	$0	$0	$1,805	$174	$0	$198	$2,177	$4
5.3	Bag House & Accessories	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.4	Other Particulate Removal Materials	$20,271	$0	$13,830	$0	$0	$34,100	$3,289	$0	$3,739	$41,128	$75
5.5	Gypsum Dewatering System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.6	Mercury Removal System	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.9	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 5.	**$106,208**	**$0**	**$37,651**	**$0**	**$0**	**$143,860**	**$13,774**	**$0**	**$15,763**	**$173,397**	**$315**
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
6.2	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.3	Compressed Air Piping	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.9	Combustion Turbine Foundations	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
7.2	HRSG Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7.3	Ductwork	$10,274	$0	$6,601	$0	$0	$16,875	$1,471	$0	$2,752	$21,099	$38
7.4	Stack	$10,328	$0	$6,044	$0	$0	$16,372	$1,576	$0	$1,795	$19,743	$36
7.9	Duct & Stack Foundations	$0	$1,185	$1,346	$0	$0	$2,531	$237	$0	$554	$3,321	$6
	SUBTOTAL 7.	**$20,603**	**$1,185**	**$13,991**	**$0**	**$0**	**$35,778**	**$3,285**	**$0**	**$5,100**	**$44,163**	**$80**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$53,046	$0	$6,890	$0	$0	$59,936	$5,744	$2,997	$6,868	$75,544	$137
8.2	Turbine Plant Auxiliaries	$348	$0	$746	$0	$0	$1,094	$107	$0	$120	$1,321	$2
8.3a	Condenser & Auxiliaries	$3,961	$0	$2,295	$0	$0	$6,257	$602	$0	$686	$7,545	$14
8.3b	Air Cooled Condenser	$36,304	$0	$7,278	$0	$0	$43,582	$4,358	$0	$9,588	$57,528	$105
8.4	Steam Piping	$21,950	$0	$10,823	$0	$0	$32,773	$2,754	$0	$5,329	$40,856	$74
8.9	TG Foundations	$0	$1,093	$1,726	$0	$0	$2,819	$267	$0	$617	$3,703	$7
	SUBTOTAL 8.	**$115,610**	**$1,093**	**$29,759**	**$0**	**$0**	**$146,461**	**$13,831**	**$2,997**	**$23,208**	**$186,497**	**$339**
9	COOLING WATER SYSTEM											
9.1	Cooling Towers	$5,545	$0	$1,727	$0	$0	$7,272	$695	$0	$797	$8,764	$16
9.2	Circulating Water Pumps	$1,155	$0	$57	$0	$0	$1,213	$102	$0	$131	$1,446	$3
9.3	Circ.Water System Auxiliaries	$327	$0	$44	$0	$0	$371	$35	$0	$41	$447	$1
9.4	Circ.Water Piping	$0	$2,594	$2,514	$0	$0	$5,107	$478	$0	$838	$6,423	$12
9.5	Make-up Water System	$287	$0	$384	$0	$0	$671	$64	$0	$110	$845	$2
9.6	Component Cooling Water Sys	$259	$0	$206	$0	$0	$465	$44	$0	$76	$586	$1
9.9	Circ.Water System Foundations& Structures	$0	$1,537	$2,441	$0	$0	$3,978	$376	$0	$871	$5,225	$10
	SUBTOTAL 9.	**$7,574**	**$4,130**	**$7,373**	**$0**	**$0**	**$19,077**	**$1,796**	**$0**	**$2,864**	**$23,737**	**$43**

Exhibit 4-40 Case L13A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 19-Oct-09
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case L13A - 1x550 MWnet USC PC
Plant Size: 550.0 MW,net **Estimate Type:** Conceptual **Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
10	ASH/SPENT SORBENT HANDLING SYS											
10.1	Ash Coolers	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.2	Cyclone Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.3	HGCU Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.4	High Temperature Ash Piping	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.5	Other Ash Recovery Equipment	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.6	Ash Storage Silos	$938	$0	$2,889	$0	$0	$3,827	$376	$0	$420	$4,622	$8
10.7	Ash Transport & Feed Equipment	$6,069	$0	$6,217	$0	$0	$12,287	$1,175	$0	$1,346	$14,808	$27
10.8	Misc. Ash Handling Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.9	Ash/Spent Sorbent Foundation	$0	$223	$262	$0	$0	$485	$45	$0	$106	$637	$1
	SUBTOTAL 10.	**$7,007**	**$223**	**$9,369**	**$0**	**$0**	**$16,599**	**$1,596**	**$0**	**$1,873**	**$20,067**	**$36**
11	ACCESSORY ELECTRIC PLANT											
11.1	Generator Equipment	$1,602	$0	$260	$0	$0	$1,862	$173	$0	$153	$2,188	$4
11.2	Station Service Equipment	$2,916	$0	$958	$0	$0	$3,874	$362	$0	$318	$4,554	$8
11.3	Switchgear & Motor Control	$3,352	$0	$570	$0	$0	$3,922	$364	$0	$429	$4,714	$9
11.4	Conduit & Cable Tray	$0	$2,102	$7,268	$0	$0	$9,369	$907	$0	$1,541	$11,818	$21
11.5	Wire & Cable	$0	$3,966	$7,656	$0	$0	$11,622	$979	$0	$1,890	$14,492	$26
11.6	Protective Equipment	$265	$0	$900	$0	$0	$1,165	$114	$0	$128	$1,406	$3
11.7	Standby Equipment	$1,279	$0	$29	$0	$0	$1,309	$120	$0	$143	$1,572	$3
11.8	Main Power Transformers	$8,454	$0	$172	$0	$0	$8,626	$655	$0	$928	$10,209	$19
11.9	Electrical Foundations	$0	$312	$765	$0	$0	$1,077	$103	$0	$236	$1,416	$3
	SUBTOTAL 11.	**$17,868**	**$6,380**	**$18,579**	**$0**	**$0**	**$42,827**	**$3,776**	**$0**	**$5,765**	**$52,368**	**$95**
12	INSTRUMENTATION & CONTROL											
12.1	PC Control Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.2	Combustion Turbine Control	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
12.3	Steam Turbine Control	w/8.1	$0	w/8.1	$0	$0	$0	$0	$0	$0	$0	$0
12.4	Other Major Component Control	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.5	Signal Processing Equipment	W/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.6	Control Boards,Panels & Racks	$450	$0	$269	$0	$0	$719	$68	$0	$118	$905	$2
12.7	Distributed Control System Equipment	$4,541	$0	$794	$0	$0	$5,335	$495	$0	$583	$6,412	$12
12.8	Instrument Wiring & Tubing	$2,462	$0	$4,883	$0	$0	$7,345	$626	$0	$1,196	$9,167	$17
12.9	Other I & C Equipment	$1,283	$0	$2,912	$0	$0	$4,195	$407	$0	$460	$5,062	$9
	SUBTOTAL 12.	**$8,736**	**$0**	**$8,858**	**$0**	**$0**	**$17,594**	**$1,595**	**$0**	**$2,357**	**$21,546**	**$39**

Exhibit 4-40 Case L13A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 19-Oct-09
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case L13A - 1x550 MWnet USC PC
Plant Size: 550.0 MW,net **Estimate Type:** Conceptual **Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
13	IMPROVEMENTS TO SITE											
13.1	Site Preparation	$0	$50	$1,000	$0	$0	$1,050	$104	$0	$231	$1,385	$3
13.2	Site Improvements	$0	$1,660	$2,062	$0	$0	$3,722	$367	$0	$818	$4,907	$9
13.3	Site Facilities	$2,975	$0	$2,934	$0	$0	$5,909	$582	$0	$1,298	$7,790	$14
	SUBTOTAL 13.	**$2,975**	**$1,710**	**$5,996**	**$0**	**$0**	**$10,682**	**$1,054**	**$0**	**$2,347**	**$14,083**	**$26**
14	BUILDINGS & STRUCTURES											
14.1	Boiler Building	$0	$10,029	$8,819	$0	$0	$18,848	$1,694	$0	$3,081	$23,623	$43
14.2	Turbine Building	$0	$11,697	$10,901	$0	$0	$22,598	$2,037	$0	$3,695	$28,330	$52
14.3	Administration Building	$0	$587	$621	$0	$0	$1,208	$110	$0	$198	$1,515	$3
14.4	Circulation Water Pumphouse	$0	$168	$134	$0	$0	$302	$27	$0	$49	$378	$1
14.5	Water Treatment Buildings	$0	$343	$313	$0	$0	$656	$59	$0	$107	$822	$1
14.6	Machine Shop	$0	$393	$264	$0	$0	$657	$58	$0	$107	$822	$1
14.7	Warehouse	$0	$266	$267	$0	$0	$533	$48	$0	$87	$669	$1
14.8	Other Buildings & Structures	$0	$217	$185	$0	$0	$403	$36	$0	$66	$505	$1
14.9	Waste Treating Building & Str.	$0	$416	$1,264	$0	$0	$1,680	$159	$0	$276	$2,115	$4
	SUBTOTAL 14.	**$0**	**$24,117**	**$22,768**	**$0**	**$0**	**$46,884**	**$4,229**	**$0**	**$7,667**	**$58,780**	**$107**
	TOTAL COST	**$601,934**	**$45,680**	**$300,965**	**$0**	**$0**	**$948,580**	**$89,700**	**$20,595**	**$127,026**	**$1,185,901**	**$2,156**

Exhibit 4-41 Case L13A Owner's Costs

Owner's Costs	$x1000	$/kW
Preproduction Costs		
6 Months Fixed O&M	$8,844	$16
1 Month Variable O&M	$2,444	$4
25% of 1 Months Fuel Cost at 100% CF	$728	$1
2% of TPC	$23,718	$43
Total	**$35,735**	**$65**
Inventory Capital		
60 day supply of fuel and consumables at 100% CF	$6,997	$13
0.5% of TPC (spare parts)	$5,930	$11
Total	**$12,927**	**$24**
Initial Cost for Catalyst and Chemicals	**$0**	**$0**
Land	**$900**	**$2**
Other Owner's Costs	**$177,885**	**$323**
Financing Costs	**$32,019**	**$58**
Total Owner's Costs	**$259,466**	**$472**
Total Overnight Cost (TOC)	**$1,445,367**	**$2,628**
TASC Multiplier	1.140	
Total As-Spent Cost (TASC)	**$1,647,719**	**$2,996**

Exhibit 4-42 Case L13A Initial and Annual O&M Costs

INITIAL & ANNUAL O&M EXPENSES						Cost Base (June)	2007
Case L13A - 1x550 MWnet USC PC						Heat Rate-net(Btu/kWh):	8,795
						MWe-net:	550
						Capacity Factor: (%):	85
OPERATING & MAINTENANCE LABOR							
Operating Labor							
Operating Labor Rate(base):	34.65	$/hour					
Operating Labor Burden:	30.00	% of base					
Labor O-H Charge Rate:	25.00	% of labor					
			Total				
Skilled Operator	2.0		2.0				
Operator	9.0		9.0				
Foreman	1.0		1.0				
Lab Tech's, etc.	2.0		2.0				
TOTAL-O.J.'s	14.0		14.0				
						Annual Cost	Annual Unit Cost
						$	$/kW-net
Annual Operating Labor Cost						$5,524,319	$10.044
Maintenance Labor Cost						$8,626,542	$15.684
Administrative & Support Labor						$3,537,715	$6.432
Property Taxes and Insurance						$23,718,023	$43.122
TOTAL FIXED OPERATING COSTS						**$41,406,599**	**$75.282**
VARIABLE OPERATING COSTS							
							$/kWh-net
Maintenance Material Cost						**$12,939,813**	**$0.00316**
Consumables	Consumption		Unit	Initial			
	Initial	/Day	Cost	Cost			
Water(/1000 gallons)	0	1,920	1.08		**$0**	**$644,333**	**$0.00016**
Chemicals							
MU & WT Chem.(lb)	0	9,294	0.17		$0	$499,037	$0.00012
Lime (ton)	0	114	75.00		$0	$2,652,591	$0.00065
Carbon (Mercury Removal) (lb)	0	3,336	1.05		$0	$1,086,920	$0.00027
MEA Solvent (ton)	0	0	2,249.89		$0	$0	$0.00000
NaOH (tons)	0	0	433.68		$0	$0	$0.00000
H2SO4 (tons)	0	0	138.78		$0	$0	$0.00000
Corrosion Inhibitor	0	0	0.00		$0	$0	$0.00000
Activated Carbon(lb)	0	0	1.05		$0	$0	$0.00000
Ammonia (19% NH3) ton	0	23	129.80		$0	$914,308	$0.00022
Subtotal Chemicals					**$0**	**$5,152,856**	**$0.00126**
Other							
Supplemental Fuel(MBtu)	0	0	0.00		$0	$0	$0.00000
SCR Catalyst(m3)	w/equip.	0.37	5,775.94		$0	$664,425	$0.00016
Emission Penalties	0	0	0.00		$0	$0	$0.00000
Subtotal Other					**$0**	**$664,425**	**$0.00016**
Waste Disposal							
Flyash (ton)	0	925	16.23		$0	$4,656,299	$0.00114
Bottom Ash(ton)	0	173	16.23		$0	$870,846	$0.00021
Subtotal-Waste Disposal					**$0**	**$5,527,145**	**$0.00135**
By-products & Emissions							
Gypsum (tons)	0	0	0.00		$0	$0	$0.00000
Subtotal By-Products					**$0**	**$0**	**$0.00000**
TOTAL VARIABLE OPERATING COSTS					**$0**	**$24,928,572**	**$0.00609**
Fuel(ton)	0	8,773	10.92		**$0**	**$29,721,373**	**$0.00726**

4.2 SC & USC PC CO_2 CAPTURE CASES (PRB AND LIGNITE)

4.2.1 Process Description

In this section the SC and USC PC processes with CO_2 capture are described. The plant configurations are similar to the non-capture cases presented in Section 4.1 with the major difference being the use of an Econamine system for CO_2 capture and subsequent compression of the captured CO_2 stream. Since the CO_2 capture and compression process increases the auxiliary load on the plant, the coal feed rate is significantly increased and the overall efficiency is significantly reduced relative to the non-capture cases. A process BFD for the four CO_2 capture cases is shown in Exhibit 4-43 and stream tables for Cases S12B, L12B, S13B, and L13B are shown in Exhibit 4-44 through Exhibit 4-47. The CO_2 removal system is described in Section 3.1.4.

Exhibit 4-43 Cases S12B, L12B, S13B, and L13B Process Flow Diagram

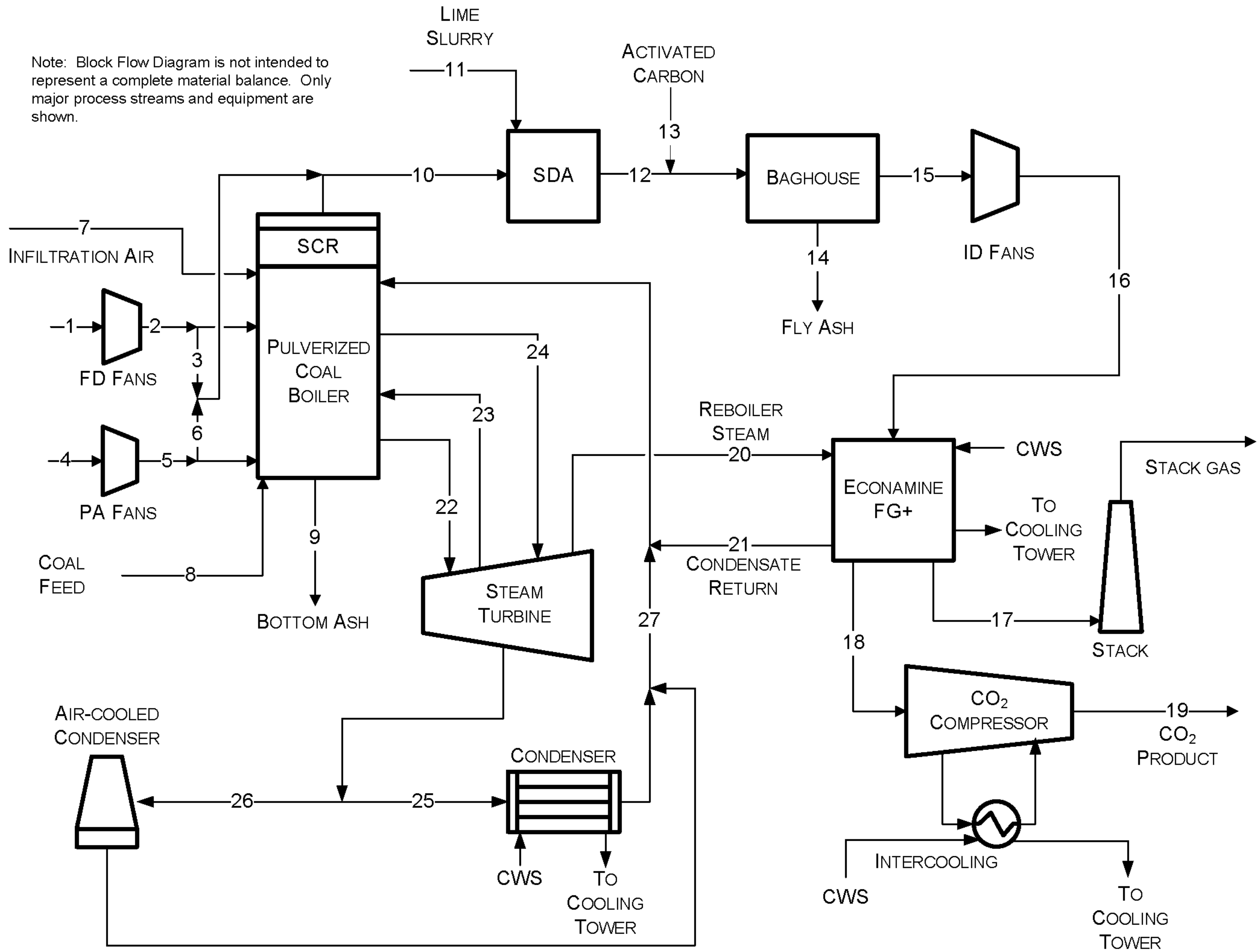

Exhibit 4-44 Case S12B Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
V-L Mole Fraction														
Ar	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0000	0.0000	0.0084	0.0000	0.0081	0.0000	0.0000
CO_2	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0000	0.0000	0.1473	0.0000	0.1414	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0000	0.0000	0.1155	1.0000	0.1515	0.0000	0.0000
N_2	0.7759	0.7759	0.7759	0.7759	0.7759	0.7759	0.7759	0.0000	0.0000	0.7044	0.0000	0.6763	0.0000	0.0000
O_2	0.2081	0.2081	0.2081	0.2081	0.2081	0.2081	0.2081	0.0000	0.0000	0.0236	0.0000	0.0226	0.0000	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0000	0.0001	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	0.0000	0.0000
V-L Flowrate (kg_{mol}/hr)	55,796	55,796	2,107	37,197	37,197	3,008	1,649	0	0	104,375	4,463	108,721	0	0
V-L Flowrate (kg/hr)	1,612,234	1,612,234	60,883	1,074,822	1,074,822	86,905	47,657	0	0	3,072,659	80,405	3,147,389	0	0
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	368,084	6,027	24,110	5,531	35,316	61	35,376
Temperature (°C)	6	10	10	6	17	17	6	6	143	143	6	82	6	82
Pressure (MPa, abs)	0.09	0.09	0.09	0.09	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.08	0.11	0.08
Enthalpy (kJ/kg)[A]	15.26	19.77	19.77	15.26	26.74	26.74	15.26	---	---	350.24	197.00	322.16	---	---
Density (kg/m^3)	1.1	1.1	1.1	1.1	1.2	1.2	1.1	---	---	0.7	1,012.1	0.8	---	---
V-L Molecular Weight	28.895	28.895	28.895	28.895	28.895	28.895	28.895	---	---	29.439	18.015	28.949	---	---
V-L Flowrate (lb_{mol}/hr)	123,009	123,009	4,645	82,006	82,006	6,631	3,636	0	0	230,107	9,840	239,690	0	0
V-L Flowrate (lb/hr)	3,554,367	3,554,367	134,224	2,369,578	2,369,578	191,593	105,065	0	0	6,774,054	177,262	6,938,805	0	0
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	811,486	13,288	53,153	12,194	77,857	134	77,991
Temperature (°F)	42	50	50	42	63	63	42	42	289	289	42	180	42	180
Pressure (psia)	13.0	13.6	13.6	13.0	14.4	14.4	13.0	13.0	12.7	12.7	13.0	12.3	16.0	12.1
Enthalpy (Btu/lb)[A]	6.6	8.5	8.5	6.6	11.5	11.5	6.6	---	---	150.6	84.7	138.5	---	---
Density (lb/ft^3)	0.070	0.072	0.072	0.070	0.075	0.075	0.070	---	---	0.047	63.182	0.052	---	---

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 4-44 Case S12B Stream Table (Continued)

	15	16	17	18	19	20	21	22	23	24	25	26	27
V-L Mole Fraction													
Ar	0.0081	0.0081	0.0107	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.1414	0.1414	0.0188	0.9957	0.9998	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.1515	0.1515	0.0431	0.0043	0.0002	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.6763	0.6763	0.8974	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0226	0.0226	0.0301	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO_2	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	108,721	108,721	81,932	13,897	13,839	56,928	56,928	128,862	108,851	108,851	24,302	24,302	48,604
V-L Flowrate (kg/hr)	3,147,389	3,147,389	2,304,811	610,047	609,010	1,025,578	1,025,578	2,321,487	1,960,987	1,960,987	437,805	437,805	875,609
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	82	92	32	21	35	152	151	593	354	593	32	32	32
Pressure (MPa, abs)	0.08	0.09	0.09	0.16	15.27	0.51	0.49	24.23	4.90	4.52	0.005	0.005	1.72
Enthalpy (kJ/kg)[A]	323.62	334.24	101.64	19.90	-212.30	2,747.83	636.75	3,477.66	3,082.68	3,653.25	2,003.96	2,003.96	137.98
Density (kg/m^3)	0.8	0.9	1.0	2.9	794.5	2.7	915.8	69.2	18.7	11.6	0.04	0.04	995.7
V-L Molecular Weight	28.949	28.949	28.131	43.898	44.006	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	239,690	239,690	180,629	30,637	30,510	125,505	125,505	284,092	239,976	239,976	53,576	53,576	107,153
V-L Flowrate (lb/hr)	6,938,805	6,938,805	5,081,239	1,344,923	1,342,637	2,261,012	2,261,012	5,118,004	4,323,236	4,323,236	965,194	965,194	1,930,388
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	180	198	89	69	95	306	304	1,100	668	1,100	90	90	90
Pressure (psia)	12.1	13.1	13.1	23.2	2,215.0	73.5	71.0	3,514.7	710.8	655.8	0.7	0.7	250.0
Enthalpy (Btu/lb)[A]	139.1	143.7	43.7	8.6	-91.3	1,181.4	273.8	1,495.1	1,325.3	1,570.6	861.5	861.5	59.3
Density (lb/ft^3)	0.051	0.054	0.063	0.181	49.600	0.169	57.172	4.319	1.166	0.722	0.003	0.003	62.162

Exhibit 4-45 Case L12B Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
V-L Mole Fraction														
Ar	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0000	0.0000	0.0081	0.0000	0.0077	0.0000	0.0000
CO_2	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0000	0.0000	0.1423	0.0000	0.1365	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	0.0000	0.0000	0.1504	1.0000	0.1855	0.0000	0.0000
N_2	0.7761	0.7761	0.7761	0.7761	0.7761	0.7761	0.7761	0.0000	0.0000	0.6755	0.0000	0.6482	0.0000	0.0000
O_2	0.2082	0.2082	0.2082	0.2082	0.2082	0.2082	0.2082	0.0000	0.0000	0.0229	0.0000	0.0220	0.0000	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0000	0.0001	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	0.0000	0.0000
V-L Flowrate (kg_{mol}/hr)	59,869	59,869	2,261	39,913	39,913	3,227	1,766	0	0	116,831	5,057	121,751	0	0
V-L Flowrate (kg/hr)	1,730,068	1,730,068	65,333	1,153,378	1,153,378	93,257	51,044	0	0	3,388,593	91,107	3,473,011	0	0
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	503,790	9,938	39,750	6,525	52,964	96	53,059
Temperature (°C)	4	9	9	4	15	15	4	4	143	143	4	82	6	82
Pressure (MPa, abs)	0.10	0.10	0.10	0.10	0.11	0.11	0.10	0.10	0.09	0.09	0.10	0.09	0.11	0.09
Enthalpy (kJ/kg)[A]	13.75	17.98	17.98	13.75	24.54	24.54	13.75	---	---	424.25	203.20	394.91	---	---
Density (kg/m^3)	1.2	1.2	1.2	1.2	1.3	1.3	1.2	---	---	0.8	1,013.1	0.9	---	---
V-L Molecular Weight	28.898	28.898	28.898	28.898	28.898	28.898	28.898	---	---	29.004	18.015	28.526	---	---
V-L Flowrate (lb_{mol}/hr)	131,988	131,988	4,984	87,992	87,992	7,115	3,894	0	0	257,568	11,149	268,414	0	0
V-L Flowrate (lb/hr)	3,814,146	3,814,146	144,034	2,542,764	2,542,764	205,596	112,533	0	0	7,470,568	200,855	7,656,679	0	0
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	1,110,668	21,909	87,635	14,385	116,765	211	116,976
Temperature (°F)	40	48	48	40	59	59	40	40	290	290	40	180	42	180
Pressure (psia)	13.8	14.4	14.4	13.8	15.2	15.2	13.8	13.8	13.5	13.5	13.8	13.1	16.0	12.9
Enthalpy (Btu/lb)[A]	5.9	7.7	7.7	5.9	10.6	10.6	5.9	---	---	182.4	87.4	169.8	---	---
Density (lb/ft^3)	0.074	0.076	0.076	0.074	0.079	0.079	0.074	---	---	0.049	63.247	0.055	---	---

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 4-45 Case L12B Stream Table (Continued)

	15	16	17	18	19	20	21	22	23	24	25	26	27
V-L Mole Fraction													
Ar	0.0077	0.0077	0.0107	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.1365	0.1365	0.0189	0.9960	0.9999	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.1855	0.1855	0.0406	0.0040	0.0001	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.6482	0.6482	0.8992	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0220	0.0220	0.0305	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO_2	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	121,751	121,751	87,767	15,021	14,964	61,553	61,553	132,522	111,965	111,965	23,715	23,715	47,431
V-L Flowrate (kg/hr)	3,473,011	3,473,011	2,471,559	659,529	658,486	1,108,895	1,108,895	2,387,418	2,017,077	2,017,077	427,238	427,238	854,477
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	82	91	32	21	35	152	151	593	353	593	32	32	32
Pressure (MPa, abs)	0.09	0.10	0.10	0.16	15.27	0.51	0.49	24.23	4.90	4.52	0.005	0.005	1.72
Enthalpy (kJ/kg)[A]	382.27	392.39	97.56	19.60	-212.30	2,747.83	636.75	3,477.66	3,082.60	3,653.25	2,006.36	2,006.36	137.98
Density (kg/m^3)	0.9	0.9	1.1	2.9	794.5	2.7	915.8	69.2	18.7	11.6	0.04	0.04	995.7
V-L Molecular Weight	28.526	28.526	28.160	43.906	44.006	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	268,414	268,414	193,493	33,117	32,989	135,701	135,701	292,161	246,840	246,840	52,283	52,283	104,567
V-L Flowrate (lb/hr)	7,656,679	7,656,679	5,448,855	1,454,012	1,451,712	2,444,695	2,444,695	5,263,357	4,446,894	4,446,894	941,900	941,900	1,883,799
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	180	196	89	69	95	306	304	1,100	668	1,100	90	90	90
Pressure (psia)	12.9	13.9	13.9	23.3	2,215.0	73.5	71.0	3,514.7	710.8	655.8	0.7	0.7	250.0
Enthalpy (Btu/lb)[A]	164.3	168.7	41.9	8.4	-91.3	1,181.4	273.8	1,495.1	1,325.3	1,570.6	862.6	862.6	59.3
Density (lb/ft^3)	0.054	0.056	0.066	0.182	49.600	0.169	57.172	4.319	1.166	0.722	0.003	0.003	62.162

Exhibit 4-46 Case S13B Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
V-L Mole Fraction														
Ar	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0000	0.0000	0.0084	0.0000	0.0081	0.0000	0.0000
CO_2	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0000	0.0000	0.1471	0.0000	0.1412	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0000	0.0000	0.1153	1.0000	0.1514	0.0000	0.0000
N_2	0.7759	0.7759	0.7759	0.7759	0.7759	0.7759	0.7759	0.0000	0.0000	0.7045	0.0000	0.6764	0.0000	0.0000
O_2	0.2081	0.2081	0.2081	0.2081	0.2081	0.2081	0.2081	0.0000	0.0000	0.0239	0.0000	0.0229	0.0000	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0000	0.0001	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	0.0000	0.0000
V-L Flowrate (kg_{mol}/hr)	52,633	52,633	1,988	35,088	35,088	2,837	1,553	0	0	98,439	4,208	102,538	0	0
V-L Flowrate (kg/hr)	1,520,821	1,520,821	57,431	1,013,881	1,013,881	81,978	44,880	0	0	2,897,842	75,812	2,968,310	0	0
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	346,641	5,676	22,705	5,222	33,271	57	33,328
Temperature (°C)	6	10	10	6	17	17	6	6	143	143	6	82	6	82
Pressure (MPa, abs)	0.09	0.09	0.09	0.09	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.08	0.11	0.08
Enthalpy (kJ/kg)[A]	15.26	19.77	19.77	15.26	26.74	26.74	15.26	---	---	349.92	197.33	321.83	---	---
Density (kg/m^3)	1.1	1.1	1.1	1.1	1.2	1.2	1.1	---	---	0.7	1,012.1	0.8	---	---
V-L Molecular Weight	28.895	28.895	28.895	28.895	28.895	28.895	28.895	---	---	29.438	18.015	28.949	---	---
V-L Flowrate (lb_{mol}/hr)	116,035	116,035	4,382	77,357	77,357	6,255	3,424	0	0	217,021	9,278	226,057	0	0
V-L Flowrate (lb/hr)	3,352,837	3,352,837	126,613	2,235,224	2,235,224	180,730	98,944	0	0	6,388,647	167,137	6,544,002	0	0
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	764,212	12,514	50,056	11,512	73,350	126	73,476
Temperature (°F)	42	50	50	42	63	63	42	42	289	289	42	180	42	180
Pressure (psia)	13.0	13.6	13.6	13.0	14.4	14.4	13.0	13.0	12.7	12.7	13.0	12.3	16.0	12.1
Enthalpy (Btu/lb)[A]	6.6	8.5	8.5	6.6	11.5	11.5	6.6	---	---	150.4	84.8	138.4	---	---
Density (lb/ft^3)	0.070	0.072	0.072	0.070	0.075	0.075	0.070	---	---	0.047	63.182	0.052	---	---

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 4-46 Case S13B Stream (Continued)

	15	16	17	18	19	20	21	22	23	24	25	26	27
V-L Mole Fraction													
Ar	0.0081	0.0081	0.0107	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.1412	0.1412	0.0187	0.9957	0.9999	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.1514	0.1514	0.0431	0.0043	0.0001	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.6764	0.6764	0.8971	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0229	0.0229	0.0304	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO_2	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	102,538	102,538	77,309	13,087	13,033	53,612	53,612	131,797	100,148	100,148	18,863	18,863	37,726
V-L Flowrate (kg/hr)	2,968,310	2,968,310	2,174,823	574,512	573,534	965,835	965,835	2,374,355	1,804,195	1,804,195	339,826	339,826	679,651
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	82	92	32	21	35	152	151	649	450	649	32	32	32
Pressure (MPa, abs)	0.08	0.09	0.09	0.16	15.27	0.51	0.49	27.68	8.27	7.78	0.005	0.005	0.86
Enthalpy (kJ/kg)[A]	323.37	333.99	101.63	19.91	-212.30	2,747.83	636.75	3,609.84	3,270.42	3,758.29	2,282.16	2,282.16	136.90
Density (kg/m^3)	0.8	0.9	1.0	2.9	794.5	2.7	915.8	72.8	27.2	18.8	0.04	0.04	995.4
V-L Molecular Weight	28.949	28.949	28.132	43.898	44.006	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	226,057	226,057	170,437	28,853	28,733	118,194	118,194	290,562	220,789	220,789	41,586	41,586	83,172
V-L Flowrate (lb/hr)	6,544,002	6,544,002	4,794,665	1,266,581	1,264,425	2,129,302	2,129,302	5,234,556	3,977,569	3,977,569	749,187	749,187	1,498,374
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	180	198	89	69	95	306	304	1,200	842	1,200	90	90	90
Pressure (psia)	12.1	13.1	13.1	23.3	2,215.0	73.5	71.0	4,014.7	1,200.0	1,128.0	0.7	0.7	125.0
Enthalpy (Btu/lb)[A]	139.0	143.6	43.7	8.6	-91.3	1,181.4	273.8	1,552.0	1,406.0	1,615.8	981.2	981.2	58.9
Density (lb/ft^3)	0.051	0.054	0.063	0.182	49.600	0.169	57.172	4.542	1.698	1.176	0.002	0.002	62.139

Exhibit 4-47 Case L13B Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
V-L Mole Fraction														
Ar	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0000	0.0000	0.0081	0.0000	0.0077	0.0000	0.0000
CO_2	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0000	0.0000	0.1421	0.0000	0.1363	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	0.0000	0.0000	0.1502	1.0000	0.1852	0.0000	0.0000
N_2	0.7761	0.7761	0.7761	0.7761	0.7761	0.7761	0.7761	0.0000	0.0000	0.6757	0.0000	0.6484	0.0000	0.0000
O_2	0.2082	0.2082	0.2082	0.2082	0.2082	0.2082	0.2082	0.0000	0.0000	0.0232	0.0000	0.0223	0.0000	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0000	0.0001	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	0.0000	0.0000
V-L Flowrate (kg_{mol}/hr)	56,367	56,367	2,184	37,578	37,578	2,983	1,660	0	0	109,969	4,757	114,597	0	0
V-L Flowrate (kg/hr)	1,628,875	1,628,875	63,101	1,085,917	1,085,917	86,212	47,975	0	0	3,189,562	85,698	3,268,974	0	0
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	473,495	9,340	37,360	6,147	49,793	90	49,883
Temperature (°C)	4	9	9	4	14	14	4	4	143	143	4	82	6	82
Pressure (MPa, abs)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.10	0.09	0.11	0.09
Enthalpy (kJ/kg)[A]	13.75	18.04	18.04	13.75	23.57	23.57	13.75	---	---	423.77	203.62	394.41	---	---
Density (kg/m^3)	1.2	1.2	1.2	1.2	1.3	1.3	1.2	---	---	0.8	1,013.1	0.9	---	---
V-L Molecular Weight	28.898	28.898	28.898	28.898	28.898	28.898	28.898	---	---	29.004	18.015	28.526	---	---
V-L Flowrate (lb_{mol}/hr)	124,268	124,268	4,814	82,845	82,845	6,577	3,660	0	0	242,441	10,487	252,644	0	0
V-L Flowrate (lb/hr)	3,591,055	3,591,055	139,114	2,394,037	2,394,037	190,066	105,766	0	0	7,031,780	188,933	7,206,854	0	0
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	1,043,879	20,591	82,365	13,552	109,775	198	109,973
Temperature (°F)	40	48	48	40	58	58	40	40	289	289	40	180	42	180
Pressure (psia)	13.8	14.4	14.4	13.8	15.1	15.1	13.8	13.8	13.5	13.5	13.8	13.1	16.0	12.9
Enthalpy (Btu/lb)[A]	5.9	7.8	7.8	5.9	10.1	10.1	5.9	---	---	182.2	87.5	169.6	---	---
Density (lb/ft^3)	0.074	0.076	0.076	0.074	0.079	0.079	0.074	---	---	0.049	63.247	0.055	---	---

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 4-47 Case L13B Stream Table (Continued)

	15	16	17	18	19	20	21	22	23	24	25	26	27
V-L Mole Fraction													
Ar	0.0077	0.0077	0.0107	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.1363	0.1363	0.0189	0.9960	0.9999	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.1852	0.1852	0.0406	0.0040	0.0002	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.6484	0.6484	0.8989	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0223	0.0223	0.0309	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO_2	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	114,597	114,597	82,659	14,118	14,064	57,852	57,852	135,243	102,845	102,845	18,259	18,259	36,519
V-L Flowrate (kg/hr)	3,268,974	3,268,974	2,327,776	619,873	618,890	1,042,216	1,042,216	2,436,432	1,852,773	1,852,773	328,949	328,949	657,899
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	82	91	32	21	35	152	151	649	450	649	32	32	32
Pressure (MPa, abs)	0.09	0.10	0.10	0.16	15.27	0.51	0.49	27.68	8.27	7.78	0.005	0.005	0.86
Enthalpy (kJ/kg)[A]	381.90	392.02	97.55	19.61	-212.30	2,747.83	636.75	3,609.84	3,270.42	3,758.29	2,285.95	2,285.95	136.90
Density (kg/m^3)	0.9	0.9	1.1	2.9	794.5	2.7	915.8	72.8	27.2	18.8	0.04	0.04	995.4
V-L Molecular Weight	28.526	28.526	28.161	43.906	44.006	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	252,644	252,644	182,232	31,126	31,005	127,541	127,541	298,159	226,733	226,733	40,255	40,255	80,510
V-L Flowrate (lb/hr)	7,206,854	7,206,854	5,131,869	1,366,585	1,364,420	2,297,694	2,297,694	5,371,413	4,084,666	4,084,666	725,209	725,209	1,450,418
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	180	196	89	69	95	306	304	1,200	842	1,200	90	90	90
Pressure (psia)	12.9	13.9	13.9	23.3	2,215.0	73.5	71.0	4,014.7	1,200.0	1,128.0	0.7	0.7	125.0
Enthalpy (Btu/lb)[A]	164.2	168.5	41.9	8.4	-91.3	1,181.4	273.8	1,552.0	1,406.0	1,615.8	982.8	982.8	58.9
Density (lb/ft^3)	0.054	0.056	0.066	0.182	49.600	0.169	57.172	4.542	1.698	1.176	0.002	0.002	62.139

4.2.2 Key System Assumptions

System assumptions for Cases S12B and L12B, SC PC with CO_2 capture, and Cases S13B and L13B, USC PC with CO_2 capture, are compiled in Exhibit 4-48.

Exhibit 4-48 PC Cases with CO_2 Capture Study Configuration Matrix

	Case S12B w/ CO_2 Capture	Case L12B w/CO_2 Capture	Case S13B w/ CO_2 Capture	Case L13B w/CO_2 Capture
Steam Cycle, MPa/°C/°C (psig/°F/°F)	24.1/593/593 (3,500/1,100/1,100)	24.1/593/593 (3,500/1,100/1,100)	27.6/649/649 (4,000/1,200/1,200)	27.6/649/649 (4,000/1,200/1,200)
Coal	Subbituminous	Lignite	Subbituminous	Lignite
Carbon Conversion, %	100	100	100	100
Condenser pressure, mm Hg (in Hg)	36 (1.4)	36 (1.4)	36 (1.4)	36 (1.4)
Combustion air preheater flue gas exit temp., °C (ºF)	143 (290)	143 (290)	143 (290)	143 (290)
Cooling water to condenser, °C (ºF)	9 (48)	8 (47)	9 (48)	8 (47)
Cooling water from condenser, °C (ºF)	20 (68)	19 (67)	20 (68)	19 (67)
FGD Outlet, °C (°F)	82 (180)	82 (180)	82 (180)	82 (180)
SO_2 Control[2]	Spray Dryer Absorption FGD & Polishing Scrubber	Spray Dryer Absorption FGD & Polishing Scrubber	Spray Dryer Absorption FGD & Polishing Scrubber	Spray Dryer Absorption FGD & Polishing Scrubber
SDA FGD Efficiency, %[1,2,3]	93	93	93	93
NOx Control	LNB w/OFA and SCR	LNB w/OFA and SCR	LNB w/OFA and SCR	LNB w/OFA and SCR
SCR Efficiency, %[1]	65	65	65	65
Ammonia Slip (end of catalyst life), ppmv	2	2	2	2
Particulate Control	Fabric Filter	Fabric Filter	Fabric Filter	Fabric Filter
Fabric Filter efficiency, %[1]	99.97	99.97	99.97	99.97
Ash Distribution, Fly/Bottom	80% / 20%	80% / 20%	80% / 20%	80% / 20%
Mercury Control	Co-benefit Capture & Carbon Injection	Carbon Injection	Co-benefit Capture & Carbon Injection	Carbon Injection
Mercury removal efficiency, %[1]	90 plus	90	90 plus	90
CO_2 Control	Econamine	Econamine	Econamine	Econamine
CO_2 Capture, %[1]	90	90	90	90
CO_2 Sequestration	Off-site Saline Formation	Off-site Saline Formation	Off-site Saline Formation	Off-site Saline Formation

[1] Equipment removal efficiencies

[2] An SO_2 polishing step is included to meet more stringent oxides of sulfur (SOx) content limits in the flue gas (< 10 ppmv) to reduce formation of amine HSS during the CO_2 absorption process

[3] SO_2 exiting the post-FGD polishing step is absorbed in the CO_2 capture process making stack emissions negligible

<u>Balance of Plant – Cases S12B, L12B, S13A, and L13B</u>

The balance of plant assumptions are common to all cases and were presented previously in Section 3.1.6.

4.2.3 Sparing Philosophy

Single trains are used throughout the design with exceptions where equipment capacity requires an additional train. There is no redundancy other than normal sparing of rotating equipment. The plant design consists of the following major subsystems:

- One dry-bottom, wall-fired PC SC or USC boiler (1 x 100 percent)
- Two SCR reactors (2 x 50 percent)
- One lime spray dryer system with two absorbers (1 x 100 percent)
- Two single-stage, in-line, multi-compartment fabric filters (2 x 50 percent)
- One steam turbine (1 x 100 percent)
- Two parallel Econamine CO_2 absorption systems, with each system consisting of two absorbers, strippers, and ancillary equipment (2 x 50 percent)

4.2.4 Cases S12B, L12B, S13B, and L13B Performance Results

The CO_2 capture SC PC plant using PRB coal produces a net output of 550 MWe at a net plant efficiency of 27.0 percent (HHV basis). The same plant configuration using lignite coal produces a net output of 550 MWe at a net plant efficiency of 25.5 percent (HHV basis).

The CO_2 capture USC PC plant using PRB coal produces a net output of 550 MWe at a net plant efficiency of 28.7 percent (HHV basis). The same plant configuration using lignite coal produces a net output of 550 MWe at a net plant efficiency of 27.2 percent (HHV basis).

Overall performance for the four plants is summarized in Exhibit 4-49, which includes auxiliary power requirements. The cooling water system, including the CWPs and cooling tower fan, and the air-cooled condenser account for about 15 percent of the auxiliary load in all cases, and the PA, FD and induced draft fans account for an additional 12 percent. CO_2 compression accounts for about 40 percent and the Econamine process about 19 percent of the auxiliary load in all cases.

Exhibit 4-49 PC Cases with CO_2 Capture Plant Performance Summary

POWER SUMMARY (Gross Power at Generator Terminals, kWe)	S12B	L12B	S13B	L13B
Steam Turbine Power	**673,000**	**683,900**	**665,400**	**675,200**
AUXILIARY LOAD SUMMARY, kWe				
Coal Handling and Conveying	630	770	600	730
Pulverizers	5,520	7,550	5,200	7,100
Lime Handling & Preparation	240	280	230	260
Ash Handling	1,220	1,860	1,150	1,750
PA Fans	3,550	3,580	3,350	3,070
FD Fans	2,090	2,110	1,970	2,010
ID Fans	9,620	10,120	9,070	9,520
SCR	20	20	20	20
Baghouse	170	260	160	240
Spray Dryer FGD	3,200	3,780	3,020	3,550
Econamine Auxiliaries	22,900	24,700	21,500	23,200
CO_2 Compression	49,000	52,930	46,110	49,750
Steam Turbine Auxiliaries	400	400	400	400
Condensate Pumps	550	540	210	210
CWP	9,140	10,200	8,540	9,510
Ground Water Pumps	690	710	640	660
Cooling Tower Fans	5,970	6,260	5,570	5,840
Air-Cooled Condenser Fans	3,680	3,370	3,270	2,990
Miscellaneous Balance of Plant[1]	2,000	2,000	2,000	2,000
Transformer Loss	2,350	2,410	2,310	2,360
TOTAL AUXILIARIES, kWe	**122,940**	**133,850**	**115,320**	**125,170**
NET POWER, kWe	**550,060**	**550,050**	**550,080**	**550,030**
Plant CF, %	85%	85%	85%	85%
Net Plant Efficiency, % (HHV)	27.0%	25.5%	28.7%	27.2%
Net Plant Heat Rate, kJ/kWh (Btu/kWh)	13,330 (12,634)	14,097 (13,361)	12,553 (11,898)	13,250 (12,558)
CONDENSER COOLING DUTY GJ/hr (10^6 Btu/hr)	**1,636 (1,550)**	**1,598 (1,515)**	**1,459 (1,383)**	**1,415 (1,341)**
CONSUMABLES				
As-Received Coal Feed, kg/hr (lb/hr)	368,084 (811,486)	503,790 (1,110,668)	346,641 (764,212)	473,495 (1,043,879)
Thermal Input, kWt[2]	2,036,717	2,153,863	1,918,067	2,024,343
Raw Water Withdrawal, m^3/min (gpm)	28.9 (7,642)	29.6 (7,817)	26.9 (7,117)	27.5 (7,261)
Raw Water Consumption, m^3/min (gpm)	20.9 (5,527)	20.7 (5,456)	19.5 (5,141)	19.2 (5,060)

[1] Includes plant control systems, lighting, HVAC, and miscellaneous low voltage loads
[2] Thermal input based on as-received HHV of coal

Environmental Performance

The environmental targets for emissions of Hg, NOx, SO_2, and PM were presented in Section 2.3. A summary of the plant air emissions for Cases S12B, L12B, S13B, and L13B is presented in Exhibit 4-50.

SO_2 emissions are controlled using a lime spray dryer FGD system that achieves a removal efficiency of 93 percent. The waste is collected in the baghouse. A portion of the waste is stored in a recycle storage silo, which is then used to mix with lime slurry to increase the reagent utilization. The CO_2 capture system includes a SO_2 polishing unit that reduces SO_2 emission to a negligible level.

NOx emissions are controlled to about 0.2 lb/10^6 Btu through the use of LNBs and OFA. An SCR unit then further reduces the NOx concentration by 65 percent to 0.07 lb/10^6 Btu.

Particulate emissions are controlled using a pulse jet fabric filter, which operates at an efficiency of 99.97 percent.

Co-benefit capture and activated carbon injection result in greater than 90 percent reduction of mercury emissions for the PRB coal. For the lignite coal, no co-benefit capture is assumed giving a total Hg capture of 90 percent.

Ninety percent of the CO_2 from the flue gas is captured in the Econamine system and compressed for sequestration

Exhibit 4-50 PC Cases with CO_2 Capture Air Emissions

	kg/GJ (lb/10^6 Btu)				Tonne/year (ton/year) 85% capacity factor				kg/MWh (lb/MWh)			
	S12B	L12B	S13B	L13B	S12B	L12B	S13B	L13B	S12B	L12B	S13B	L13B
SO_2	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	37 (40)	41 (45)	36 (40)	36 (40)	0.007 (0.020)	0.009 (0.020)	0.007 (0.020)	0.007 (0.020)
NO_X	0.030 (0.070)	0.030 (0.070)	0.030 (0.070)	0.030 (0.070)	1,643 (1,811)	1,738 (1,915)	1,547 (1,706)	1,633 (1,800)	0.328 (0.723)	0.341 (0.753)	0.313 (0.689)	0.325 (0.716)
Particulates	0.006 (0.0130)	0.006 (0.0130)	0.006 (0.0130)	0.006 (0.0130)	305 (336)	323 (356)	287 (317)	303 (334)	0.061 (0.134)	0.063 (0.140)	0.058 (0.128)	0.060 (0.133)
Hg	2.57E-7 (5.97E-7)	4.82E-7 (1.12E-6)	2.57E-7 (5.97E-7)	4.82E-7 (1.12E-6)	0.014 (0.015)	0.028 (0.031)	0.013 (0.015)	0.026 (0.029)	2.80E-6 (6.16E-6)	5.46E-6 (1.20E-5)	2.66E-6 (5.87E-6)	5.20E-6 (1.15E-5)
CO_2	9.2 (21.5)	9.4 (21.9)	9.2 (21.5)	9.4 (21.9)	503,823 (555,370)	544,753 (600,488)	474,474 (523,018)	512,997 (564,380)	101 (222)	107 (236)	96 (211)	102 (225)
CO_2[1]									123 (271)	133 (293)	116 (255)	125 (276)

[1] CO_2 emissions based on net power instead of gross power

The carbon balances for the four CO_2 capture PC cases are shown in Exhibit 4-51 and Exhibit 4-52. The carbon input to the plant consists of carbon in the air in addition to carbon in the coal. Carbon leaves the plant as CO_2 in the stack gas and CO_2 product. 100 percent carbon conversion is assumed since carbon conversion for low rank PC plants is typically about 99.9 percent. The CO_2 capture efficiency is defined by the following fraction:

1-[(Stack Gas Carbon-Air Carbon)/(Total Carbon In-Air Carbon)] or
1-[(40,712-822)/(407,251-822)] * 100 = 90.2 percent (S12B)
1-[(44,019-882)/(440,403-882)] * 100 = 90.2 percent (L12B)
1-[(38,340-775)/(383,528-775)] * 100 = 90.2 percent (S13B)
1-[(41,372-830)/(413,921-830)] * 100 = 90.2 percent (L13B)

Exhibit 4-51 Cases S12B and L12B Carbon Balance

Carbon In, kg/hr (lb/hr)			Carbon Out, kg/hr (lb/hr)		
	S12B	**L12B**		**S12B**	**L12B**
Coal	184,293 (406,296)	199,268 (439,310)	**Ash**	61 (134)	96 (211)
Air (CO_2)	373 (822)	400 (882)	**Stack Gas**	18,487 (40,756)	19,967 (44,019)
Activated Carbon	61 (134)	96 (211)	**CO_2 Product**	166,379 (366,802)	179,701 (396,172)
Total	**184,726 (407,251)**	**199,763 (440,403)**	**Total**	**184,726 (407,251)**	**199,763 (440,403)**

Exhibit 4-52 Cases S13B and L13B Carbon Balance

Carbon In, kg/hr (lb/hr)			Carbon Out, kg/hr (lb/hr)		
	S13B	**L13B**		**S13B**	**L13B**
Coal	173,557 (382,627)	187,285 (412,893)	**Ash**	57 (126)	90 (198)
Air (CO_2)	352 (775)	377 (830)	**Stack Gas**	17,391 (38,340)	18,766 (41,372)
Activated Carbon	57 (126)	90 (198)	**CO_2 Product**	156,517 (345,061)	168,895 (372,350)
Total	**173,965 (383,528)**	**187,751 (413,921)**	**Total**	**173,965 (383,528)**	**187,751 (413,921)**

Carbon in the air is not neglected here since the Aspen model accounts for air components throughout. The activated carbon injected for mercury removal is captured in the baghouse and removed with the ash.

Exhibit 4-53 and Exhibit 4-54 show the sulfur balances for the four capture PC cases. Sulfur input comes solely from the sulfur in the coal. Sulfur output is the sulfur combined with lime in the ash, the sulfur from the polishing scrubber, and the SO_2 emitted in the stack gas. The sulfur exits the Econamine system in the form of sodium sulfite and HSS.

Exhibit 4-53 Cases S12B and L12B Sulfur Balance

Sulfur In, kg/hr (lb/hr)			Sulfur Out, kg/hr (lb/hr)		
	S12B	**L12B**		**S12B**	**L12B**
Coal	2,678 (5,903)	3,156 (6,957)	**Ash**	2,490 (5,490)	2,935 (6,470)
			Polishing Scrubber / Econamine FG+	185 (408)	218 (481)
			Stack Gas	2 (5)	3 (6)
Total	**2,678 (5,903)**	**3,156 (6,957)**	**Total**	**2,678 (5,903)**	**3,156 (6,957)**

Exhibit 4-54 Cases S13B and L13B Sulfur Balance

Sulfur In, kg/hr (lb/hr)			Sulfur Out, kg/hr (lb/hr)		
	S13B	**L13B**		**S13B**	**L13B**
Coal	2,522 (5,559)	2,966 (6,593)	**Ash**	2,345 (5,170)	2,758 (6,081)
			Polishing Scrubber / Econamine FG+	174 (384)	205 (452)
			Stack Gas	2 (5)	2 (5)
Total	**2,522 (5,559)**	**2,966 (6,593)**	**Total**	**2,522 (5,559)**	**2,966 (6,539)**

Exhibit 4-55, Exhibit 4-56, Exhibit 4-57, and Exhibit 4-58 show the overall water balances for the plants. Raw water withdrawal is obtained from groundwater (50 percent) and from municipal sources (50 percent). Water demand represents the total amount of water required for a particular process. Some water is recovered within the process and that water is re-used as internal recycle. Raw water withdrawal is the difference between water demand and internal recycle. Some water is discharged from the process to a permitted outfall. The difference between the withdrawal and discharge is the consumption.

Exhibit 4-55 Case S12B Water Balance

Water Use	Water Demand, m^3/min (gpm)	Internal Recycle, m^3/min (gpm)	Raw Water Withdrawal, m^3/min (gpm)	Process Water Discharge, m^3/min (gpm)	Raw Water Consumption, m^3/min (gpm)
Econamine	0.15 (40)	0 (0)	0.15 (40)	0 (0)	0.15 (40)
FGD Makeup	1.34 (355)	0 (0)	1.34 (355)	0 (0)	1.34 (355)
BFW Makeup	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cooling Tower Makeup	35.6 (9,406)	8.17 (2,158)	27.4 (7,248)	8.01 (2,115)	19.43 (5,133)
Total	**37.1 (9,800)**	**8.17 (2,158)**	**28.9 (7,642)**	**8.01 (2,115)**	**20.92 (5,527)**

Exhibit 4-56 Case L12B Water Balance

Water Use	Water Demand, m^3/min (gpm)	Internal Recycle, m^3/min (gpm)	Raw Water Withdrawal, m^3/min (gpm)	Process Water Discharge, m^3/min (gpm)	Raw Water Consumption, m^3/min (gpm)
Econamine	0.16 (43)	0 (0)	0.16 (43)	0 (0)	0.16 (43)
FGD Makeup	1.52 (402)	0 (0)	1.52 (402)	0 (0)	1.52 (402)
BFW Makeup	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cooling Tower Makeup	39.7 (10,497)	11.8 (3,125)	27.9 (7,372)	8.9 (2,361)	19.0 (5,011)
Total	**41.4 (10,941)**	**11.8 (3,125)**	**29.6 (7,817)**	**8.9 (2,361)**	**20.7 (5,456)**

Exhibit 4-57 Case S13B Water Balance

Water Use	Water Demand, m^3/min (gpm)	Internal Recycle, m^3/min (gpm)	Raw Water Withdrawal, m^3/min (gpm)	Process Water Discharge, m^3/min (gpm)	Raw Water Consumption, m^3/min (gpm)
Econamine	0.14 (37)	0 (0)	0.14 (37)	0 (0)	0.14 (37)
FGD Makeup	1.27 (334)	0 (0)	1.27 (334)	0 (0)	1.27 (334)
BFW Makeup	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cooling Tower Makeup	33.3 (8,786)	7.72 (2,041)	25.5 (6,745)	7.48 (1,976)	18.05 (4,769)
Total	**34.7 (9,157)**	**7.72 (2,041)**	**26.9 (7,117)**	**7.48 (1,976)**	**19.46 (5,141)**

Exhibit 4-58 Case L13B Water Balance

Water Use	Water Demand, m^3/min (gpm)	Internal Recycle, m^3/min (gpm)	Raw Water Withdrawal, m^3/min (gpm)	Process Water Discharge, m^3/min (gpm)	Raw Water Consumption, m^3/min (gpm)
Econamine	0.15 (40)	0 (0)	0.15 (40)	0 (0)	0.15 (40)
FGD Makeup	1.43 (378)	0 (0)	1.43 (378)	0 (0)	1.43 (378)
BFW Makeup	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cooling Tower Makeup	37.1 (9,788)	11.15 (2,945)	25.9 (6,843)	8.33 (2,201)	17.57 (4,642)
Total	**38.6 (10,206)**	**11.15 (2,945)**	**27.5 (7,261)**	**8.33 (2,201)**	**19.15 (5,060)**

Heat and Mass Balance Diagrams

Heat and mass balance diagrams are shown for the following subsystems in Exhibit 4-59 through Exhibit 4-66:

- Boiler and flue gas cleanup
- Steam and FW

Overall plant energy balances are provided in tabular form in Exhibit 4-67 for the two SC cases and in Exhibit 4-68 for the two USC cases. The sulfur exits the Econamine system in the form of sodium sulfite and HSS, but is shown as SO_2. The power out is the steam turbine power after generator losses.

Exhibit 4-59 Case S12B Boiler and Gas Cleanup System Heat and Mass Balance Diagram

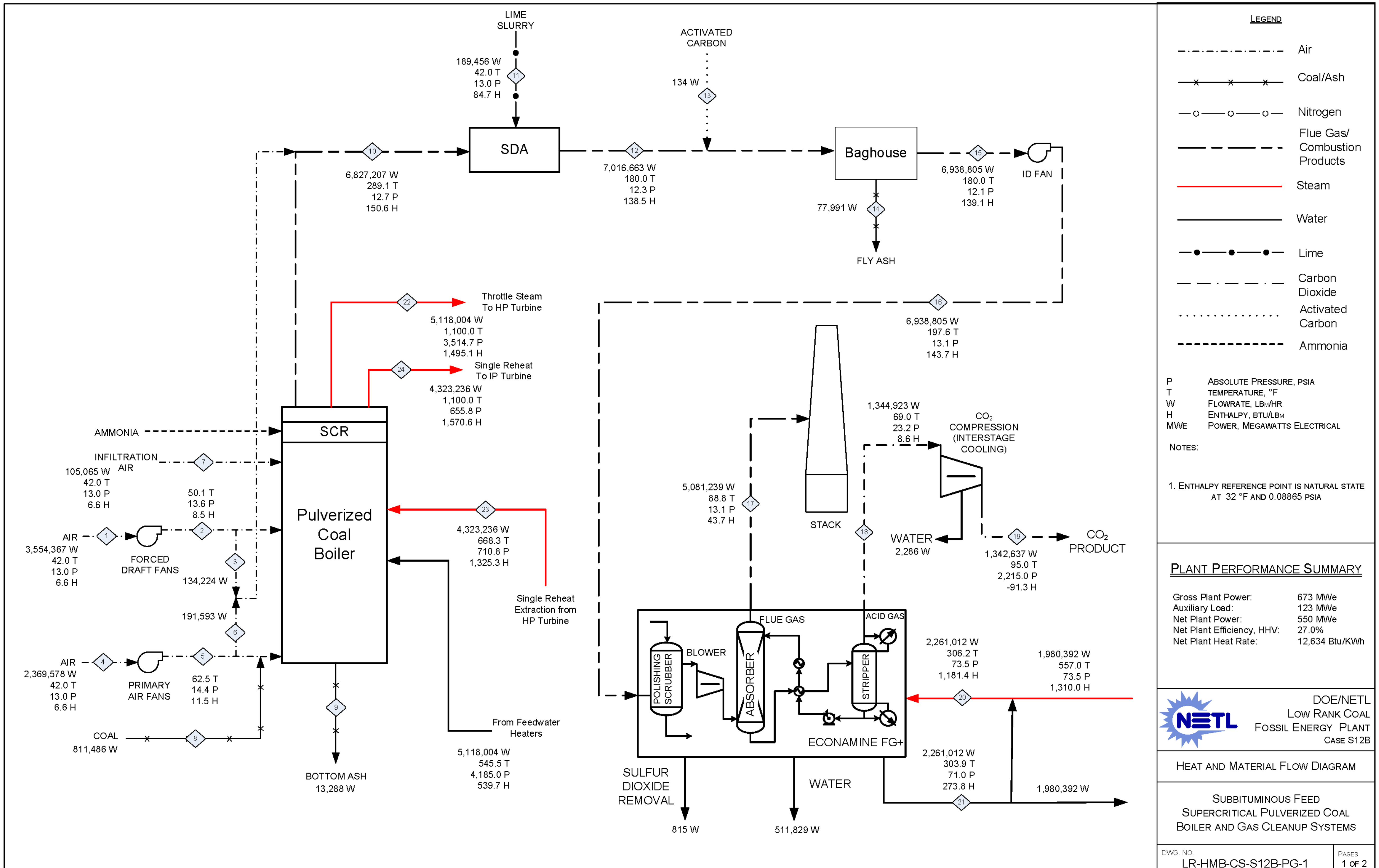

Exhibit 4-60 Case S12B Power Block System Heat and Mass Balance Diagram

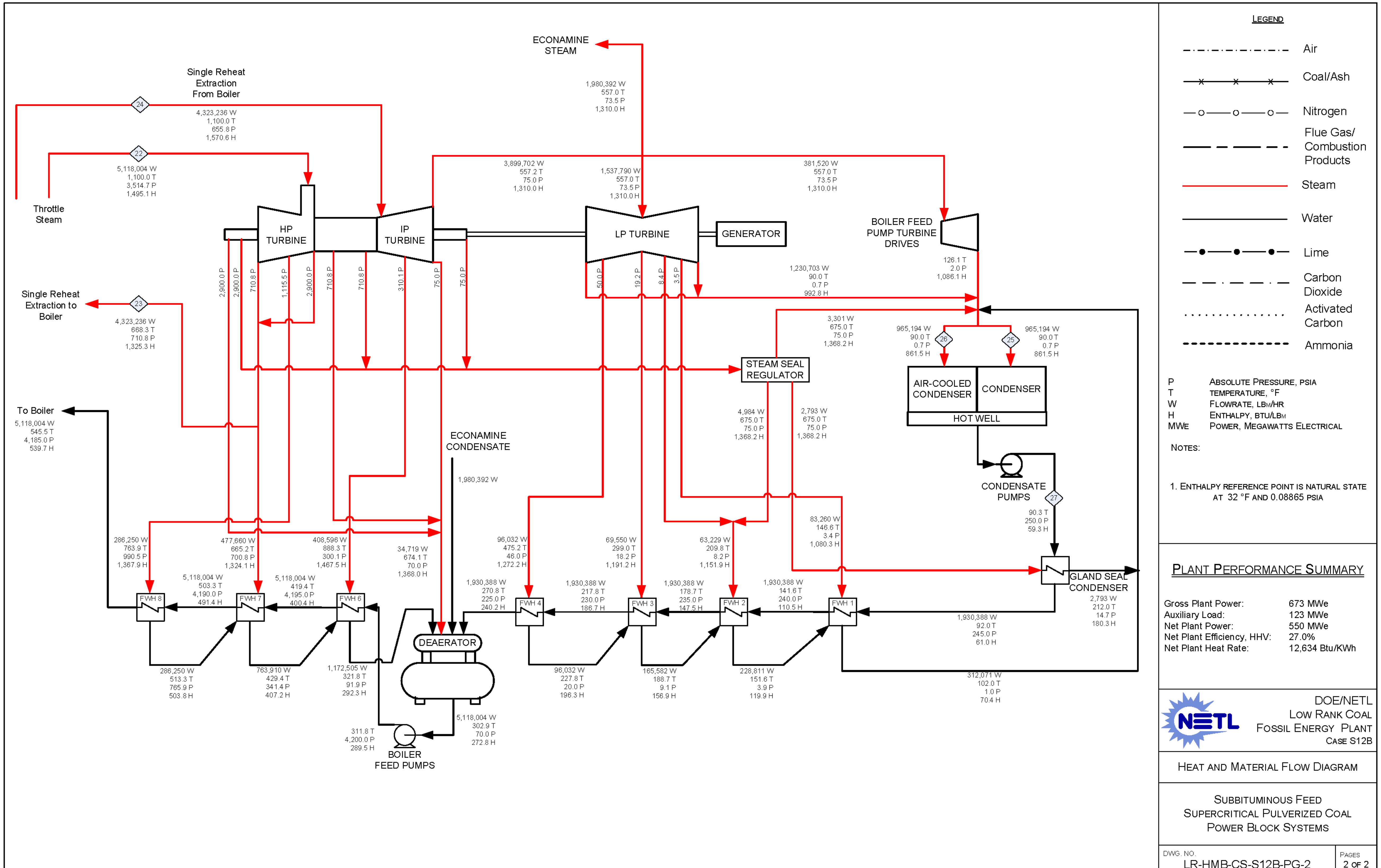

Exhibit 4-61 Case L12B Boiler and Gas Cleanup System Heat and Mass Balance Diagram

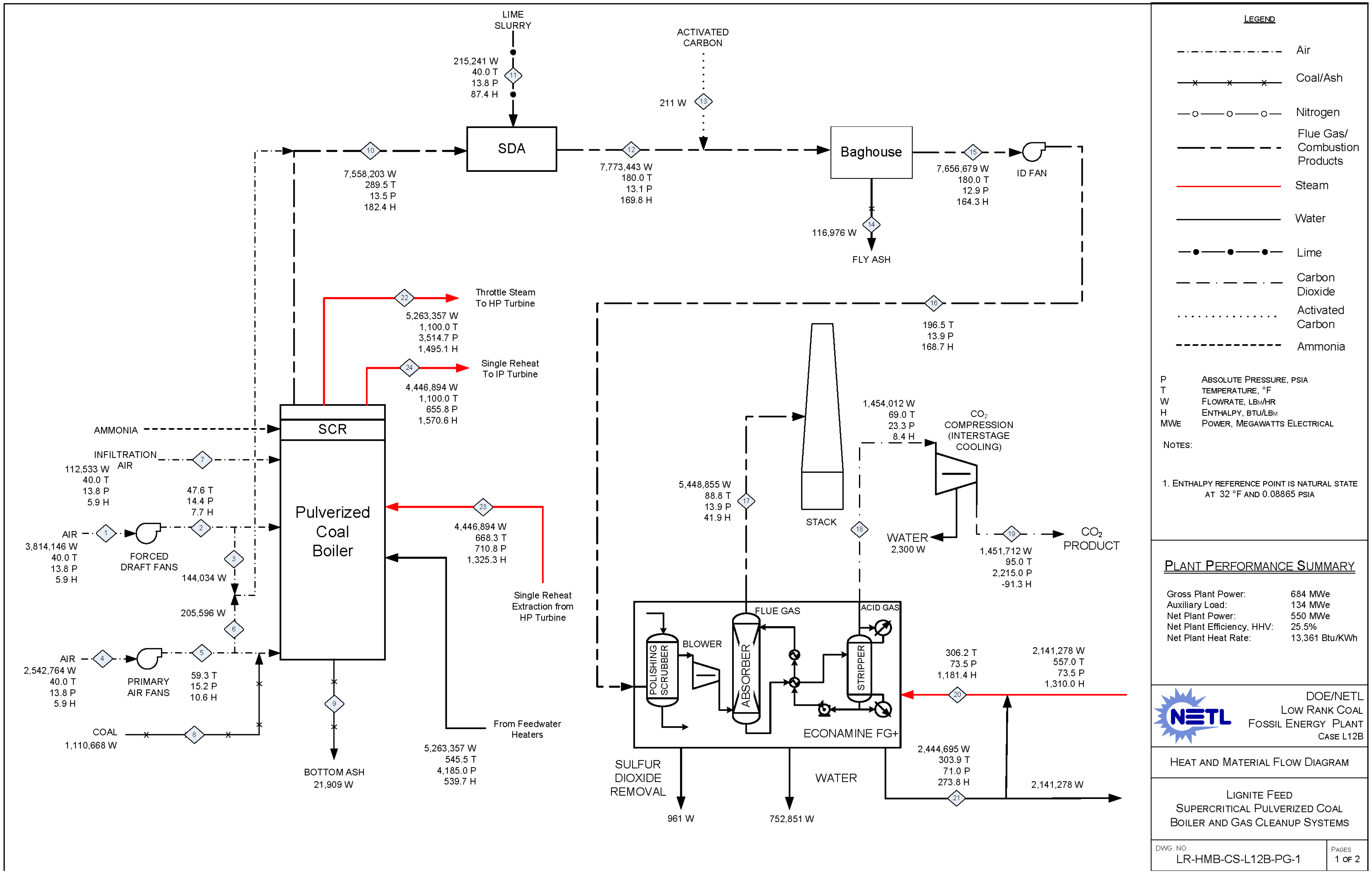

Exhibit 4-62 Case L12B Power Block System Heat and Mass Balance Diagram

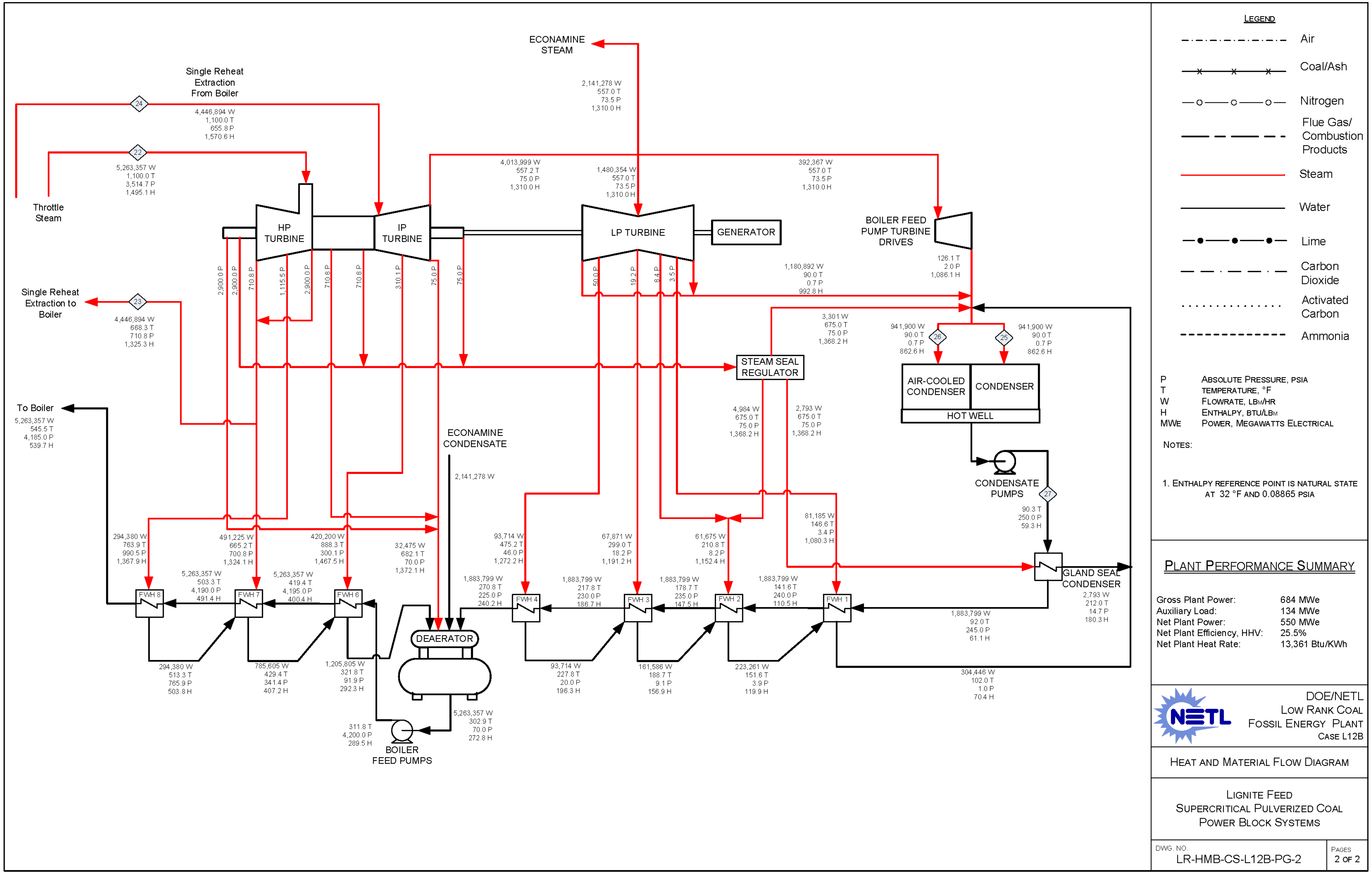

Exhibit 4-63 Case S13B Boiler and Gas Cleanup System Heat and Mass Balance Diagram

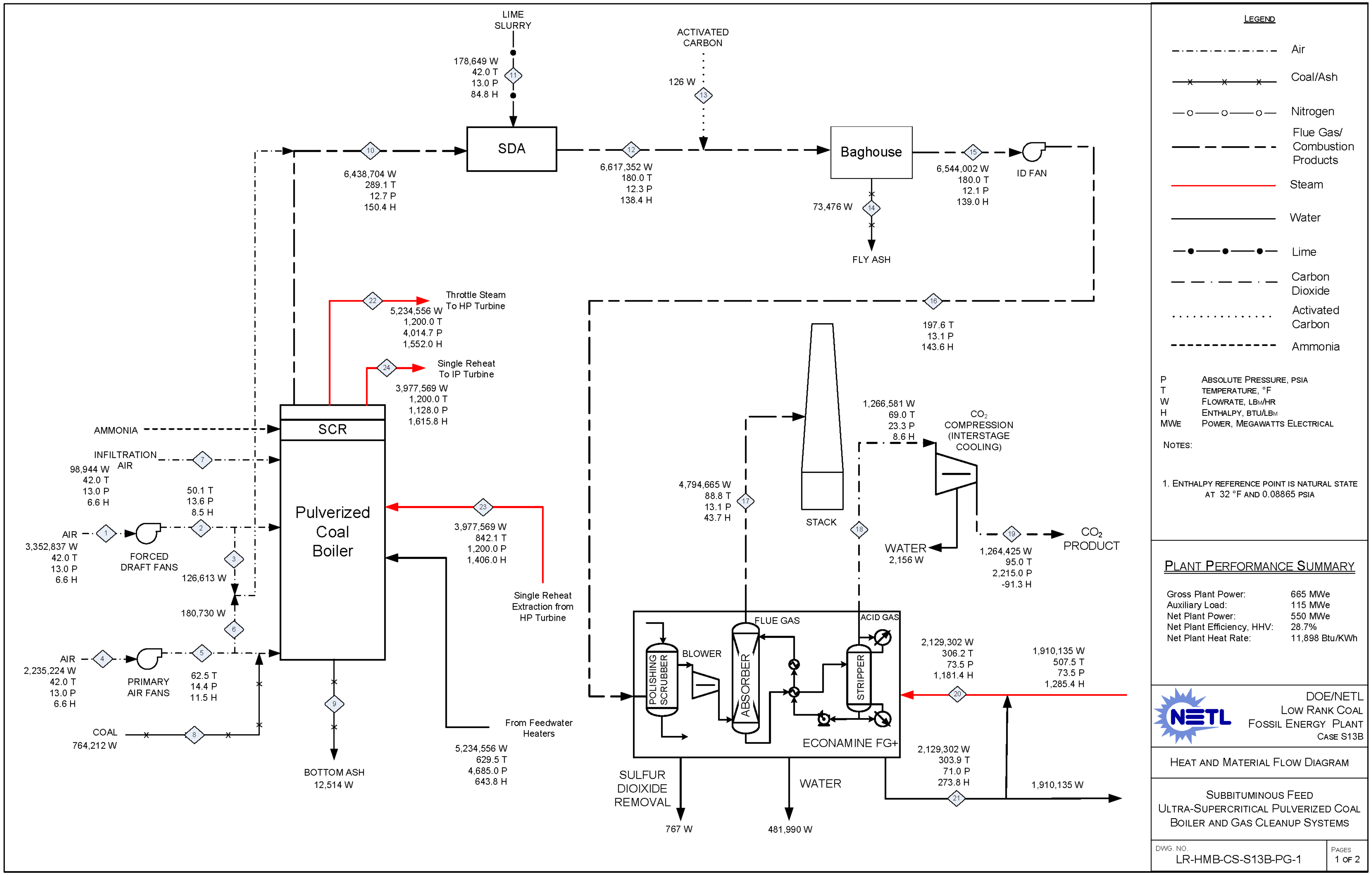

Exhibit 4-64 Case S13B Power Block System Heat and Mass Balance Diagram

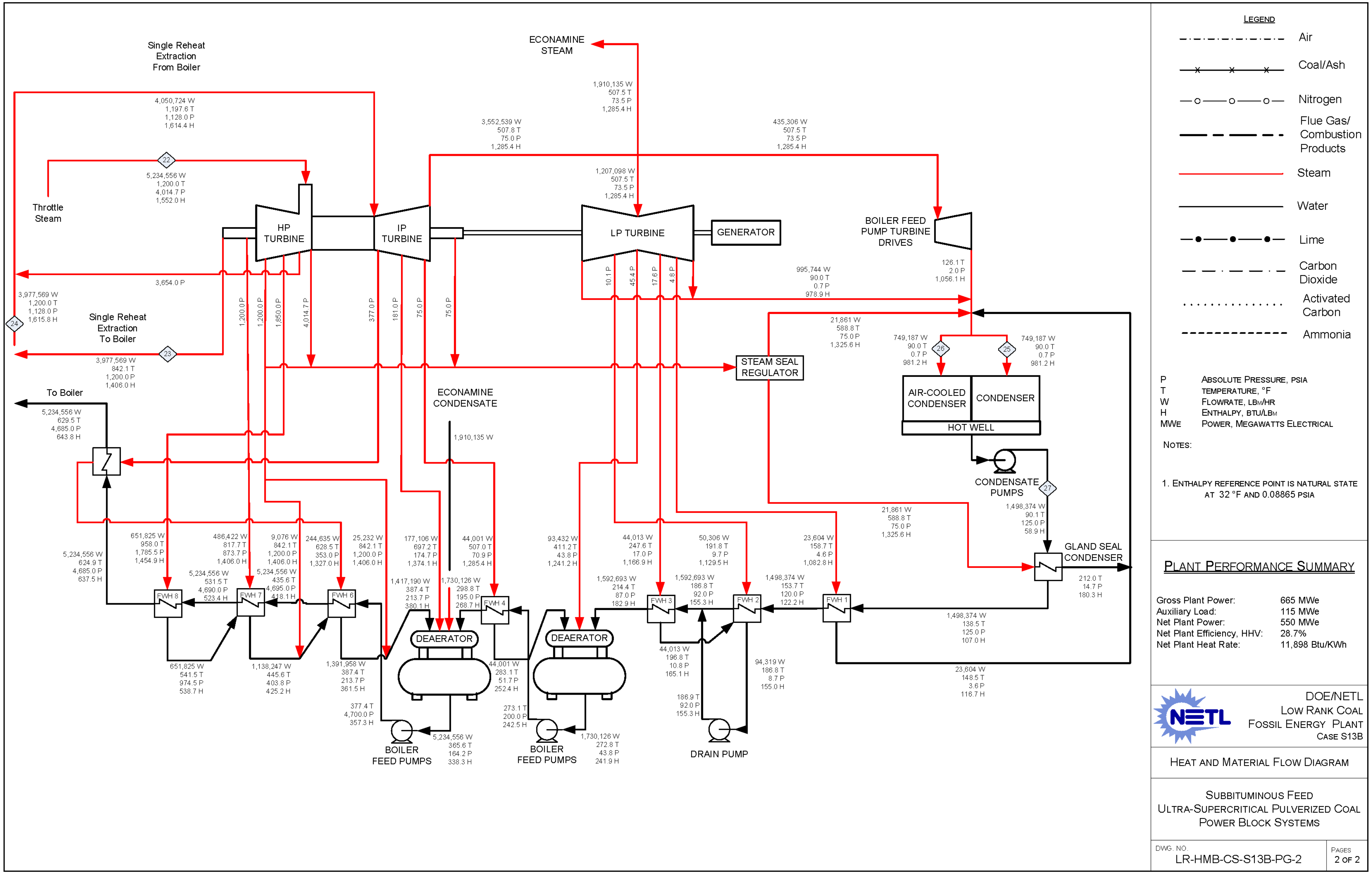

Exhibit 4-65 Case L13B Boiler and Gas Cleanup System Heat and Mass Balance Diagram

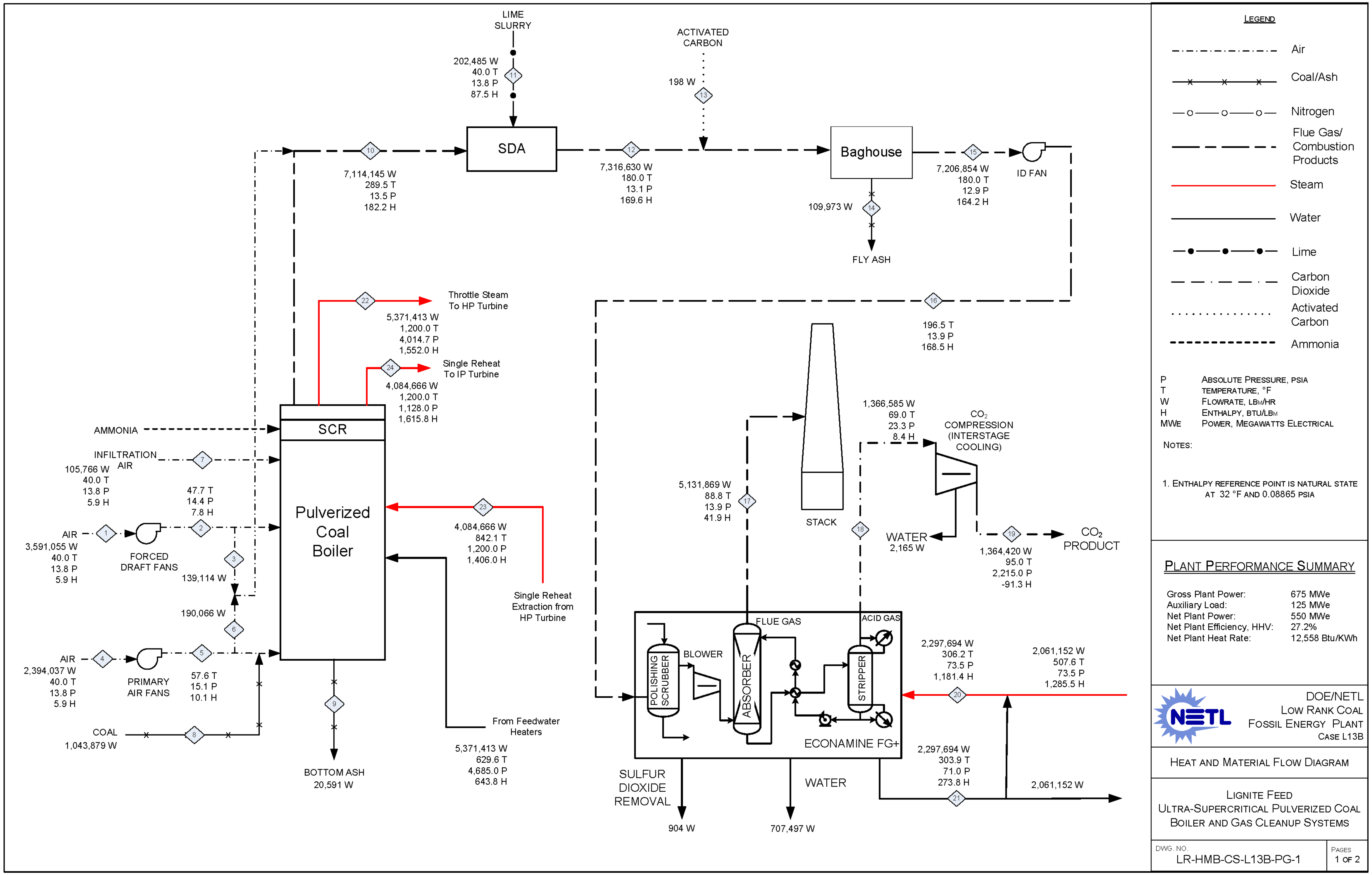

Exhibit 4-66 Case L13B Power Block System Heat and Mass Balance Diagram

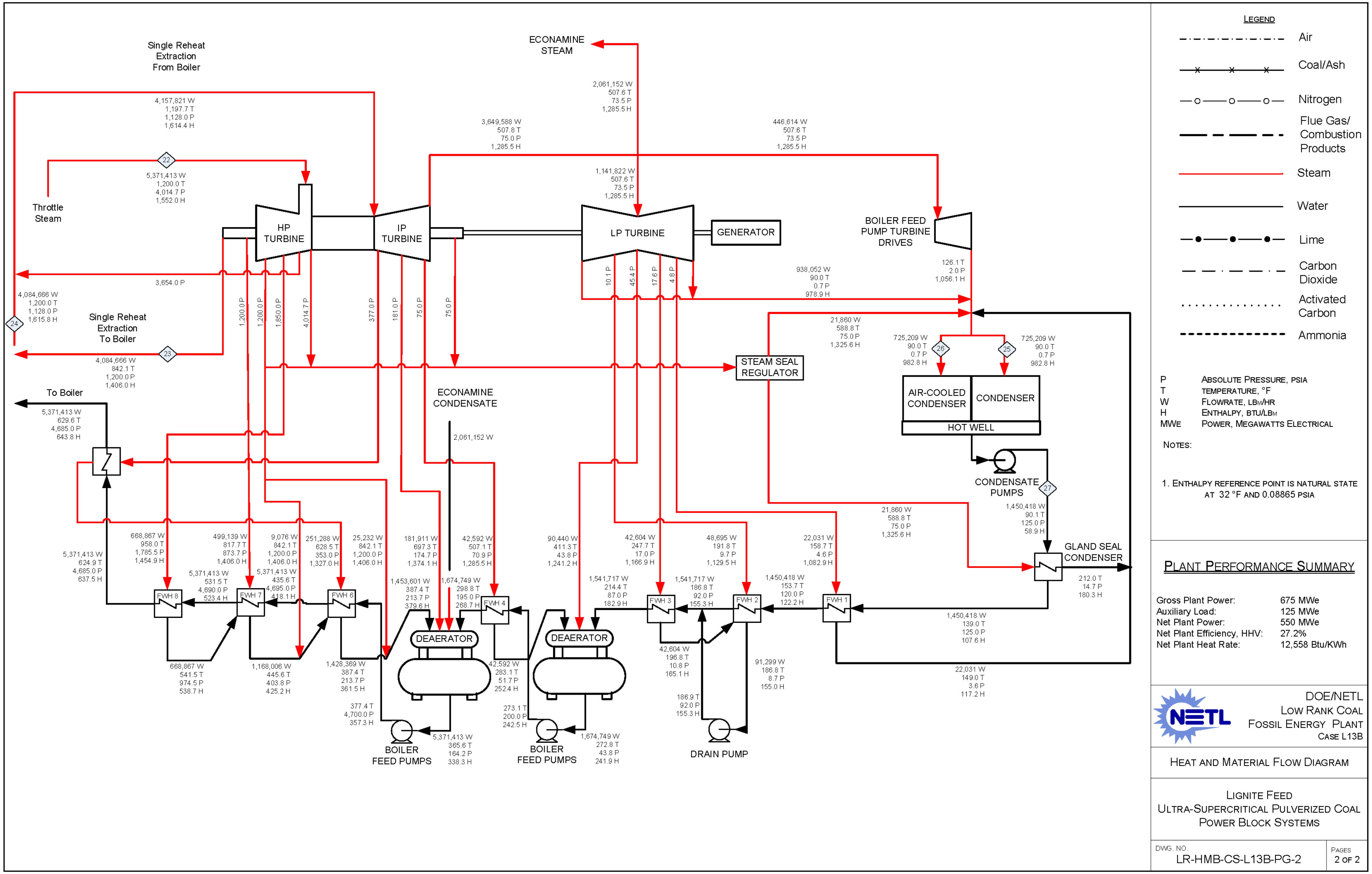

Exhibit 4-67 Cases S12B and L12B Energy Balance (0°C [32°F] Reference)

	HHV		Sensible + Latent		Power		Total	
	S12B	L12B	S12B	L12B	S12B	L12B	S12B	L12B
Heat In, GJ/hr (MMBtu/hr)								
Coal	7,332 (6,950)	7,754 (7,349)	3.8 (3.6)	4.5 (4.3)			7,336 (6,953)	7,758 (7,354)
Combustion Air			41.7 (39.6)	40.3 (38.2)			41.7 (39.6)	40.3 (38.2)
Raw Water Makeup			40.3 (38.2)	33.0 (31.3)			40.3 (38.2)	33.0 (31.3)
Lime			0.02 (0.02)	0.02 (0.02)			0.02 (0.02)	0.02 (0.02)
Auxiliary Power					443 (419)	482 (457)	443 (419)	482 (457)
Totals	**7,332 (6,950)**	**7,754 (7,349)**	**85.8 (81.4)**	**77.8 (73.8)**	**443 (419)**	**482 (457)**	**7,861 (7,450)**	**8,314 (7,880)**
Heat Out, GJ/hr (MMBtu/hr)								
Bottom Ash			0.7 (0.6)	1.1 (1.1)			0.7 (0.6)	1.1 (1.1)
Fly Ash + FGD Ash			2.3 (2.2)	3.5 (3.3)			2.3 (2.2)	3.5 (3.3)
Flue Gas			234 (222)	241 (229)			234 (222)	241 (229)
Condenser			1,636 (1,550)	1,598 (1,515)			1,636 (1,550)	1,598 (1,515)
CO_2			-129 (-123)	-140 (-133)			-129 (-123)	-140 (-133)
Cooling Tower Blowdown			44.6 (42.3)	48.4 (45.9)			44.6 (42.3)	48.4 (45.9)
Econamine Losses			3,316 (3,143)	3,810 (3,611)			3,316 (3,143)	3,810 (3,611)
Process Losses[1]			333.5 (316.1)	289.1 (274.0)			333.5 (316.1)	289.1 (274.0)
Power					2,423 (2,296)	2,462 (2,334)	2,423 (2,296)	2,462 (2,334)
Totals	**0 (0)**	**0 (0)**	**5,438 (5,154)**	**5,852 (5,546)**	**2,423 (2,296)**	**2,462 (2,334)**	**7,861 (7,450)**	**8,314 (7,880)**

[1] Process losses including steam turbine, combustion reactions, and gas cooling are estimated to match the heat input to the plant.

Exhibit 4-68 Cases S13B and L13B Energy Balance (0°C [32°F] Reference)

	HHV		Sensible + Latent		Power		Total	
	S13B	L13B	S13B	L13B	S13B	L13B	S13B	L13B
Heat In, GJ/hr (MMBtu/hr)								
Coal	6,905 (6,545)	7,288 (6,907)	3.5 (3.4)	4.2 (4.0)			6,909 (6,548)	7,292 (6,911)
Combustion Air			39.4 (37.3)	38.0 (36.0)			39.4 (37.3)	38.0 (36.0)
Raw Water Makeup			37.5 (35.6)	30.6 (29.0)			37.5 (35.6)	30.6 (29.0)
Lime			0.02 (0.02)	0.02 (0.02)			0.02 (0.02)	0.02 (0.02)
Auxiliary Power					415 (393)	451 (427)	415 (393)	451 (427)
Totals	**6,905 (6,545)**	**7,288 (6,907)**	**80.5 (76.3)**	**72.9 (69.1)**	**415 (393)**	**451 (427)**	**7,401 (7,014)**	**7,811 (7,404)**
Heat Out, GJ/hr (MMBtu/hr)								
Bottom Ash			0.6 (0.6)	1.0 (1.0)			0.6 (0.6)	1.0 (1.0)
Fly Ash + FGD Ash			2.2 (2.1)	3.3 (3.1)			2.2 (2.1)	3.3 (3.1)
Flue Gas			221 (209)	227 (215)			221 (209)	227 (215)
Condenser			1,459 (1,383)	1,415 (1,341)			1,459 (1,383)	1,415 (1,341)
CO_2			-122 (-115)	-131 (-125)			-122 (-115)	-131 (-125)
Cooling Tower Blowdown			41.7 (39.5)	45.1 (42.8)			41.7 (39.5)	45.1 (42.8)
Econamine Losses			3,122 (2,959)	3,580 (3,393)			3,122 (2,959)	3,580 (3,393)
Process Losses*			281.0 (266.3)	240.8 (228.3)			281.0 (266.3)	240.8 (228.3)
Power					2,395 (2,270)	2,431 (2,304)	2,395 (2,270)	2,431 (2,304)
Totals	**0 (0)**	**0 (0)**	**5,005 (4,744)**	**5,380 (5,100)**	**2,395 (2,270)**	**2,431 (2,304)**	**7,401 (7,014)**	**7,811 (7,404)**

* Process losses including steam turbine, combustion reactions, and gas cooling are estimated to match the heat input to the plant.

4.2.5 PC Cases with CO_2 Capture Equipment Lists

Major equipment items for SC and USC PC with CO_2 capture and using PRB or lignite coal are shown in the following tables. The equipment lists are not meant to be comprehensive, but rather representative. The accounts used in the equipment list correspond to the account numbers used in the cost estimates in Section 4.2.6. In general, the design conditions include a 10 percent contingency for flows and heat duties and a 21 percent contingency for heads on pumps and fans.

ACCOUNT 1 FUEL AND SORBENT HANDLING

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
1	Bottom Trestle Dumper and Receiving Hoppers	N/A	2(0)	181 tonne (200 ton)	181 tonne (200 ton)	181 tonne (200 ton)	181 tonne (200 ton)
2	Feeder	Belt	2(0)	572 tonne/hr (630 tph)	572 tonne/hr (630 tph)	572 tonne/hr (630 tph)	572 tonne/hr (630 tph)
3	Conveyor No. 1	Belt	1(0)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)
4	Transfer Tower No. 1	Enclosed	1(0)	N/A	N/A	N/A	N/A
5	Conveyor No. 2	Belt	1(0)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)
6	As-Received Coal Sampling System	Two-stage	1(0)	N/A	N/A	N/A	N/A
7	Stacker/Reclaimer	Traveling, linear	1(0)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)
8	Reclaim Hopper	N/A	2(1)	73 tonne (80 ton)	109 tonne (120 ton)	73 tonne (80 ton)	100 tonne (110 ton)
9	Feeder	Vibratory	2(1)	308 tonne/hr (340 tph)	417 tonne/hr (460 tph)	290 tonne/hr (320 tph)	390 tonne/hr (430 tph)
10	Conveyor No. 3	Belt w/ tripper	1(0)	608 tonne/hr (670 tph)	835 tonne/hr (920 tph)	572 tonne/hr (630 tph)	780 tonne/hr (860 tph)
11	Crusher Tower	N/A	1(0)	N/A	N/A	N/A	N/A
12	Coal Surge Bin w/ Vent Filter	Dual outlet	2(0)	308 tonne (340 ton)	417 tonne (460 ton)	290 tonne (320 ton)	390 tonne (430 ton)
13	Crusher	Impactor reduction	2(0)	8cm x 0 - 3cm x 0 (3” x 0 - 1-1/4” x 0)	8cm x 0 - 3cm x 0 (3” x 0 - 1-1/4” x 0)	8cm x 0 - 3cm x 0 (3” x 0 - 1-1/4” x 0)	8cm x 0 - 3cm x 0 (3” x 0 - 1-1/4” x 0)
14	As-Fired Coal Sampling System	Swing hammer	1(1)	N/A	N/A	N/A	N/A
15	Conveyor No. 4	Belt w/tripper	1(0)	608 tonne/hr (670 tph)	835 tonne/hr (920 tph)	572 tonne/hr (630 tph)	780 tonne/hr (860 tph)
16	Transfer Tower No. 2	Enclosed	1(0)	N/A	N/A	N/A	N/A

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
17	Conveyor No. 5	Belt w/ tripper	1(0)	608 tonne/hr (670 tph)	835 tonne/hr (920 tph)	572 tonne/hr (630 tph)	780 tonne/hr (860 tph)
18	Coal Silo w/ Vent Filter and Slide Gates	Field erected	6(0)	635 tonne (700 ton)	907 tonne (1,000 ton)	635 tonne (700 ton)	907 tonne (1,000 ton)
19	Lime Truck Unloading System	N/A	1(0)	27 tonne/hr (30 tph)	27 tonne/hr (30 tph)	18 tonne/hr (20 tph)	27 tonne/hr (30 tph)
20	Lime Bulk Storage Silo w/Vent Filter	Field erected	3(0)	726 tonne (800 ton)	816 tonne (900 ton)	635 tonne (700 ton)	726 tonne (800 ton)
21	Lime Live Storage Transport	Pneumatic	1(0)	9 tonne/hr (10 tph)	11 tonne/hr (12 tph)	9 tonne/hr (10 tph)	10 tonne/hr (11 tph)
22	Lime Day Bin	w/ actuator	2(0)	73 tonne (80 ton)	91 tonne (100 ton)	73 tonne (80 ton)	82 tonne (90 ton)
23	Activated Carbon Storage Silo and Feeder System with Vent Filter	Shop assembled	1(0)	Silo - 45 tonne (50 ton) Feeder - 68 kg/hr (150 lb/hr)	Silo - 73 tonne (80 ton) Feeder - 104 kg/hr (230 lb/hr)	Silo - 45 tonne (50 ton) Feeder - 64 kg/hr (140 lb/hr)	Silo - 73 tonne (80 ton) Feeder - 100 kg/hr (220 lb/hr)

ACCOUNT 2 COAL AND SORBENT PREPARATION AND FEED

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
1	Coal Feeder	Gravimetric	6(0)	64 tonne/hr (70 tph)	91 tonne/hr (100 tph)	64 tonne/hr (70 tph)	91 tonne/hr (100 tph)
2	Coal Pulverizer	Ball type or equivalent	6(0)	64 tonne/hr (70 tph)	91 tonne/hr (100 tph)	64 tonne/hr (70 tph)	91 tonne/hr (100 tph)
3	Lime Slaker	N/A	1(1)	8 tonne/hr (9 tph)	10 tonne/hr (11 tph)	8 tonne/hr (9 tph)	9 tonne/hr (10 tph)
4	Lime Slurry Tank	Field Erected	1(1)	389,900 liters (103,000 gal)	458,038 liters (121,000 gal)	367,188 liters (97,000 gal)	431,540 liters (114,000 gal)
5	Lime Slurry Feed Pumps	Horizontal centrifugal	1(1)	416 lpm @ 9m H_2O (110 gpm @ 30 ft H_2O)	492 lpm @ 9m H_2O (130 gpm @ 30 ft H_2O)	379 lpm @ 9m H_2O (100 gpm @ 30 ft H_2O)	454 lpm @ 9m H_2O (120 gpm @ 30 ft H_2O)

ACCOUNT 3 FEEDWATER AND MISCELLANEOUS SYSTEMS AND EQUIPMENT

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
1	Demineralized Water Storage Tank	Vertical, cylindrical, outdoor	2(0)	1,536,877 liters (406,000 gal)	1,578,517 liters (417,000 gal)	1,570,946 liters (415,000 gal)	1,612,585 liters (426,000 gal)
2	Condensate Pumps	Vertical canned	1(1)	16,656 lpm @ 213 m H_2O (4,400 gpm @ 700 ft H_2O)	16,277 lpm @ 213 m H_2O (4,300 gpm @ 700 ft H_2O)	12,870 lpm @ 91 m H_2O (3,400 gpm @ 300 ft H_2O)	12,492 lpm @ 91 m H_2O (3,300 gpm @ 300 ft H_2O)
3	Deaerator and Storage Tank	Horizontal spray type	1(0)	2,556,450 kg/hr (5,636,000 lb/hr), 5 min. tank	2,629,021 kg/hr (5,796,000 lb/hr), 5 min. tank	2,614,053 kg/hr (5,763,000 lb/hr), 5 min. tank	2,683,545 kg/hr (5,914,000 lb/hr), 5 min. tank
4	Boiler Feed Pump/Turbine	Barrel type, multi-stage, centrifugal	1(1)	42,775 lpm @ 3,505 m H_2O (11,300 gpm @ 11,500 ft H_2O)	44,289 lpm @ 3,505 m H_2O (11,700 gpm @ 11,500 ft H_2O)	43,911 lpm @ 3,871 m H_2O (11,600 gpm @ 12,700 ft H_2O)	45,046 lpm @ 3,871 m H_2O (11,900 gpm @ 12,700 ft H_2O)
5	Startup Boiler Feed Pump, Electric Motor Driven	Barrel type, multi-stage, centrifugal	1(0)	12,870 lpm @ 3,505 m H_2O (3,400 gpm @ 11,500 ft H_2O)	13,249 lpm @ 3,505 m H_2O (3,500 gpm @ 11,500 ft H_2O)	13,249 lpm @ 3,871 m H_2O (3,500 gpm @ 12,700 ft H_2O)	13,249 lpm @ 3,871 m H_2O (3,500 gpm @ 12,700 ft H_2O)
6	LP Feedwater Heater 1A/1B	Horizontal U-tube	2(0)	494,416 kg/hr (1,090,000 lb/hr)	485,344 kg/hr (1,070,000 lb/hr)	385,554 kg/hr (850,000 lb/hr)	371,946 kg/hr (820,000 lb/hr)
7	LP Feedwater Heater 2A/2B	Horizontal U-tube	2(0)	494,416 kg/hr (1,090,000 lb/hr)	485,344 kg/hr (1,070,000 lb/hr)	385,554 kg/hr (850,000 lb/hr)	371,946 kg/hr (820,000 lb/hr)
8	LP Feedwater Heater 3A/3B	Horizontal U-tube	2(0)	494,416 kg/hr (1,090,000 lb/hr)	485,344 kg/hr (1,070,000 lb/hr)	385,554 kg/hr (850,000 lb/hr)	371,946 kg/hr (820,000 lb/hr)
9	LP Feedwater Heater 4A/4B	Horizontal U-tube	2(0)	494,416 kg/hr (1,090,000 lb/hr)	485,344 kg/hr (1,070,000 lb/hr)	385,554 kg/hr (850,000 lb/hr)	371,946 kg/hr (820,000 lb/hr)
10	HP Feedwater Heater 6	Horizontal U-tube	1(0)	2,558,261 kg/hr (5,640,000 lb/hr)	2,630,836 kg/hr (5,800,000 lb/hr)	2,612,692 kg/hr (5,760,000 lb/hr)	2,680,731 kg/hr (5,910,000 lb/hr)
11	HP Feedwater Heater 7	Horizontal U-tube	1(0)	2,558,261 kg/hr (5,640,000 lb/hr)	2,630,836 kg/hr (5,800,000 lb/hr)	2,612,692 kg/hr (5,760,000 lb/hr)	2,680,731 kg/hr (5,910,000 lb/hr)
12	HP Feedwater heater 8	Horizontal U-tube	1(0)	2,558,261 kg/hr (5,640,000 lb/hr)	2,630,836 kg/hr (5,800,000 lb/hr)	2,612,692 kg/hr (5,760,000 lb/hr)	2,680,731 kg/hr (5,910,000 lb/hr)

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
13	Auxiliary Boiler	Shop fabricated, water tube	1(0)	18,144 kg/hr, 2.8 MPa, 343°C (40,000 lb/hr, 400 psig, 650°F)	18,144 kg/hr, 2.8 MPa, 343°C (40,000 lb/hr, 400 psig, 650°F)	18,144 kg/hr, 2.8 MPa, 343°C (40,000 lb/hr, 400 psig, 650°F)	18,144 kg/hr, 2.8 MPa, 343°C (40,000 lb/hr, 400 psig, 650°F)
14	Fuel Oil System	No. 2 fuel oil for light off	1(0)	1,135,624 liter (300,000 gal)	1,135,624 liter (300,000 gal)	1,135,624 liter (300,000 gal)	1,135,624 liter (300,000 gal)
15	Service Air Compressors	Flooded Screw	2(1)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)
16	Instrument Air Dryers	Duplex, regenerative	2(1)	28 m^3/min (1,000 scfm)	28 m^3/min (1,000 scfm)	28 m^3/min (1,000 scfm)	28 m^3/min (1,000 scfm)
17	Closed Cycle Cooling Heat Exchangers	Shell and tube	2(0)	53 GJ/hr (50 MMBtu/hr) each	53 GJ/hr (50 MMBtu/hr) each	53 GJ/hr (50 MMBtu/hr) each	53 GJ/hr (50 MMBtu/hr) each
18	Closed Cycle Cooling Water Pumps	Horizontal centrifugal	2(1)	20,820 lpm @ 30 m H_2O (5,500 gpm @ 100 ft H_2O)	20,820 lpm @ 30 m H_2O (5,500 gpm @ 100 ft H_2O)	20,820 lpm @ 30 m H_2O (5,500 gpm @ 100 ft H_2O)	20,820 lpm @ 30 m H_2O (5,500 gpm @ 100 ft H_2O)
19	Engine-Driven Fire Pump	Vertical turbine, diesel engine	1(1)	3,785 lpm @ 88 m H_2O (1,000 gpm @ 290 ft H_2O)	3,785 lpm @ 88 m H_2O (1,000 gpm @ 290 ft H_2O)	3,785 lpm @ 88 m H_2O (1,000 gpm @ 290 ft H_2O)	3,785 lpm @ 88 m H_2O (1,000 gpm @ 290 ft H_2O)
20	Fire Service Booster Pump	Two-stage horizontal centrifugal	1(1)	2,650 lpm @ 64 m H_2O (700 gpm @ 210 ft H_2O)	2,650 lpm @ 64 m H_2O (700 gpm @ 210 ft H_2O)	2,650 lpm @ 64 m H_2O (700 gpm @ 210 ft H_2O)	2,650 lpm @ 64 m H_2O (700 gpm @ 210 ft H_2O)
21	Raw Water Pumps	Stainless steel, single suction	2(1)	8,858 lpm @ 43 m H_2O (2,340 gpm @ 140 ft H_2O)	19,003 lpm @ 43 m H_2O (5,020 gpm @ 140 ft H_2O)	8,290 lpm @ 43 m H_2O (2,190 gpm @ 140 ft H_2O)	8,858 lpm @ 43 m H_2O (2,340 gpm @ 140 ft H_2O)
22	Ground Water Pumps	Stainless steel, single suction	2(1)	2,953 lpm @ 268 m H_2O (780 gpm @ 880 ft H_2O)	2,725 lpm @ 268 m H_2O (720 gpm @ 880 ft H_2O)	2,763 lpm @ 268 m H_2O (730 gpm @ 880 ft H_2O)	2,953 lpm @ 268 m H_2O (780 gpm @ 880 ft H_2O)

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
23	Filtered Water Pumps	Stainless steel, single suction	2(1)	492 lpm @ 49 m H_2O (130 gpm @ 160 ft H_2O)	530 lpm @ 49 m H_2O (140 gpm @ 160 ft H_2O)	530 lpm @ 49 m H_2O (140 gpm @ 160 ft H_2O)	530 lpm @ 49 m H_2O (140 gpm @ 160 ft H_2O)
24	Filtered Water Tank	Vertical, cylindrical	1(0)	480,747 liter (127,000 gal)	499,674 liter (132,000 gal)	499,674 liter (132,000 gal)	518,601 liter (137,000 gal)
25	Makeup Water Demineralizer	Multi-media filter, cartridge filter, RO membrane assembly, electrodeionization unit	1(1)	1,022 lpm (270 gpm)	1,060 lpm (280 gpm)	1,022 lpm (270 gpm)	1,060 lpm (280 gpm)
26	Liquid Waste Treatment System	--	1(0)	10 years, 24-hour storm	10 years, 24-hour storm	10 years, 24-hour storm	10 years, 24-hour storm

ACCOUNT 4 BOILER AND ACCESSORIES

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
1	Boiler	Once thru, wall-fired, low NOx burners, overfire air	1(0)	Supercritical, 2,558,261 kg/hr steam @ 25.5 MPa/602°C/602°C (5,640,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)	Supercritical, 2,630,836 kg/hr steam @ 25.5 MPa/602°C/602°C (5,800,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)	Ultra-supercritical, 2,612,692 kg/hr steam @ 29.0 MPa/657°C/657°C (5,760,000 lb/hr steam @ 4,200 psig/1,215°F/1,215°F)	Ultra-supercritical, 2,680,731 kg/hr steam @ 29.0 MPa/657°C/657°C (5,910,000 lb/hr steam @ 4,200 psig/1,215°F/1,215°F)
2	Primary Air Fan	Centrifugal	2(0)	591,938 kg/hr, 8,821 m^3/min @ 123 cm WG (1,305,000 lb/hr, 311,400 acfm @ 48 in. WG)	635,029 kg/hr, 8,877 m^3/min @ 123 cm WG (1,400,000 lb/hr, 313,500 acfm @ 48 in. WG)	557,919 kg/hr, 8,317 m^3/min @ 123 cm WG (1,230,000 lb/hr, 293,700 acfm @ 48 in. WG)	597,835 kg/hr, 8,369 m^3/min @ 112 cm WG (1,318,000 lb/hr, 295,100 acfm @ 44 in. WG)

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
3	Forced Draft Fan	Centrifugal	2(0)	887,680 kg/hr, 13,230 m^3/min @ 47 cm WG (1,957,000 lb/hr, 467,100 acfm @ 19 in. WG)	952,544 kg/hr, 13,317 m^3/min @ 47 cm WG (2,100,000 lb/hr, 470,300 acfm @ 19 in. WG)	837,332 kg/hr, 12,474 m^3/min @ 47 cm WG (1,846,000 lb/hr, 440,500 acfm @ 19 in. WG)	897,752 kg/hr, 12,536 m^3/min @ 48 cm WG (1,977,000 lb/hr, 442,700 acfm @ 19 in. WG)
4	Induced Draft Fan	Centrifugal	2(0)	1,732,723 kg/hr, 35,288 m^3/min @ 82 cm WG (3,820,000 lb/hr, 1,246,200 acfm @ 32 in. WG)	1,912,345 kg/hr, 37,061 m^3/min @ 82 cm WG (4,216,000 lb/hr, 1,308,800 acfm @ 32 in. WG)	1,633,840 kg/hr, 33,275 m^3/min @ 82 cm WG (3,602,000 lb/hr, 1,175,100 acfm @ 32 in. WG)	1,799,855 kg/hr, 34,878 m^3/min @ 82 cm WG (3,968,000 lb/hr, 1,231,700 acfm @ 32 in. WG)
5	SCR Reactor Vessel	Space for spare layer	2(0)	3,465,446 kg/hr (7,640,000 lb/hr)	3,823,784 kg/hr (8,430,000 lb/hr)	3,265,865 kg/hr (7,200,000 lb/hr)	3,601,523 kg/hr (7,940,000 lb/hr)
6	SCR Catalyst	--	3(0)	--	--	--	--
7	Dilution Air Blower	Centrifugal	2(1)	59 m^3/min @ 108 cm WG (2,100 acfm @ 42 in. WG)	62 m^3/min @ 108 cm WG (2,200 acfm @ 42 in. WG)	54 m^3/min @ 108 cm WG (1,900 acfm @ 42 in. WG)	57 m^3/min @ 108 cm WG (2,000 acfm @ 42 in. WG)
8	Ammonia Storage	Horizontal tank	5(0)	64,352 liter (17,000 gal)	68,137 liter (18,000 gal)	60,567 liter (16,000 gal)	64,352 liter (17,000 gal)
9	Ammonia Feed Pump	Centrifugal	2(1)	12 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)	13 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)	12 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)	12 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)

ACCOUNT 5 FLUE GAS CLEANUP

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
1	Fabric Filter	Single stage, high-ratio with pulse-jet online cleaning system, air-to-cloth ratio - 3.5 ft/min	2(0)	1,732,723 kg/hr (3,820,000 lb/hr) 99.9% efficiency	1,912,345 kg/hr (4,216,000 lb/hr) 99.9% efficiency	1,633,840 kg/hr (3,602,000 lb/hr) 99.9% efficiency	1,799,855 kg/hr (3,968,000 lb/hr) 99.9% efficiency
2	Spray Dryer	Co-current open spray	2(0)	37,831 m^3/min (1,336,000 acfm)	39,842 m^3/min (1,407,000 acfm)	35,651 m^3/min (1,259,000 acfm)	37,492 m^3/min (1,324,000 acfm)
3	Atomizer	Rotary	2(1)	227 lpm @ 64 m H_2O (60 gpm @ 210 ft H_2O)	265 lpm @ 64 m H_2O (70 gpm @ 210 ft H_2O)	227 lpm @ 64 m H_2O (60 gpm @ 210 ft H_2O)	265 lpm @ 64 m H_2O (70 gpm @ 210 ft H_2O)
4	Spray Dryer Solids Conveying	---	2(0)	---	---	---	---
5	Carbon Injectors	---	1(0)	68 kg/hr (150 lb/hr)	104 kg/hr (230 lb/hr)	64 kg/hr (140 lb/hr)	100 kg/hr (220 lb/hr)

ACCOUNT 5B CARBON DIOXIDE RECOVERY

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
1	Econamine FG Plus	Amine-based CO_2 capture technology	2(0)	1,732,723 kg/h (3,820,000 lb/h) 21.5 wt % CO_2 concentration	1,912,345 kg/h (4,216,000 lb/h) 21.1 wt % CO_2 concentration	1,633,840 kg/h (3,602,000 lb/h) 21.5 wt % CO_2 concentration	1,799,855 kg/h (3,968,000 lb/h) 21.1 wt % CO_2 concentration
2	Econamine Condensate Pump	Centrifugal	1(1)	18,851 lpm @ 52 m H_2O (4,980 gpm @ 170 ft H_2O)	20,366 lpm @ 52 m H_2O (5,380 gpm @ 170 ft H_2O)	17,754 lpm @ 52 m H_2O (4,690 gpm @ 170 ft H_2O)	19,154 lpm @ 52 m H_2O (5,060 gpm @ 170 ft H_2O)
3	CO_2 Compressor	Integrally geared, multi-stage centrifugal	2(0)	335,298 kg/h @ 15.3 MPa (739,205 lb/h @ 2,215 psia)	362,560 kg/h @ 15.3 MPa (799,309 lb/h @ 2,215 psia)	315,693 kg/h @ 15.3 MPa (695,984 lb/h @ 2,215 psia)	340,699 kg/h @ 15.3 MPa (751,114 lb/h @ 2,215 psia)

ACCOUNT 6 COMBUSTION TURBINE/ACCESSORIES

N/A

ACCOUNT 7 DUCTING & STACK

Equipment No.	Description	Type	Operating Qty.	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
1	Stack	Reinforced concrete with FRP liner	1(0)	152 m (500 ft) high x 6.1 m (20 ft) diameter"	152 m (500 ft) high x 6.1 m (20 ft) diameter"	152 m (500 ft) high x 5.9 m (19 ft) diameter"	152 m (500 ft) high x 5.9 m (19 ft) diameter"

ACCOUNT 8 STEAM TURBINE GENERATOR AND AUXILIARIES

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
1	Steam Turbine	Commercially available advanced steam turbine	1(0)	709 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)	720 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)	701 MW 27.6 MPa/649°C/649°C (4000 psig/ 1200°F/1200°F)	711 MW 27.6 MPa/649°C/649°C (4000 psig/ 1200°F/1200°F)
2	Steam Turbine Generator	Hydrogen cooled, static excitation	1(0)	790 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	800 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	780 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	790 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase
3	Surface Condenser	Single pass, divided waterbox including vacuum pumps	1(0)	900 GJ/hr (850 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 9°C (48°F), Water temperature rise 11°C (20°F)	880 GJ/hr (830 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 8°C (47°F), Water temperature rise 11°C (20°F)	800 GJ/hr (760 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 9°C (48°F), Water temperature rise 11°C (20°F)	770 GJ/hr (730 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 8°C (47°F), Water temperature rise 11°C (20°F)

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
4	Air-cooled Condenser	---	1(0)	900 GJ/hr (850 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 6°C (42°F)	880 GJ/hr (830 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 4°C (40°F)	800 GJ/hr (760 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 6°C (42°F)	770 GJ/hr (730 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 4°C (40°F)

ACCOUNT 9 COOLING WATER SYSTEM

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
1	Circulating Water Pumps	Vertical, wet pit	2(1)	916,100 lpm @ 30 m (242,000 gpm @ 100 ft)	1,022,100 lpm @ 30 m (270,000 gpm @ 100 ft)	855,500 lpm @ 30 m (226,000 gpm @ 100 ft)	953,900 lpm @ 30 m (253,000 gpm @ 100 ft)
2	Cooling Tower	Evaporative, mechanical draft, multi-cell	1(0)	3°C (37°F) wet bulb / 9°C (48°F) CWT / 20°C (68°F) HWT / 5,117 GJ/hr (4,850 MMBtu/hr) heat duty	2°C (36°F) wet bulb / 8°C (47°F) CWT / 19°C (67°F) HWT / 5,708 GJ/hr (5,410 MMBtu/hr) heat duty	3°C (37°F) wet bulb / 9°C (48°F) CWT / 20°C (68°F) HWT / 4,779 GJ/hr (4,530 MMBtu/hr) heat duty	2°C (36°F) wet bulb / 8°C (47°F) CWT / 19°C (67°F) HWT / 5,317 GJ/hr (5,040 MMBtu/hr) heat duty

ACCOUNT 10 ASH/SPENT SORBENT RECOVERY AND HANDLING

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
1	Economizer Hopper (part of boiler scope of supply)	--	4(0)	--	--	--	--

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
2	Bottom Ash Hopper (part of boiler scope of supply)	--	2(0)	--	--	--	--
3	Clinker Grinder	--	1(1)	6.4 tonne/hr (7 tph)	10.9 tonne/hr (12 tph)	6.4 tonne/hr (7 tph)	10.0 tonne/hr (11 tph)
4	Pyrites Hopper (part of pulverizer scope of supply included with boiler)	--	6(0)	--	--	--	--
5	Hydroejectors	--	12(0)	--	--	--	--
6	Economizer /Pyrites Transfer Tank	--	1(0)	--	--	--	--
7	Ash Sluice Pumps	Vertical, wet pit	1(1)	265 lpm @ 17 m H_2O (70 gpm @ 56 ft H_2O)	416 lpm @ 17 m H_2O (110 gpm @ 56 ft H_2O)	265 lpm @ 17 m H_2O (70 gpm @ 56 ft H_2O)	416 lpm @ 17 m H_2O (110 gpm @ 56 ft H_2O)
8	Ash Seal Water Pumps	Vertical, wet pit	1(1)	7,571 lpm @ 9 m H_2O (2,000 gpm @ 28 ft H_2O)	7,571 lpm @ 9 m H_2O (2,000 gpm @ 28 ft H_2O)	7,571 lpm @ 9 m H_2O (2,000 gpm @ 28 ft H_2O)	7,571 lpm @ 9 m H_2O (2,000 gpm @ 28 ft H_2O)
9	Hydrobins	--	1(1)	265 lpm (70 gpm)	416 lpm (110 gpm)	265 lpm (70 gpm)	416 lpm (110 gpm)
10	Baghouse Hopper (part of baghouse scope of supply)	--	24(0)	--	--	--	--
11	Air Heater Hopper (part of boiler scope of supply)	--	10(0)	--	--	--	--
12	Air Blower	--	1(0)	36 m^3/min @ 0.2 MPa (1,260 scfm @ 24 psi)	54 m^3/min @ 0.2 MPa (1,890 scfm @ 24 psi)	33 m^3/min @ 0.2 MPa (1,180 scfm @ 24 psi)	50 m^3/min @ 0.2 MPa (1,770 scfm @ 24 psi)
13	Fly Ash Silo	Reinforced concrete	2(0)	2,360 tonne (2,600 ton)	3,540 tonne (3,900 ton)	2,180 tonne (2,400 ton)	3,270 tonne (3,600 ton)
14	Slide Gate Valves	--	2(0)	--	--	--	--
15	Unloader	--	1(0)	--	--	--	--

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
16	Telescoping Unloading Chute	--	1(0)	218 tonne/hr (240 tph)	327 tonne/hr (360 tph)	209 tonne/hr (230 tph)	308 tonne/hr (340 tph)
17	Recycle Waste Storage Silo	Reinforced concrete	2(0)	454 tonne (500 ton)	454 tonne (500 ton)	363 tonne (400 ton)	454 tonne (500 ton)
18	Recycle Waste Conveyor	--	1(0)	54 tonne/hr (60 tph)	54 tonne/hr (60 tph)	45 tonne/hr (50 tph)	54 tonne/hr (60 tph)
19	Recycle Slurry Mixer	--	1(1)	1,401 lpm (370 gpm)	1,590 lpm (420 gpm)	1,325 lpm (350 gpm)	1,476 lpm (390 gpm)
20	Recycle Waste Slurry Tank	--	1(0)	83,280 liters (22,000 gal)	94,640 liters (25,000 gal)	79,490 liters (21,000 gal)	90,850 liters (24,000 gal)
21	Recycle Waste Pump	--	1(1)	1,401 lpm (370 gpm)	1,590 lpm (420 gpm)	1,325 lpm (350 gpm)	1,476 lpm (390 gpm)

ACCOUNT 11 ACCESSORY ELECTRIC PLANT

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
1	STG Transformer	Oil-filled	1(0)	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz
2	Auxiliary Transformer	Oil-filled	1(1)	24 kV/4.16 kV, 134 MVA, 3-ph, 60 Hz	24 kV/4.16 kV, 146 MVA, 3-ph, 60 Hz	24 kV/4.16 kV, 126 MVA, 3-ph, 60 Hz	24 kV/4.16 kV, 137 MVA, 3-ph, 60 Hz
3	Low Voltage Transformer	Dry ventilated	1(1)	4.16 kV/480 V, 20 MVA, 3-ph, 60 Hz	4.16 kV/480 V, 22 MVA, 3-ph, 60 Hz	4.16 kV/480 V, 19 MVA, 3-ph, 60 Hz	4.16 kV/480 V, 20 MVA, 3-ph, 60 Hz
4	STG Isolated Phase Bus Duct and Tap Bus	Aluminum, self-cooled	1(0)	24 kV, 3-ph, 60 Hz	24 kV, 3-ph, 60 Hz	24 kV, 3-ph, 60 Hz	24 kV, 3-ph, 60 Hz
5	Medium Voltage Switchgear	Metal clad	1(1)	4.16 kV, 3-ph, 60 Hz	4.16 kV, 3-ph, 60 Hz	4.16 kV, 3-ph, 60 Hz	4.16 kV, 3-ph, 60 Hz
6	Low Voltage Switchgear	Metal enclosed	1(1)	480 V, 3-ph, 60 Hz	480 V, 3-ph, 60 Hz	480 V, 3-ph, 60 Hz	480 V, 3-ph, 60 Hz

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
7	Emergency Diesel Generator	Sized for emergency shutdown	1(0)	750 kW, 480 V, 3-ph, 60 Hz	750 kW, 480 V, 3-ph, 60 Hz	750 kW, 480 V, 3-ph, 60 Hz	750 kW, 480 V, 3-ph, 60 Hz

ACCOUNT 12 INSTRUMENTATION AND CONTROL

Equipment No.	Description	Type	Operating Qty. (Spares)	S12B Design Condition	L12B Design Condition	S13B Design Condition	L13B Design Condition
1	DCS - Main Control	Monitor/keyboard, Operator printer, Engineering printer	1(0)	Operator stations/printers and engineering stations/printers	Operator stations/printers and engineering stations/printers	Operator stations/printers and engineering stations/printers	Operator stations/printers and engineering stations/printers
2	DCS - Processor	Microprocessor with redundant input/output	1(0)	N/A	N/A	N/A	N/A
3	DCS - Data Highway	Fiber optic	1(0)	Fully redundant, 25% spare	Fully redundant, 25% spare	Fully redundant, 25% spare	Fully redundant, 25% spare

4.2.6 PC Cases with CO_2 Capture – Cost Estimating

Costs Results

The cost estimating methodology was described previously in Section 2.6. The TPC summary organized by cost account, detailed breakdown of capital costs, owner's costs, and initial and annual O&M costs for the SC PC PRB case with CO_2 capture (S12B) are shown in Exhibit 4-69, Exhibit 4-70, Exhibit 4-71, and Exhibit 4-72 respectively. The same data for the SC PC lignite case with CO_2 capture (L12B) are shown in Exhibit 4-73, Exhibit 4-74, Exhibit 4-75, and Exhibit 4-76; the USC PC PRB case with CO_2 capture (S13B) are shown in Exhibit 4-77, Exhibit 4-78, Exhibit 4-79, and Exhibit 4-80, and the USC PC Lignite case with CO_2 capture (L13B) are shown in Exhibit 4-81, Exhibit 4-82, Exhibit 4-83, and Exhibit 4-84.

The estimated TOC of the SC PC plant with CO_2 capture using PRB coal is $3,987/kW and using lignite coal is $4,341/kW. Project and process contingencies represent 10.2 and 2.6 percent respectively in both cases. The COE is 107.5 mills/kWh for the PRB case and 116.4 mills/kWh for the lignite case. The estimated TOC of the USC PC plant with CO_2 capture using PRB coal is $4,049/kW and using lignite coal is $4,372/kW. Project and process contingencies represent 10.0 and 3.5 percent respectively in both cases. The COE is 107.7 mills/kWh for the PRB case and 115.4 mills/kWh for the lignite case.

Exhibit 4-69 Case S12B Total Plant Cost Summary

Client: USDOE/NETL — **Report Date:** 2009-Oct-19
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case S12B - 1x550 MWnet SuperCritical PC w/ CO2 Capture
Plant Size: 550.1 MW,net — **Estimate Type:** Conceptual — **Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING	$21,259	$6,454	$14,082	$0	$0	**$41,795**	$3,763	$0	$6,834	**$52,392**	$95
2	COAL & SORBENT PREP & FEED	$10,794	$867	$3,013	$0	$0	**$14,674**	$1,290	$0	$2,395	**$18,358**	$33
3	FEEDWATER & MISC. BOP SYSTEMS	$54,568	$0	$26,010	$0	$0	**$80,578**	$7,381	$0	$14,334	**$102,292**	$186
4	PC BOILER											
4.1	PC Boiler & Accessories	$238,347	$0	$116,754	$0	$0	**$355,101**	$34,524	$0	$38,963	**$428,588**	$779
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.3	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.4-4.9	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 4	**$238,347**	**$0**	**$116,754**	**$0**	**$0**	**$355,101**	**$34,524**	**$0**	**$38,963**	**$428,588**	**$779**
5	FLUE GAS CLEANUP	$128,583	$0	$45,583	$0	$0	**$174,167**	$16,676	$0	$19,084	**$209,927**	$382
5B	CO_2 REMOVAL & COMPRESSION	$251,154	$0	$76,507	$0	$0	**$327,661**	$31,328	$57,801	$83,358	**$500,148**	$909
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
6.2-6.9	Combustion Turbine Other	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 6	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
7.2-7.9	HRSG Accessories, Ductwork and Stack	$19,809	$1,085	$13,417	$0	$0	**$34,311**	$3,143	$0	$4,923	**$42,377**	$77
	SUBTOTAL 7	**$19,809**	**$1,085**	**$13,417**	**$0**	**$0**	**$34,311**	**$3,143**	**$0**	**$4,923**	**$42,377**	**$77**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$57,374	$0	$7,620	$0	$0	**$64,994**	$6,229	$0	$7,122	**$78,345**	$142
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$55,142	$1,214	$21,496	$0	$0	**$77,852**	$7,227	$0	$14,540	**$99,619**	$181
	SUBTOTAL 8	**$112,516**	**$1,214**	**$29,116**	**$0**	**$0**	**$142,846**	**$13,456**	**$0**	**$21,662**	**$177,964**	**$324**
9	COOLING WATER SYSTEM	$19,330	$9,370	$17,301	$0	$0	**$46,000**	$4,329	$0	$6,787	**$57,116**	$104
10	ASH/SPENT SORBENT HANDLING SYS	$7,003	$223	$9,363	$0	$0	**$16,588**	$1,595	$0	$1,871	**$20,054**	$36
11	ACCESSORY ELECTRIC PLANT	$25,972	$11,079	$31,373	$0	$0	**$68,424**	$6,053	$0	$9,359	**$83,836**	$152
12	INSTRUMENTATION & CONTROL	$9,991	$0	$10,131	$0	$0	**$20,122**	$1,824	$1,006	$2,819	**$25,772**	$47
13	IMPROVEMENTS TO SITE	$3,345	$1,923	$6,742	$0	$0	**$12,011**	$1,185	$0	$2,639	**$15,835**	$29
14	BUILDINGS & STRUCTURES	$0	$25,901	$24,501	$0	$0	**$50,403**	$4,546	$0	$8,242	**$63,191**	$115
	TOTAL COST	**$902,672**	**$58,115**	**$423,893**	**$0**	**$0**	**$1,384,680**	**$131,094**	**$58,807**	**$223,270**	**$1,797,852**	**$3,268**

Exhibit 4-70 Case S12B Total Plant Cost Details

Client: USDOE/NETL **Report Date:** 2009-Oct-19
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case S12B - 1x550 MWnet SuperCritical PC w/ CO2 Capture
Plant Size: 550.1 MW,net **Estimate Type:** Conceptual **Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING											
1.1	Coal Receive & Unload	$5,150	$0	$2,352	$0	$0	$7,502	$670	$0	$1,226	$9,399	$17
1.2	Coal Stackout & Reclaim	$6,656	$0	$1,508	$0	$0	$8,164	$714	$0	$1,332	$10,210	$19
1.3	Coal Conveyors	$6,188	$0	$1,492	$0	$0	$7,680	$673	$0	$1,253	$9,606	$17
1.4	Other Coal Handling	$1,619	$0	$345	$0	$0	$1,964	$172	$0	$320	$2,456	$4
1.5	Sorbent Receive & Unload	$62	$0	$19	$0	$0	$81	$7	$0	$13	$102	$0
1.6	Sorbent Stackout & Reclaim	$1,008	$0	$185	$0	$0	$1,192	$104	$0	$194	$1,491	$3
1.7	Sorbent Conveyors	$360	$78	$88	$0	$0	$525	$45	$0	$86	$657	$1
1.8	Other Sorbent Handling	$217	$51	$114	$0	$0	$382	$34	$0	$62	$478	$1
1.9	Coal & Sorbent Hnd.Foundations	$0	$6,325	$7,979	$0	$0	$14,304	$1,344	$0	$2,347	$17,995	$33
	SUBTOTAL 1.	**$21,259**	**$6,454**	**$14,082**	**$0**	**$0**	**$41,795**	**$3,763**	**$0**	**$6,834**	**$52,392**	**$95**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$3,032	$0	$591	$0	$0	$3,622	$316	$0	$591	$4,529	$8
2.2	Coal Conveyor to Storage	$7,762	$0	$1,694	$0	$0	$9,456	$827	$0	$1,542	$11,825	$21
2.3	Coal Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.4	Misc.Coal Prep & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.5	Sorbent Prep Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.6	Sorbent Storage & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.7	Sorbent Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.8	Booster Air Supply System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.9	Coal & Sorbent Feed Foundation	$0	$867	$728	$0	$0	$1,595	$148	$0	$261	$2,004	$4
	SUBTOTAL 2.	**$10,794**	**$867**	**$3,013**	**$0**	**$0**	**$14,674**	**$1,290**	**$0**	**$2,395**	**$18,358**	**$33**
3	FEEDWATER & MISC. BOP SYSTEMS											
3.1	FeedwaterSystem	$23,170	$0	$7,485	$0	$0	$30,655	$2,679	$0	$5,000	$38,333	$70
3.2	Water Makeup & Pretreating	$6,304	$0	$2,029	$0	$0	$8,333	$788	$0	$1,824	$10,945	$20
3.3	Other Feedwater Subsystems	$7,093	$0	$2,998	$0	$0	$10,091	$904	$0	$1,649	$12,645	$23
3.4	Service Water Systems	$1,236	$0	$672	$0	$0	$1,908	$179	$0	$417	$2,505	$5
3.5	Other Boiler Plant Systems	$9,256	$0	$9,138	$0	$0	$18,394	$1,747	$0	$3,021	$23,162	$42
3.6	FO Supply Sys & Nat Gas	$279	$0	$348	$0	$0	$627	$59	$0	$103	$789	$1
3.7	Waste Treatment Equipment	$4,274	$0	$2,436	$0	$0	$6,710	$653	$0	$1,473	$8,836	$16
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	$2,957	$0	$903	$0	$0	$3,860	$371	$0	$846	$5,078	$9
	SUBTOTAL 3.	**$54,568**	**$0**	**$26,010**	**$0**	**$0**	**$80,578**	**$7,381**	**$0**	**$14,334**	**$102,292**	**$186**

Exhibit 4-70 Case S12B Total Plant Cost Details (Continued)

Client:	USDOE/NETL	**Report Date:**	2009-Oct-19
Project:	Low Rank (Western) Coal Baseline Study		

TOTAL PLANT COST SUMMARY

Case:	Case S12B - 1x550 MWnet SuperCritical PC w/ CO2 Capture					
Plant Size:	550.1 MW,net	**Estimate Type:**	Conceptual	**Cost Base (June)**	2007	($x1000)

Acct		Equipment	Material	Labor		Sales	Bare Erected	Eng'g CM	Contingencies		TOTAL PLANT COST	
No.	Item/Description	Cost	Cost	Direct	Indirect	Tax	Cost $	H.O.& Fee	Process	Project	$	$/kW
4	PC BOILER											
4.1	PC Boiler & Accessories	$238,347	$0	$116,754	$0	$0	$355,101	$34,524	$0	$38,963	$428,588	$779
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.3	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.4	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.5	Primary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.6	Secondary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.8	Major Component Rigging	$0	w/4.1	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.9	Boiler Foundations	$0	w/14.1	w/14.1	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 4.	**$238,347**	**$0**	**$116,754**	**$0**	**$0**	**$355,101**	**$34,524**	**$0**	**$38,963**	**$428,588**	**$779**
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$102,716	$0	$27,980	$0	$0	$130,697	$12,484	$0	$14,318	$157,498	$286
5.2	Other FGD	$1,326	$0	$860	$0	$0	$2,186	$211	$0	$240	$2,636	$5
5.3	Bag House & Accessories	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.4	Other Particulate Removal Materials	$24,541	$0	$16,743	$0	$0	$41,284	$3,982	$0	$4,527	$49,793	$91
5.5	Gypsum Dewatering System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.6	Mercury Removal System	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.9	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 5.	**$128,583**	**$0**	**$45,583**	**$0**	**$0**	**$174,167**	**$16,676**	**$0**	**$19,084**	**$209,927**	**$382**
5B	CO_2 REMOVAL & COMPRESSION											
5B.1	CO_2 Removal System	$221,730	$0	$67,276	$0	$0	$289,006	$27,631	$57,801	$74,888	$449,326	$817
5B.2	CO_2 Compression & Drying	$29,424	$0	$9,231	$0	$0	$38,655	$3,697	$0	$8,470	$50,822	$92
	SUBTOTAL 5.	**$251,154**	**$0**	**$76,507**	**$0**	**$0**	**$327,661**	**$31,328**	**$57,801**	**$83,358**	**$500,148**	**$909**
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
6.2	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.3	Compressed Air Piping	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.9	Combustion Turbine Foundations	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
7.2	HRSG Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7.3	Ductwork	$10,350	$0	$6,650	$0	$0	$17,000	$1,482	$0	$2,772	$21,255	$39
7.4	Stack	$9,459	$0	$5,535	$0	$0	$14,993	$1,443	$0	$1,644	$18,081	$33
7.9	Duct & Stack Foundations	$0	$1,085	$1,233	$0	$0	$2,318	$217	$0	$507	$3,042	$6
	SUBTOTAL 7.	**$19,809**	**$1,085**	**$13,417**	**$0**	**$0**	**$34,311**	**$3,143**	**$0**	**$4,923**	**$42,377**	**$77**

Exhibit 4-70 Case S12B Total Plant Cost Details (Continued)

Client:	USDOE/NETL					Report Date:	2009-Oct-19
Project:	Low Rank (Western) Coal Baseline Study						
	TOTAL PLANT COST SUMMARY						
Case:	Case S12B - 1x550 MWnet SuperCritical PC w/ CO2 Capture						
Plant Size:	550.1 MW,net	Estimate Type:	Conceptual	Cost Base (June)	2007	($x1000)	

Acct		Equipment	Material	Labor		Sales	Bare Erected	Eng'g CM	Contingencies		TOTAL PLANT COST	
No.	Item/Description	Cost	Cost	Direct	Indirect	Tax	Cost $	H.O.& Fee	Process	Project	$	$/kW
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$57,374	$0	$7,620	$0	$0	$64,994	$6,229	$0	$7,122	$78,345	$142
8.2	Turbine Plant Auxiliaries	$387	$0	$829	$0	$0	$1,216	$119	$0	$133	$1,468	$3
8.3a	Condenser & Auxiliaries	$3,246	$0	$2,054	$0	$0	$5,299	$511	$0	$581	$6,391	$12
8.3b	Air Cooled Condenser	$29,743	$0	$5,963	$0	$0	$35,706	$3,571	$0	$7,855	$47,132	$86
8.4	Steam Piping	$21,767	$0	$10,732	$0	$0	$32,499	$2,730	$0	$5,284	$40,514	$74
8.9	TG Foundations	$0	$1,214	$1,918	$0	$0	$3,132	$296	$0	$686	$4,114	$7
	SUBTOTAL 8.	**$112,516**	**$1,214**	**$29,116**	**$0**	**$0**	**$142,846**	**$13,456**	**$0**	**$21,662**	**$177,964**	**$324**
9	COOLING WATER SYSTEM											
9.1	Cooling Towers	$14,406	$0	$4,486	$0	$0	$18,892	$1,807	$0	$2,070	$22,769	$41
9.2	Circulating Water Pumps	$3,006	$0	$225	$0	$0	$3,230	$273	$0	$350	$3,853	$7
9.3	Circ.Water System Auxiliaries	$743	$0	$99	$0	$0	$841	$80	$0	$92	$1,014	$2
9.4	Circ.Water Piping	$0	$5,886	$5,705	$0	$0	$11,591	$1,085	$0	$1,901	$14,578	$27
9.5	Make-up Water System	$587	$0	$784	$0	$0	$1,371	$131	$0	$225	$1,728	$3
9.6	Component Cooling Water Sys	$588	$0	$468	$0	$0	$1,056	$100	$0	$173	$1,330	$2
9.9	Circ.Water System Foundations& Structures	$0	$3,483	$5,534	$0	$0	$9,017	$853	$0	$1,974	$11,844	$22
	SUBTOTAL 9.	**$19,330**	**$9,370**	**$17,301**	**$0**	**$0**	**$46,000**	**$4,329**	**$0**	**$6,787**	**$57,116**	**$104**
10	ASH/SPENT SORBENT HANDLING SYS											
10.1	Ash Coolers	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.2	Cyclone Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.3	HGCU Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.4	High Temperature Ash Piping	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.5	Other Ash Recovery Equipment	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.6	Ash Storage Silos	$937	$0	$2,887	$0	$0	$3,824	$375	$0	$420	$4,619	$8
10.7	Ash Transport & Feed Equipment	$6,066	$0	$6,213	$0	$0	$12,279	$1,174	$0	$1,345	$14,798	$27
10.8	Misc. Ash Handling Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.9	Ash/Spent Sorbent Foundation	$0	$223	$262	$0	$0	$485	$45	$0	$106	$636	$1
	SUBTOTAL 10.	**$7,003**	**$223**	**$9,363**	**$0**	**$0**	**$16,588**	**$1,595**	**$0**	**$1,871**	**$20,054**	**$36**

Exhibit 4-70 Case S12B Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 2009-Oct-19
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case S12B - 1x550 MWnet SuperCritical PC w/ CO2 Capture
Plant Size: 550.1 MW,net **Estimate Type:** Conceptual **Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT											
11.1	Generator Equipment	$1,743	$0	$283	$0	$0	$2,026	$188	$0	$166	$2,380	$4
11.2	Station Service Equipment	$5,158	$0	$1,695	$0	$0	$6,853	$641	$0	$562	$8,056	$15
11.3	Switchgear & Motor Control	$5,930	$0	$1,008	$0	$0	$6,938	$643	$0	$758	$8,339	$15
11.4	Conduit & Cable Tray	$0	$3,718	$12,856	$0	$0	$16,574	$1,605	$0	$2,727	$20,905	$38
11.5	Wire & Cable	$0	$7,016	$13,543	$0	$0	$20,559	$1,732	$0	$3,344	$25,634	$47
11.6	Protective Equipment	$270	$0	$920	$0	$0	$1,190	$116	$0	$131	$1,437	$3
11.7	Standby Equipment	$1,370	$0	$31	$0	$0	$1,401	$129	$0	$153	$1,683	$3
11.8	Main Power Transformers	$11,500	$0	$191	$0	$0	$11,691	$886	$0	$1,258	$13,835	$25
11.9	Electrical Foundations	$0	$345	$847	$0	$0	$1,192	$114	$0	$261	$1,567	$3
	SUBTOTAL 11.	**$25,972**	**$11,079**	**$31,373**	**$0**	**$0**	**$68,424**	**$6,053**	**$0**	**$9,359**	**$83,836**	**$152**
12	INSTRUMENTATION & CONTROL											
12.1	PC Control Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.2	Combustion Turbine Control	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
12.3	Steam Turbine Control	w/8.1	$0	w/8.1	$0	$0	$0	$0	$0	$0	$0	$0
12.4	Other Major Component Control	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.5	Signal Processing Equipment	W/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.6	Control Boards,Panels & Racks	$514	$0	$308	$0	$0	$823	$78	$41	$141	$1,083	$2
12.7	Distributed Control System Equipment	$5,194	$0	$908	$0	$0	$6,101	$566	$305	$697	$7,669	$14
12.8	Instrument Wiring & Tubing	$2,815	$0	$5,585	$0	$0	$8,400	$716	$420	$1,430	$10,967	$20
12.9	Other I & C Equipment	$1,468	$0	$3,330	$0	$0	$4,798	$465	$240	$550	$6,053	$11
	SUBTOTAL 12.	**$9,991**	**$0**	**$10,131**	**$0**	**$0**	**$20,122**	**$1,824**	**$1,006**	**$2,819**	**$25,772**	**$47**
13	IMPROVEMENTS TO SITE											
13.1	Site Preparation	$0	$56	$1,125	$0	$0	$1,181	$117	$0	$260	$1,558	$3
13.2	Site Improvements	$0	$1,867	$2,319	$0	$0	$4,185	$413	$0	$920	$5,518	$10
13.3	Site Facilities	$3,345	$0	$3,299	$0	$0	$6,645	$655	$0	$1,460	$8,759	$16
	SUBTOTAL 13.	**$3,345**	**$1,923**	**$6,742**	**$0**	**$0**	**$12,011**	**$1,185**	**$0**	**$2,639**	**$15,835**	**$29**
14	BUILDINGS & STRUCTURES											
14.1	Boiler Building	$0	$9,810	$8,627	$0	$0	$18,438	$1,657	$0	$3,014	$23,109	$42
14.2	Turbine Building	$0	$12,924	$12,046	$0	$0	$24,970	$2,251	$0	$4,083	$31,304	$57
14.3	Administration Building	$0	$647	$684	$0	$0	$1,330	$121	$0	$218	$1,669	$3
14.4	Circulation Water Pumphouse	$0	$297	$236	$0	$0	$533	$48	$0	$87	$667	$1
14.5	Water Treatment Buildings	$0	$800	$729	$0	$0	$1,529	$138	$0	$250	$1,916	$3
14.6	Machine Shop	$0	$432	$291	$0	$0	$723	$64	$0	$118	$905	$2
14.7	Warehouse	$0	$293	$294	$0	$0	$587	$53	$0	$96	$736	$1
14.8	Other Buildings & Structures	$0	$239	$204	$0	$0	$443	$40	$0	$72	$556	$1
14.9	Waste Treating Building & Str.	$0	$459	$1,391	$0	$0	$1,850	$176	$0	$304	$2,329	$4
	SUBTOTAL 14.	**$0**	**$25,901**	**$24,501**	**$0**	**$0**	**$50,403**	**$4,546**	**$0**	**$8,242**	**$63,191**	**$115**
	TOTAL COST	**$902,672**	**$58,115**	**$423,893**	**$0**	**$0**	**$1,384,680**	**$131,094**	**$58,807**	**$223,270**	**$1,797,852**	**$3,268**

Exhibit 4-71 Case S12B Owner's Costs

Owner's Costs	$x1000	$/kW
Preproduction Costs		
6 Months Fixed O&M	$11,714	$21
1 Month Variable O&M	$3,730	$7
25% of 1 Months Fuel Cost at 100% CF	$1,127	$2
2% of TPC	$35,957	$65
Total	**$52,528**	**$95**
Inventory Capital		
60 day supply of fuel and consumables at 100% CF	$11,612	$21
0.5% of TPC (spare parts)	$8,989	$16
Total	**$20,602**	**$37**
Initial Cost for Catalyst and Chemicals	**$2,776**	**$5**
Land	**$900**	**$2**
Other Owner's Costs	**$269,678**	**$490**
Financing Costs	**$48,542**	**$88**
Total Owner's Costs	**$395,025**	**$718**
Total Overnight Cost (TOC)	**$2,192,877**	**$3,987**
TASC Multiplier	1.140	
Total As-Spent Cost (TASC)	**$2,499,879**	**$4,545**

Exhibit 4-72 Case S12B Initial and Annual O&M Costs

INITIAL & ANNUAL O&M EXPENSES						Cost Base (June):	2007
Case S12B - 1x550 MWnet SuperCritical PC w/ CO2 Capture						Heat Rate-net (Btu/kWh):	12,634
						MWe-net:	550
						Capacity Factor (%):	85
OPERATING & MAINTENANCE LABOR							
Operating Labor							
Operating Labor Rate(base):	34.65	$/hour					
Operating Labor Burden:	30.00	% of base					
Labor O-H Charge Rate:	25.00	% of labor					
			Total				
Skilled Operator	2.0		2.0				
Operator	11.3		11.3				
Foreman	1.0		1.0				
Lab Tech's, etc.	2.0		2.0				
TOTAL-O.J.'s	16.3		16.3				
						Annual Cost	Annual Unit Cost
						$	$/kW-net
Annual Operating Labor Cost						$6,444,907	$11.717
Maintenance Labor Cost						$12,297,744	$22.357
Administrative & Support Labor						$4,685,663	$8.518
Property Taxes and Insurance						$35,957,041	$65.369
TOTAL FIXED OPERATING COSTS						**$59,385,355**	**$107.962**
VARIABLE OPERATING COSTS							
							$/kWh-net
Maintenance Material Cost						**$18,446,616**	**$0.00450**
Consumables	Consumption Initial	/Day	Unit Cost	Initial Cost			
Water(/1000 gallons)	0	6,323	1.08	**$0**		**$2,121,948**	**$0.00052**
Chemicals							
MU & WT Chem.(lb)	0	30,608	0.17	$0		$1,643,454	$0.00040
Lime (ton)	0	147	75.00	$0		$3,409,058	$0.00083
Carbon (Mercury Removal) (lb)	0	3,216	1.05	$0		$1,047,822	$0.00026
MEA Solvent (ton)	1,144	1.62	2,249.89	$2,573,869		$1,130,804	$0.00028
NaOH (tons)	74	11.60	433.68	$32,092		$1,561,303	$0.00038
H2SO4 (tons)	82	7.70	138.78	$11,380		$331,707	$0.00008
Corrosion Inhibitor	0	0	0.00	$158,171		$7,532	$0.00000
Activated Carbon(lb)	0	1,935	1.05	$0		$630,453	$0.00015
Ammonia (19% NH3) ton	0	32	129.80	$0		$1,304,773	$0.00032
Subtotal Chemicals				**$2,775,512**		**$11,066,906**	**$0.00270**
Other							
Supplemental Fuel(MBtu)	0	0	0.00	$0		$0	$0.00000
SCR Catalyst(m3)	w/equip.	0.49	5,775.94	$0		$885,355	$0.00022
Emission Penalties	0	0	0.00	$0		$0	$0.00000
Subtotal Other				**$0**		**$885,355**	**$0.00022**
Waste Disposal							
Flyash (ton)	0	937	16.23	$0		$4,717,118	$0.00115
Bottom Ash(ton)	0	160	16.23	$0		$803,704	$0.00020
Subtotal-Waste Disposal				**$0**		**$5,520,822**	**$0.00135**
By-products & Emissions							
Gypsum (tons)	0	0	0.00	$0		$0	$0.00000
Subtotal By-Products				**$0**		**$0**	**$0.00000**
TOTAL VARIABLE OPERATING COSTS				**$2,775,512**		**$38,041,648**	**$0.00929**
Fuel(ton)	0	9,750	15.22	**$0**		**$46,039,608**	**$0.01124**

Exhibit 4-73 Case L12B Total Plant Cost Summary

Client: USDOE/NETL **Report Date:** 2009-Oct-19
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case L12B - 1x550 MWnet SuperCritical PC w/ CO2 Capture
Plant Size: 550.0 MW,net **Estimate Type:** Conceptual **Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING	$25,656	$7,827	$17,067	$0	$0	**$50,550**	$4,552	$0	$8,265	**$63,368**	$115
2	COAL & SORBENT PREP & FEED	$13,279	$1,067	$3,707	$0	$0	**$18,053**	$1,587	$0	$2,946	**$22,586**	$41
3	FEEDWATER & MISC. BOP SYSTEMS	$57,093	$0	$27,785	$0	$0	**$84,877**	$7,784	$0	$15,090	**$107,752**	$196
4	PC BOILER											
4.1	PC Boiler & Accessories	$291,672	$0	$132,051	$0	$0	**$423,723**	$41,173	$0	$46,490	**$511,386**	$930
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.3	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.4-4.9	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 4	**$291,672**	**$0**	**$132,051**	**$0**	**$0**	**$423,723**	**$41,173**	**$0**	**$46,490**	**$511,386**	**$930**
5	FLUE GAS CLEANUP	$138,303	$0	$49,029	$0	$0	**$187,332**	$17,937	$0	$20,527	**$225,796**	$411
5B	CO_2 REMOVAL & COMPRESSION	$263,425	$0	$80,245	$0	$0	**$343,671**	$32,859	$60,625	$87,431	**$524,586**	$954
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
6.2-6.9	Combustion Turbine Other	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 6	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
7.2-7.9	HRSG Accessories, Ductwork and Stack	$19,918	$1,091	$13,492	$0	$0	**$34,501**	$3,160	$0	$4,950	**$42,611**	$77
	SUBTOTAL 7	**$19,918**	**$1,091**	**$13,492**	**$0**	**$0**	**$34,501**	**$3,160**	**$0**	**$4,950**	**$42,611**	**$77**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$57,953	$0	$7,702	$0	$0	**$65,655**	$6,292	$0	$7,195	**$79,142**	$144
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$55,032	$1,229	$21,668	$0	$0	**$77,928**	$7,224	$0	$14,521	**$99,673**	$181
	SUBTOTAL 8	**$112,985**	**$1,229**	**$29,370**	**$0**	**$0**	**$143,583**	**$13,516**	**$0**	**$21,716**	**$178,816**	**$325**
9	COOLING WATER SYSTEM	$20,849	$10,008	$18,530	$0	$0	**$49,387**	$4,648	$0	$7,276	**$61,311**	$111
10	ASH/SPENT SORBENT HANDLING SYS	$8,839	$281	$11,818	$0	$0	**$20,938**	$2,013	$0	$2,362	**$25,313**	$46
11	ACCESSORY ELECTRIC PLANT	$26,789	$11,513	$32,587	$0	$0	**$70,890**	$6,272	$0	$9,702	**$86,864**	$158
12	INSTRUMENTATION & CONTROL	$9,963	$0	$10,102	$0	$0	**$20,065**	$1,819	$1,003	$2,811	**$25,698**	$47
13	IMPROVEMENTS TO SITE	$3,372	$1,938	$6,795	$0	$0	**$12,104**	$1,194	$0	$2,660	**$15,958**	$29
14	BUILDINGS & STRUCTURES	$0	$27,244	$25,695	$0	$0	**$52,939**	$4,775	$0	$8,657	**$66,371**	$121
	TOTAL COST	**$992,143**	**$62,198**	**$458,273**	**$0**	**$0**	**$1,512,614**	**$143,290**	**$61,629**	**$240,883**	**$1,958,416**	**$3,561**

Exhibit 4-74 Case L12B Total Plant Cost Details

Client:	USDOE/NETL	**Report Date:**	2009-Oct-19
Project:	Low Rank (Western) Coal Baseline Study		
	TOTAL PLANT COST SUMMARY		
Case:	Case L12B - 1x550 MWnet SuperCritical PC w/ CO2 Capture		
Plant Size:	550.0 MW,net **Estimate Type:** Conceptual	**Cost Base (June)**	2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING											
1.1	Coal Receive & Unload	$6,257	$0	$2,858	$0	$0	$9,115	$815	$0	$1,489	$11,419	$21
1.2	Coal Stackout & Reclaim	$8,086	$0	$1,832	$0	$0	$9,918	$868	$0	$1,618	$12,404	$23
1.3	Coal Conveyors	$7,518	$0	$1,813	$0	$0	$9,331	$818	$0	$1,522	$11,671	$21
1.4	Other Coal Handling	$1,967	$0	$419	$0	$0	$2,386	$208	$0	$389	$2,984	$5
1.5	Sorbent Receive & Unload	$69	$0	$21	$0	$0	$90	$8	$0	$15	$113	$0
1.6	Sorbent Stackout & Reclaim	$1,119	$0	$205	$0	$0	$1,324	$115	$0	$216	$1,655	$3
1.7	Sorbent Conveyors	$399	$86	$98	$0	$0	$583	$50	$0	$95	$729	$1
1.8	Other Sorbent Handling	$241	$57	$126	$0	$0	$424	$37	$0	$69	$531	$1
1.9	Coal & Sorbent Hnd.Foundations	$0	$7,685	$9,694	$0	$0	$17,379	$1,632	$0	$2,852	$21,863	$40
	SUBTOTAL 1.	**$25,656**	**$7,827**	**$17,067**	**$0**	**$0**	**$50,550**	**$4,552**	**$0**	**$8,265**	**$63,368**	**$115**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$3,730	$0	$727	$0	$0	$4,457	$389	$0	$727	$5,572	$10
2.2	Coal Conveyor to Storage	$9,550	$0	$2,084	$0	$0	$11,634	$1,017	$0	$1,898	$14,549	$26
2.3	Coal Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.4	Misc.Coal Prep & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.5	Sorbent Prep Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.6	Sorbent Storage & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.7	Sorbent Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.8	Booster Air Supply System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.9	Coal & Sorbent Feed Foundation	$0	$1,067	$895	$0	$0	$1,962	$182	$0	$322	$2,465	$4
	SUBTOTAL 2.	**$13,279**	**$1,067**	**$3,707**	**$0**	**$0**	**$18,053**	**$1,587**	**$0**	**$2,946**	**$22,586**	**$41**
3	FEEDWATER & MISC. BOP SYSTEMS											
3.1	FeedwaterSystem	$23,593	$0	$7,621	$0	$0	$31,214	$2,728	$0	$5,091	$39,033	$71
3.2	Water Makeup & Pretreating	$6,637	$0	$2,136	$0	$0	$8,773	$830	$0	$1,921	$11,523	$21
3.3	Other Feedwater Subsystems	$7,223	$0	$3,053	$0	$0	$10,275	$920	$0	$1,679	$12,875	$23
3.4	Service Water Systems	$1,301	$0	$708	$0	$0	$2,009	$189	$0	$440	$2,637	$5
3.5	Other Boiler Plant Systems	$10,573	$0	$10,438	$0	$0	$21,011	$1,996	$0	$3,451	$26,458	$48
3.6	FO Supply Sys & Nat Gas	$281	$0	$352	$0	$0	$633	$60	$0	$104	$796	$1
3.7	Waste Treatment Equipment	$4,499	$0	$2,565	$0	$0	$7,064	$688	$0	$1,550	$9,302	$17
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	$2,986	$0	$912	$0	$0	$3,898	$375	$0	$854	$5,127	$9
	SUBTOTAL 3.	**$57,093**	**$0**	**$27,785**	**$0**	**$0**	**$84,877**	**$7,784**	**$0**	**$15,090**	**$107,752**	**$196**

Exhibit 4-74 Case L12B Total Plant Cost Details (Continued)

Client:	USDOE/NETL	Report Date:	2009-Oct-19
Project:	Low Rank (Western) Coal Baseline Study		

TOTAL PLANT COST SUMMARY

Case:	Case L12B - 1x550 MWnet SuperCritical PC w/ CO2 Capture					
Plant Size:	550.0 MW,net	Estimate Type:	Conceptual	Cost Base (June)	2007	($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
4	PC BOILER											
4.1	PC Boiler & Accessories	$291,672	$0	$132,051	$0	$0	$423,723	$41,173	$0	$46,490	$511,386	$930
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.3	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.4	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.5	Primary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.6	Secondary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.8	Major Component Rigging	$0	w/4.1	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.9	Boiler Foundations	$0	w/14.1	w/14.1	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 4.	**$291,672**	**$0**	**$132,051**	**$0**	**$0**	**$423,723**	**$41,173**	**$0**	**$46,490**	**$511,386**	**$930**
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$110,481	$0	$30,095	$0	$0	$140,576	$13,427	$0	$15,400	$169,404	$308
5.2	Other FGD	$1,426	$0	$925	$0	$0	$2,351	$227	$0	$258	$2,835	$5
5.3	Bag House & Accessories	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.4	Other Particulate Removal Materials	$26,396	$0	$18,009	$0	$0	$44,405	$4,283	$0	$4,869	$53,557	$97
5.5	Gypsum Dewatering System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.6	Mercury Removal System	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.9	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 5.	**$138,303**	**$0**	**$49,029**	**$0**	**$0**	**$187,332**	**$17,937**	**$0**	**$20,527**	**$225,796**	**$411**
5B	CO_2 REMOVAL & COMPRESSION											
5B.1	CO_2 Removal System	$232,564	$0	$70,563	$0	$0	$303,127	$28,981	$60,625	$78,547	$471,280	$857
5B.2	CO_2 Compression & Drying	$30,862	$0	$9,682	$0	$0	$40,544	$3,878	$0	$8,884	$53,306	$97
	SUBTOTAL 5.	**$263,425**	**$0**	**$80,245**	**$0**	**$0**	**$343,671**	**$32,859**	**$60,625**	**$87,431**	**$524,586**	**$954**
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
6.2	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.3	Compressed Air Piping	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.9	Combustion Turbine Foundations	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
7.2	HRSG Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7.3	Ductwork	$10,407	$0	$6,687	$0	$0	$17,094	$1,491	$0	$2,788	$21,372	$39
7.4	Stack	$9,511	$0	$5,565	$0	$0	$15,076	$1,451	$0	$1,653	$18,181	$33
7.9	Duct & Stack Foundations	$0	$1,091	$1,240	$0	$0	$2,331	$218	$0	$510	$3,058	$6
	SUBTOTAL 7.	**$19,918**	**$1,091**	**$13,492**	**$0**	**$0**	**$34,501**	**$3,160**	**$0**	**$4,950**	**$42,611**	**$77**

Exhibit 4-74 Case L12B Total Plant Cost Details (Continued)

Client:	USDOE/NETL	Report Date:	2009-Oct-19
Project:	Low Rank (Western) Coal Baseline Study		

TOTAL PLANT COST SUMMARY

Case:	Case L12B - 1x550 MWnet SuperCritical PC w/ CO2 Capture						
Plant Size:	550.0 MW,net	Estimate Type:	Conceptual	Cost Base (June)	2007	($x1000)	

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$57,953	$0	$7,702	$0	$0	$65,655	$6,292	$0	$7,195	$79,142	$144
8.2	Turbine Plant Auxiliaries	$392	$0	$839	$0	$0	$1,230	$120	$0	$135	$1,486	$3
8.3a	Condenser & Auxiliaries	$3,192	$0	$2,079	$0	$0	$5,270	$508	$0	$578	$6,356	$12
8.3b	Air Cooled Condenser	$29,251	$0	$5,865	$0	$0	$35,116	$3,512	$0	$7,726	$46,353	$84
8.4	Steam Piping	$22,197	$0	$10,945	$0	$0	$33,142	$2,784	$0	$5,389	$41,315	$75
8.9	TG Foundations	$0	$1,229	$1,941	$0	$0	$3,169	$300	$0	$694	$4,163	$8
	SUBTOTAL 8.	**$112,985**	**$1,229**	**$29,370**	**$0**	**$0**	**$143,583**	**$13,516**	**$0**	**$21,716**	**$178,816**	**$325**
9	COOLING WATER SYSTEM											
9.1	Cooling Towers	$15,571	$0	$4,849	$0	$0	$20,420	$1,953	$0	$2,237	$24,610	$45
9.2	Circulating Water Pumps	$3,244	$0	$250	$0	$0	$3,495	$295	$0	$379	$4,169	$8
9.3	Circ.Water System Auxiliaries	$793	$0	$106	$0	$0	$898	$85	$0	$98	$1,082	$2
9.4	Circ.Water Piping	$0	$6,284	$6,091	$0	$0	$12,375	$1,158	$0	$2,030	$15,564	$28
9.5	Make-up Water System	$613	$0	$819	$0	$0	$1,432	$137	$0	$235	$1,805	$3
9.6	Component Cooling Water Sys	$628	$0	$500	$0	$0	$1,128	$107	$0	$185	$1,420	$3
9.9	Circ.Water System Foundations& Structures	$0	$3,723	$5,916	$0	$0	$9,639	$912	$0	$2,110	$12,661	$23
	SUBTOTAL 9.	**$20,849**	**$10,008**	**$18,530**	**$0**	**$0**	**$49,387**	**$4,648**	**$0**	**$7,276**	**$61,311**	**$111**
10	ASH/SPENT SORBENT HANDLING SYS											
10.1	Ash Coolers	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.2	Cyclone Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.3	HGCU Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.4	High Temperature Ash Piping	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.5	Other Ash Recovery Equipment	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.6	Ash Storage Silos	$1,183	$0	$3,644	$0	$0	$4,827	$474	$0	$530	$5,831	$11
10.7	Ash Transport & Feed Equipment	$7,656	$0	$7,843	$0	$0	$15,499	$1,482	$0	$1,698	$18,679	$34
10.8	Misc. Ash Handling Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.9	Ash/Spent Sorbent Foundation	$0	$281	$331	$0	$0	$612	$57	$0	$134	$803	$1
	SUBTOTAL 10.	**$8,839**	**$281**	**$11,818**	**$0**	**$0**	**$20,938**	**$2,013**	**$0**	**$2,362**	**$25,313**	**$46**

Exhibit 4-74 Case L12B Total Plant Cost Details (Continued)

Client:	USDOE/NETL	**Report Date:**	2009-Oct-19
Project:	Low Rank (Western) Coal Baseline Study		
	TOTAL PLANT COST SUMMARY		
Case:	Case L12B - 1x550 MWnet SuperCritical PC w/ CO2 Capture		
Plant Size:	550.0 MW,net **Estimate Type:** Conceptual	**Cost Base (June)**	2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT											
11.1	Generator Equipment	$1,760	$0	$286	$0	$0	$2,046	$190	$0	$168	$2,403	$4
11.2	Station Service Equipment	$5,365	$0	$1,763	$0	$0	$7,128	$666	$0	$585	$8,379	$15
11.3	Switchgear & Motor Control	$6,168	$0	$1,048	$0	$0	$7,216	$669	$0	$789	$8,674	$16
11.4	Conduit & Cable Tray	$0	$3,867	$13,371	$0	$0	$17,238	$1,669	$0	$2,836	$21,743	$40
11.5	Wire & Cable	$0	$7,297	$14,086	$0	$0	$21,383	$1,802	$0	$3,478	$26,663	$48
11.6	Protective Equipment	$280	$0	$952	$0	$0	$1,232	$120	$0	$135	$1,488	$3
11.7	Standby Equipment	$1,381	$0	$32	$0	$0	$1,412	$130	$0	$154	$1,696	$3
11.8	Main Power Transformers	$11,835	$0	$193	$0	$0	$12,028	$912	$0	$1,294	$14,234	$26
11.9	Electrical Foundations	$0	$349	$856	$0	$0	$1,206	$115	$0	$264	$1,585	$3
	SUBTOTAL 11.	**$26,789**	**$11,513**	**$32,587**	**$0**	**$0**	**$70,890**	**$6,272**	**$0**	**$9,702**	**$86,864**	**$158**
12	INSTRUMENTATION & CONTROL											
12.1	PC Control Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.2	Combustion Turbine Control	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
12.3	Steam Turbine Control	w/8.1	$0	w/8.1	$0	$0	$0	$0	$0	$0	$0	$0
12.4	Other Major Component Control	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.5	Signal Processing Equipment	W/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.6	Control Boards,Panels & Racks	$513	$0	$307	$0	$0	$820	$77	$41	$141	$1,080	$2
12.7	Distributed Control System Equipment	$5,179	$0	$905	$0	$0	$6,084	$564	$304	$695	$7,647	$14
12.8	Instrument Wiring & Tubing	$2,807	$0	$5,569	$0	$0	$8,376	$714	$419	$1,426	$10,935	$20
12.9	Other I & C Equipment	$1,463	$0	$3,321	$0	$0	$4,784	$464	$239	$549	$6,036	$11
	SUBTOTAL 12.	**$9,963**	**$0**	**$10,102**	**$0**	**$0**	**$20,065**	**$1,819**	**$1,003**	**$2,811**	**$25,698**	**$47**
13	IMPROVEMENTS TO SITE											
13.1	Site Preparation	$0	$57	$1,133	$0	$0	$1,190	$118	$0	$262	$1,570	$3
13.2	Site Improvements	$0	$1,881	$2,337	$0	$0	$4,218	$416	$0	$927	$5,561	$10
13.3	Site Facilities	$3,372	$0	$3,325	$0	$0	$6,696	$660	$0	$1,471	$8,828	$16
	SUBTOTAL 13.	**$3,372**	**$1,938**	**$6,795**	**$0**	**$0**	**$12,104**	**$1,194**	**$0**	**$2,660**	**$15,958**	**$29**
14	BUILDINGS & STRUCTURES											
14.1	Boiler Building	$0	$10,970	$9,647	$0	$0	$20,618	$1,853	$0	$3,371	$25,842	$47
14.2	Turbine Building	$0	$13,052	$12,164	$0	$0	$25,216	$2,273	$0	$4,123	$31,612	$57
14.3	Administration Building	$0	$650	$687	$0	$0	$1,338	$121	$0	$219	$1,678	$3
14.4	Circulation Water Pumphouse	$0	$298	$237	$0	$0	$535	$48	$0	$87	$671	$1
14.5	Water Treatment Buildings	$0	$842	$768	$0	$0	$1,609	$145	$0	$263	$2,017	$4
14.6	Machine Shop	$0	$435	$292	$0	$0	$727	$64	$0	$119	$910	$2
14.7	Warehouse	$0	$295	$296	$0	$0	$590	$53	$0	$97	$740	$1
14.8	Other Buildings & Structures	$0	$241	$205	$0	$0	$446	$40	$0	$73	$559	$1
14.9	Waste Treating Building & Str.	$0	$461	$1,399	$0	$0	$1,860	$177	$0	$305	$2,342	$4
	SUBTOTAL 14.	**$0**	**$27,244**	**$25,695**	**$0**	**$0**	**$52,939**	**$4,775**	**$0**	**$8,657**	**$66,371**	**$121**
	TOTAL COST	**$992,143**	**$62,198**	**$458,273**	**$0**	**$0**	**$1,512,614**	**$143,290**	**$61,629**	**$240,883**	**$1,958,416**	**$3,561**

Exhibit 4-75 Case L12B Owner's Costs

Owner's Costs	$x1000	$/kW
Preproduction Costs		
6 Months Fixed O&M	$12,575	$23
1 Month Variable O&M	$4,424	$8
25% of 1 Months Fuel Cost at 100% CF	$1,107	$2
2% of TPC	$39,168	$71
Total	**$57,274**	**$104**
Inventory Capital		
60 day supply of fuel and consumables at 100% CF	$11,867	$22
0.5% of TPC (spare parts)	$9,792	$18
Total	**$21,659**	**$39**
Initial Cost for Catalyst and Chemicals	**$2,999**	**$5**
Land	**$900**	**$2**
Other Owner's Costs	**$293,762**	**$534**
Financing Costs	**$52,877**	**$96**
Total Owner's Costs	**$429,472**	**$781**
Total Overnight Cost (TOC)	**$2,387,887**	**$4,341**
TASC Multiplier	1.140	
Total As-Spent Cost (TASC)	**$2,722,191**	**$4,949**

Exhibit 4-76 Case L12B Initial and Annual O&M Costs

INITIAL & ANNUAL O&M EXPENSES					Cost Base (June)	2007
Case L12B - 1x550 MWnet SuperCritical PC w/ CO2 Capture					Heat Rate-net(Btu/kWh):	13,361
					MWe-net:	550
					Capacity Factor: (%):	85
OPERATING & MAINTENANCE LABOR						
Operating Labor						
Operating Labor Rate(base):	34.65	$/hour				
Operating Labor Burden:	30.00	% of base				
Labor O-H Charge Rate:	25.00	% of labor				
			Total			
Skilled Operator	2.0		2.0			
Operator	11.3		11.3			
Foreman	1.0		1.0			
	2.0		2.0			
TOTAL-O.J.'s	16.3		16.3			
					Annual Cost	Annual Unit Cost
					$	$/kW-net
Annual Operating Labor Cost					$6,444,907	$11.718
Maintenance Labor Cost					$13,675,321	$24.864
Administrative & Support Labor					$5,030,057	$9.145
Property Taxes and Insurance					$39,168,311	$71.214
TOTAL FIXED OPERATING COSTS					**$64,318,596**	**$116.941**
VARIABLE OPERATING COSTS						
						$/kWh-net
Maintenance Material Cost					**$20,512,981**	**$0.00501**
Consumables	Consumption Initial	Consumption /Day	Unit Cost	Initial Cost		
Water(/1000 gallons)	0	6,798	1.08	**$0**	**$2,281,420**	**$0.00056**
Chemicals						
MU & WT Chem.(lb)	0	32,908	0.17	$0	$1,766,965	$0.00043
Lime (ton)	0	173	75.00	$0	$4,014,418	$0.00098
Carbon (Mercury Removal) (lb)	0	5,064	1.05	$0	$1,649,929	$0.00040
MEA Solvent (ton)	1,236	1.75	2,249.89	$2,780,858	$1,222,943	$0.00030
NaOH (tons)	83	13.82	433.68	$35,995	$1,860,002	$0.00045
H2SO4 (tons)	83	8.33	138.78	$11,519	$358,575	$0.00009
Corrosion Inhibitor	0	0	0.00	$170,899	$8,138	$0.00000
Activated Carbon(lb)	0	2,093	1.05	$0	$681,932	$0.00017
Ammonia (19% NH3) ton	0	34	129.80	$0	$1,377,261	$0.00034
Subtotal Chemicals				**$2,999,271**	**$12,940,162**	**$0.00316**
Other						
Supplemental Fuel(MBtu)	0	0	0.00	$0	$0	$0.00000
SCR Catalyst(m3)	w/equip.	0.55	5,775.94	$0	$988,455	$0.00024
Emission Penalties	0	0	0.00	$0	$0	$0.00000
Subtotal Other				**$0**	**$988,455**	**$0.00024**
Waste Disposal						
Flyash (ton)	0	1,405	16.23	$0	$7,074,167	$0.00173
Bottom Ash(ton)	0	263	16.23	$0	$1,325,251	$0.00032
Subtotal-Waste Disposal				**$0**	**$8,399,418**	**$0.00205**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	$0.00000
Subtotal By-Products				**$0**	**$0**	**$0.00000**
TOTAL VARIABLE OPERATING COSTS				**$2,999,271**	**$45,122,437**	**$0.01102**
Fuel(ton)	0	13,347	10.92	**$0**	**$45,218,244**	**$0.01104**

Exhibit 4-77 Case S13B Total Plant Cost Summary

Client:	USDOE/NETL		Report Date:	2009-Oct-19
Project:	Low Rank (Western) Coal Baseline Study			
	TOTAL PLANT COST SUMMARY			
Case:	Case S13B - 1x550 MWnet USC PC w/ CO2 Capture			
Plant Size:	550.1 MW,net	Estimate Type: Conceptual	Cost Base (June)	2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING	$20,469	$6,213	$13,558	$0	$0	**$40,240**	$3,623	$0	$6,580	**$50,443**	$92
2	COAL & SORBENT PREP & FEED	$10,366	$833	$2,893	$0	$0	**$14,092**	$1,239	$0	$2,300	**$17,631**	$32
3	FEEDWATER & MISC. BOP SYSTEMS	$57,128	$0	$27,126	$0	$0	**$84,254**	$7,704	$0	$14,889	**$106,846**	$194
4	PC BOILER											
4.1	PC Boiler & Accessories	$254,288	$0	$124,562	$0	$0	**$378,851**	$36,833	$18,943	$43,463	**$478,089**	$869
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.3	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.4-4.9	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 4	**$254,288**	**$0**	**$124,562**	**$0**	**$0**	**$378,851**	**$36,833**	**$18,943**	**$43,463**	**$478,089**	**$869**
5	FLUE GAS CLEANUP	$123,462	$0	$43,768	$0	$0	**$167,230**	$16,012	$0	$18,324	**$201,567**	$366
5B	CO_2 REMOVAL & COMPRESSION	$242,327	$0	$73,818	$0	$0	**$316,144**	$30,227	$55,769	$80,428	**$482,569**	$877
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
6.2-6.9	Combustion Turbine Other	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 6	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
7.2-7.9	HRSG Accessories, Ductwork and Stack	$19,026	$1,042	$12,887	$0	$0	**$32,956**	$3,019	$0	$4,728	**$40,703**	$74
	SUBTOTAL 7	**$19,026**	**$1,042**	**$12,887**	**$0**	**$0**	**$32,956**	**$3,019**	**$0**	**$4,728**	**$40,703**	**$74**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$58,202	$0	$7,560	$0	$0	**$65,761**	$6,302	$3,288	$7,535	**$82,886**	$151
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$58,533	$1,205	$23,908	$0	$0	**$83,646**	$7,667	$0	$15,340	**$106,653**	$194
	SUBTOTAL 8	**$116,735**	**$1,205**	**$31,467**	**$0**	**$0**	**$149,407**	**$13,969**	**$3,288**	**$22,876**	**$189,540**	**$345**
9	COOLING WATER SYSTEM	$18,462	$8,998	$16,586	$0	$0	**$44,046**	$4,146	$0	$6,504	**$54,696**	$99
10	ASH/SPENT SORBENT HANDLING SYS	$6,772	$215	$9,054	$0	$0	**$16,041**	$1,542	$0	$1,810	**$19,393**	$35
11	ACCESSORY ELECTRIC PLANT	$25,439	$10,788	$30,559	$0	$0	**$66,786**	$5,907	$0	$9,131	**$81,824**	$149
12	INSTRUMENTATION & CONTROL	$10,047	$0	$10,187	$0	$0	**$20,234**	$1,835	$1,012	$2,835	**$25,915**	$47
13	IMPROVEMENTS TO SITE	$3,328	$1,913	$6,708	$0	$0	**$11,950**	$1,179	$0	$2,626	**$15,754**	$29
14	BUILDINGS & STRUCTURES	$0	$25,459	$24,094	$0	$0	**$49,553**	$4,470	$0	$8,103	**$62,126**	$113
	TOTAL COST	**$907,849**	**$56,667**	**$427,268**	**$0**	**$0**	**$1,391,784**	**$131,705**	**$79,012**	**$224,595**	**$1,827,095**	**$3,322**

Exhibit 4-78 Case S13B Total Plant Cost Details

Client: USDOE/NETL — Report Date: 2009-Oct-19
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case S13B - 1x550 MWnet USC PC w/ CO2 Capture
Plant Size: 550.1 MW,net — Estimate Type: Conceptual — Cost Base (June) 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING											
1.1	Coal Receive & Unload	$4,958	$0	$2,265	$0	$0	$7,223	$645	$0	$1,180	$9,048	$16
1.2	Coal Stackout & Reclaim	$6,408	$0	$1,452	$0	$0	$7,859	$688	$0	$1,282	$9,829	$18
1.3	Coal Conveyors	$5,957	$0	$1,436	$0	$0	$7,394	$648	$0	$1,206	$9,248	$17
1.4	Other Coal Handling	$1,559	$0	$332	$0	$0	$1,891	$165	$0	$308	$2,365	$4
1.5	Sorbent Receive & Unload	$60	$0	$18	$0	$0	$78	$7	$0	$13	$98	$0
1.6	Sorbent Stackout & Reclaim	$971	$0	$178	$0	$0	$1,149	$100	$0	$187	$1,437	$3
1.7	Sorbent Conveyors	$347	$75	$85	$0	$0	$507	$44	$0	$83	$633	$1
1.8	Other Sorbent Handling	$209	$49	$110	$0	$0	$368	$33	$0	$60	$461	$1
1.9	Coal & Sorbent Hnd.Foundations	$0	$6,089	$7,682	$0	$0	$13,771	$1,293	$0	$2,260	$17,324	$31
	SUBTOTAL 1.	**$20,469**	**$6,213**	**$13,558**	**$0**	**$0**	**$40,240**	**$3,623**	**$0**	**$6,580**	**$50,443**	**$92**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$2,911	$0	$567	$0	$0	$3,479	$303	$0	$567	$4,349	$8
2.2	Coal Conveyor to Storage	$7,454	$0	$1,627	$0	$0	$9,082	$794	$0	$1,481	$11,357	$21
2.3	Coal Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.4	Misc.Coal Prep & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.5	Sorbent Prep Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.6	Sorbent Storage & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.7	Sorbent Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.8	Booster Air Supply System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.9	Coal & Sorbent Feed Foundation	$0	$833	$699	$0	$0	$1,532	$142	$0	$251	$1,925	$3
	SUBTOTAL 2.	**$10,366**	**$833**	**$2,893**	**$0**	**$0**	**$14,092**	**$1,239**	**$0**	**$2,300**	**$17,631**	**$32**
3	FEEDWATER & MISC. BOP SYSTEMS											
3.1	FeedwaterSystem	$25,238	$0	$8,153	$0	$0	$33,391	$2,918	$0	$5,446	$41,755	$76
3.2	Water Makeup & Pretreating	$6,006	$0	$1,933	$0	$0	$7,939	$751	$0	$1,738	$10,428	$19
3.3	Other Feedwater Subsystems	$7,727	$0	$3,265	$0	$0	$10,992	$985	$0	$1,796	$13,773	$25
3.4	Service Water Systems	$1,177	$0	$641	$0	$0	$1,818	$171	$0	$398	$2,387	$4
3.5	Other Boiler Plant Systems	$9,693	$0	$9,570	$0	$0	$19,263	$1,830	$0	$3,164	$24,256	$44
3.6	FO Supply Sys & Nat Gas	$277	$0	$346	$0	$0	$623	$59	$0	$102	$784	$1
3.7	Waste Treatment Equipment	$4,072	$0	$2,321	$0	$0	$6,393	$622	$0	$1,403	$8,418	$15
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	$2,938	$0	$898	$0	$0	$3,836	$369	$0	$841	$5,046	$9
	SUBTOTAL 3.	**$57,128**	**$0**	**$27,126**	**$0**	**$0**	**$84,254**	**$7,704**	**$0**	**$14,889**	**$106,846**	**$194**
4	PC BOILER											
4.1	PC Boiler & Accessories	$254,288	$0	$124,562	$0	$0	$378,851	$36,833	$18,943	$43,463	$478,089	$869
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.3	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.4	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.5	Primary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.6	Secondary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.8	Major Component Rigging	$0	w/4.1	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.9	Boiler Foundations	$0	w/14.1	w/14.1	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 4.	**$254,288**	**$0**	**$124,562**	**$0**	**$0**	**$378,851**	**$36,833**	**$18,943**	**$43,463**	**$478,089**	**$869**

Exhibit 4-78 Case S13B Total Plant Cost Details (Continued)

Client:	USDOE/NETL	Report Date:	2009-Oct-19
Project:	Low Rank (Western) Coal Baseline Study		

TOTAL PLANT COST SUMMARY

Case:	Case S13B - 1x550 MWnet USC PC w/ CO2 Capture						
Plant Size:	550.1 MW,net	Estimate Type:	Conceptual	Cost Base (June)	2007	($x1000)	

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$98,625	$0	$26,866	$0	$0	$125,491	$11,987	$0	$13,748	$151,226	$275
5.2	Other FGD	$1,273	$0	$826	$0	$0	$2,099	$202	$0	$230	$2,531	$5
5.3	Bag House & Accessories	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.4	Other Particulate Removal Materials	$23,564	$0	$16,077	$0	$0	$39,640	$3,823	$0	$4,346	$47,810	$87
5.5	Gypsum Dewatering System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.6	Mercury Removal System	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.9	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 5.	**$123,462**	**$0**	**$43,768**	**$0**	**$0**	**$167,230**	**$16,012**	**$0**	**$18,324**	**$201,567**	**$366**
5B	CO_2 REMOVAL & COMPRESSION											
5B.1	CO_2 Removal System	$213,936	$0	$64,911	$0	$0	$278,847	$26,660	$55,769	$72,255	$433,532	$788
5B.2	CO_2 Compression & Drying	$28,390	$0	$8,906	$0	$0	$37,297	$3,567	$0	$8,173	$49,036	$89
	SUBTOTAL 5.	**$242,327**	**$0**	**$73,818**	**$0**	**$0**	**$316,144**	**$30,227**	**$55,769**	**$80,428**	**$482,569**	**$877**
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
6.2	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.3	Compressed Air Piping	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.9	Combustion Turbine Foundations	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
7.2	HRSG Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7.3	Ductwork	$9,941	$0	$6,387	$0	$0	$16,328	$1,424	$0	$2,663	$20,415	$37
7.4	Stack	$9,085	$0	$5,316	$0	$0	$14,401	$1,386	$0	$1,579	$17,366	$32
7.9	Duct & Stack Foundations	$0	$1,042	$1,184	$0	$0	$2,226	$208	$0	$487	$2,921	$5
	SUBTOTAL 7.	**$19,026**	**$1,042**	**$12,887**	**$0**	**$0**	**$32,956**	**$3,019**	**$0**	**$4,728**	**$40,703**	**$74**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$58,202	$0	$7,560	$0	$0	$65,761	$6,302	$3,288	$7,535	$82,886	$151
8.2	Turbine Plant Auxiliaries	$384	$0	$822	$0	$0	$1,206	$118	$0	$132	$1,457	$3
8.3a	Condenser & Auxiliaries	$3,001	$0	$2,038	$0	$0	$5,039	$486	$0	$552	$6,077	$11
8.3b	Air Cooled Condenser	$27,502	$0	$5,514	$0	$0	$33,016	$3,302	$0	$7,264	$43,581	$79
8.4	Steam Piping	$27,646	$0	$13,631	$0	$0	$41,277	$3,468	$0	$6,712	$51,457	$94
8.9	TG Foundations	$0	$1,205	$1,903	$0	$0	$3,107	$294	$0	$680	$4,082	$7
	SUBTOTAL 8.	**$116,735**	**$1,205**	**$31,467**	**$0**	**$0**	**$149,407**	**$13,969**	**$3,288**	**$22,876**	**$189,540**	**$345**
9	COOLING WATER SYSTEM											
9.1	Cooling Towers	$13,755	$0	$4,283	$0	$0	$18,039	$1,725	$0	$1,976	$21,740	$40
9.2	Circulating Water Pumps	$2,866	$0	$210	$0	$0	$3,076	$260	$0	$334	$3,669	$7
9.3	Circ.Water System Auxiliaries	$713	$0	$95	$0	$0	$808	$77	$0	$88	$973	$2
9.4	Circ.Water Piping	$0	$5,651	$5,476	$0	$0	$11,127	$1,042	$0	$1,825	$13,994	$25
9.5	Make-up Water System	$564	$0	$753	$0	$0	$1,316	$126	$0	$216	$1,659	$3
9.6	Component Cooling Water Sys	$565	$0	$449	$0	$0	$1,014	$96	$0	$167	$1,277	$2
9.9	Circ.Water System Foundations& Structures	$0	$3,348	$5,319	$0	$0	$8,667	$820	$0	$1,897	$11,384	$21
	SUBTOTAL 9.	**$18,462**	**$8,998**	**$16,586**	**$0**	**$0**	**$44,046**	**$4,146**	**$0**	**$6,504**	**$54,696**	**$99**

Exhibit 4-78 Case S13B Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 2009-Oct-19
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case S13B - 1x550 MWnet USC PC w/ CO2 Capture
Plant Size: 550.1 MW,net **Estimate Type:** Conceptual **Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
10	ASH/SPENT SORBENT HANDLING SYS											
10.1	Ash Coolers	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.2	Cyclone Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.3	HGCU Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.4	High Temperature Ash Piping	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.5	Other Ash Recovery Equipment	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.6	Ash Storage Silos	$906	$0	$2,792	$0	$0	$3,698	$363	$0	$406	$4,467	$8
10.7	Ash Transport & Feed Equipment	$5,866	$0	$6,008	$0	$0	$11,874	$1,135	$0	$1,301	$14,310	$26
10.8	Misc. Ash Handling Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.9	Ash/Spent Sorbent Foundation	$0	$215	$254	$0	$0	$469	$44	$0	$103	$615	$1
	SUBTOTAL 10.	**$6,772**	**$215**	**$9,054**	**$0**	**$0**	**$16,041**	**$1,542**	**$0**	**$1,810**	**$19,393**	**$35**
11	ACCESSORY ELECTRIC PLANT											
11.1	Generator Equipment	$1,732	$0	$281	$0	$0	$2,013	$187	$0	$165	$2,365	$4
11.2	Station Service Equipment	$5,020	$0	$1,649	$0	$0	$6,669	$623	$0	$547	$7,839	$14
11.3	Switchgear & Motor Control	$5,771	$0	$981	$0	$0	$6,752	$626	$0	$738	$8,115	$15
11.4	Conduit & Cable Tray	$0	$3,618	$12,510	$0	$0	$16,128	$1,561	$0	$2,653	$20,343	$37
11.5	Wire & Cable	$0	$6,827	$13,179	$0	$0	$20,006	$1,685	$0	$3,254	$24,945	$45
11.6	Protective Equipment	$264	$0	$898	$0	$0	$1,162	$113	$0	$128	$1,403	$3
11.7	Standby Equipment	$1,363	$0	$31	$0	$0	$1,394	$128	$0	$152	$1,674	$3
11.8	Main Power Transformers	$11,289	$0	$189	$0	$0	$11,478	$870	$0	$1,235	$13,584	$25
11.9	Electrical Foundations	$0	$343	$840	$0	$0	$1,183	$113	$0	$259	$1,555	$3
	SUBTOTAL 11.	**$25,439**	**$10,788**	**$30,559**	**$0**	**$0**	**$66,786**	**$5,907**	**$0**	**$9,131**	**$81,824**	**$149**
12	INSTRUMENTATION & CONTROL											
12.1	PC Control Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.2	Combustion Turbine Control	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
12.3	Steam Turbine Control	w/8.1	$0	w/8.1	$0	$0	$0	$0	$0	$0	$0	$0
12.4	Other Major Component Control	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.5	Signal Processing Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.6	Control Boards,Panels & Racks	$517	$0	$310	$0	$0	$827	$78	$41	$142	$1,089	$2
12.7	Distributed Control System Equipment	$5,222	$0	$913	$0	$0	$6,135	$569	$307	$701	$7,712	$14
12.8	Instrument Wiring & Tubing	$2,831	$0	$5,616	$0	$0	$8,447	$720	$422	$1,438	$11,028	$20
12.9	Other I & C Equipment	$1,476	$0	$3,349	$0	$0	$4,825	$468	$241	$553	$6,087	$11
	SUBTOTAL 12.	**$10,047**	**$0**	**$10,187**	**$0**	**$0**	**$20,234**	**$1,835**	**$1,012**	**$2,835**	**$25,915**	**$47**

Exhibit 4-78 Case S13B Total Plant Cost Details (Continued)

Client:	USDOE/NETL							**Report Date:**	2009-Oct-19
Project:	Low Rank (Western) Coal Baseline Study								
	TOTAL PLANT COST SUMMARY								
Case:	Case S13B - 1x550 MWnet USC PC w/ CO2 Capture								
Plant Size:	550.1 MW,net	**Estimate Type:**	Conceptual				**Cost Base (June)**	2007	($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
13	IMPROVEMENTS TO SITE											
13.1	Site Preparation	$0	$56	$1,119	$0	$0	$1,175	$117	$0	$258	$1,550	$3
13.2	Site Improvements	$0	$1,857	$2,307	$0	$0	$4,164	$411	$0	$915	$5,490	$10
13.3	Site Facilities	$3,328	$0	$3,282	$0	$0	$6,611	$652	$0	$1,452	$8,715	$16
	SUBTOTAL 13.	**$3,328**	**$1,913**	**$6,708**	**$0**	**$0**	**$11,950**	**$1,179**	**$0**	**$2,626**	**$15,754**	**$29**
14	BUILDINGS & STRUCTURES											
14.1	Boiler Building	$0	$9,667	$8,501	$0	$0	$18,168	$1,633	$0	$2,970	$22,771	$41
14.2	Turbine Building	$0	$12,672	$11,810	$0	$0	$24,482	$2,207	$0	$4,003	$30,691	$56
14.3	Administration Building	$0	$644	$681	$0	$0	$1,326	$120	$0	$217	$1,663	$3
14.4	Circulation Water Pumphouse	$0	$296	$235	$0	$0	$531	$47	$0	$87	$665	$1
14.5	Water Treatment Buildings	$0	$762	$695	$0	$0	$1,456	$131	$0	$238	$1,826	$3
14.6	Machine Shop	$0	$431	$290	$0	$0	$720	$64	$0	$118	$902	$2
14.7	Warehouse	$0	$292	$293	$0	$0	$585	$53	$0	$96	$734	$1
14.8	Other Buildings & Structures	$0	$239	$203	$0	$0	$442	$40	$0	$72	$554	$1
14.9	Waste Treating Building & Str.	$0	$457	$1,386	$0	$0	$1,843	$175	$0	$303	$2,321	$4
	SUBTOTAL 14.	**$0**	**$25,459**	**$24,094**	**$0**	**$0**	**$49,553**	**$4,470**	**$0**	**$8,103**	**$62,126**	**$113**
	TOTAL COST	**$907,849**	**$56,667**	**$427,268**	**$0**	**$0**	**$1,391,784**	**$131,705**	**$79,012**	**$224,595**	**$1,827,095**	**$3,322**

Exhibit 4-79 Case S13B Owner's Costs

Owner's Costs	$x1000	$/kW
Preproduction Costs		
6 Months Fixed O&M	$11,792	$21
1 Month Variable O&M	$3,631	$7
25% of 1 Months Fuel Cost at 100% CF	$1,061	$2
2% of TPC	$36,542	$66
Total	**$53,025**	**$96**
Inventory Capital		
60 day supply of fuel and consumables at 100% CF	$10,926	$20
0.5% of TPC (spare parts)	$9,135	$17
Total	**$20,062**	**$36**
Initial Cost for Catalyst and Chemicals	**$2,608**	**$5**
Land	**$900**	**$2**
Other Owner's Costs	**$274,064**	**$498**
Financing Costs	**$49,332**	**$90**
Total Owner's Costs	**$399,991**	**$727**
Total Overnight Cost (TOC)	**$2,227,086**	**$4,049**
TASC Multiplier	1.140	
Total As-Spent Cost (TASC)	**$2,538,878**	**$4,615**

Exhibit 4-80 Case S13B Initial and Annual O&M Costs

INITIAL & ANNUAL O&M EXPENSES						Cost Base (June):	2007
Case S13B - 1x550 MWnet USC PC w/ CO2 Capture						Heat Rate-net (Btu/kWh):	11,898
						MWe-net:	550
						Capacity Factor (%):	85
OPERATING & MAINTENANCE LABOR							
Operating Labor							
Operating Labor Rate(base):	34.65	$/hour					
Operating Labor Burden:	30.00	% of base					
Labor O-H Charge Rate:	25.00	% of labor					
			Total				
Skilled Operator	2.0		2.0				
Operator	11.3		11.3				
Foreman	1.0		1.0				
Lab Tech's, etc.	2.0		2.0				
TOTAL-O.J.'s	16.3		16.3				
						Annual Cost	Annual Unit Cost
						$	$/kW-net
Annual Operating Labor Cost						$6,444,907	$11.717
Maintenance Labor Cost						$12,421,693	$22.582
Administrative & Support Labor						$4,716,650	$8.575
Property Taxes and Insurance						$36,541,902	$66.431
TOTAL FIXED OPERATING COSTS						**$60,125,153**	**$109.305**
VARIABLE OPERATING COSTS							
							$/kWh-net
Maintenance Material Cost						**$18,632,540**	**$0.00455**
Consumables	Consumption Initial	Consumption /Day	Unit Cost	Initial Cost			
Water(/1000 gallons)	0	5,891	1.08	**$0**		**$1,976,960**	**$0.00048**
Chemicals							
MU & WT Chem.(lb)	0	28,518	0.17	$0		$1,531,257	$0.00037
Lime (ton)	0	138	75.00	$0		$3,219,464	$0.00079
Carbon (Mercury Removal) (lb)	0	3,027	1.05	$0		$986,243	$0.00024
MEA Solvent (ton)	1,075	1.53	2,249.89	$2,418,627		$1,070,792	$0.00026
NaOH (tons)	70	10.90	433.68	$30,357		$1,466,043	$0.00036
H2SO4 (tons)	72	7.25	138.78	$9,992		$312,074	$0.00008
Corrosion Inhibitor	0	0	0.00	$148,677		$7,080	$0.00000
Activated Carbon(lb)	0	1,822	1.05	$0		$593,636	$0.00014
Ammonia (19% NH3) ton	0	30	129.80	$0		$1,208,282	$0.00030
Subtotal Chemicals				**$2,607,653**		**$10,394,870**	**$0.00254**
Other							
Supplemental Fuel(MBtu)	0	0	0.00	$0		$0	$0.00000
SCR Catalyst(m3)	w/equip.	0.46	5,775.94	$0		$832,986	$0.00020
Emission Penalties	0	0	0.00	$0		$0	$0.00000
Subtotal Other				**$0**		**$832,986**	**$0.00020**
Waste Disposal							
Flyash (ton)	0	882	16.23	$0		$4,439,834	$0.00108
Bottom Ash(ton)	0	150	16.23	$0		$757,191	$0.00018
Subtotal-Waste Disposal				**$0**		**$5,197,025**	**$0.00127**
By-products & Emissions							
Gypsum (tons)	0	0	0.00	$0		$0	$0.00000
Subtotal By-Products				**$0**		**$0**	**$0.00000**
TOTAL VARIABLE OPERATING COSTS				**$2,607,653**		**$37,034,381**	**$0.00904**
Fuel(ton)	0	9,171	15.22	**$0**		**$43,303,496**	**$0.01057**

Exhibit 4-81 Case L13B Total Plant Cost Summary

Client: USDOE/NETL
Report Date: 2009-Oct-19
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case L13B - 1x550 MWnet USC PC w/ CO2 Capture
Plant Size: 550.1 MW,net
Estimate Type: Conceptual
Cost Base (June) 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING	$24,673	$7,526	$16,410	$0	$0	**$48,610**	$4,377	$0	$7,948	**$60,935**	$111
2	COAL & SORBENT PREP & FEED	$12,735	$1,023	$3,555	$0	$0	**$17,313**	$1,522	$0	$2,825	**$21,661**	$39
3	FEEDWATER & MISC. BOP SYSTEMS	$59,190	$0	$28,752	$0	$0	**$87,942**	$8,052	$0	$15,528	**$111,522**	$203
4	PC BOILER											
4.1	PC Boiler & Accessories	$307,732	$0	$139,322	$0	$0	**$447,054**	$43,440	$22,353	$51,285	**$564,131**	$1,026
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.3	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.4-4.9	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 4	**$307,732**	**$0**	**$139,322**	**$0**	**$0**	**$447,054**	**$43,440**	**$22,353**	**$51,285**	**$564,131**	**$1,026**
5	FLUE GAS CLEANUP	$131,420	$0	$46,589	$0	$0	**$178,008**	$17,044	$0	$19,505	**$214,558**	$390
5B	CO_2 REMOVAL & COMPRESSION	$251,763	$0	$76,692	$0	$0	**$328,455**	$31,404	$57,941	$83,560	**$501,361**	$911
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
6.2-6.9	Combustion Turbine Other	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 6	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
7.2-7.9	HRSG Accessories, Ductwork and Stack	$18,932	$1,037	$12,823	$0	$0	**$32,792**	$3,004	$0	$4,705	**$40,501**	$74
	SUBTOTAL 7	**$18,932**	**$1,037**	**$12,823**	**$0**	**$0**	**$32,792**	**$3,004**	**$0**	**$4,705**	**$40,501**	**$74**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$58,260	$0	$7,567	$0	$0	**$65,827**	$6,308	$3,291	$7,543	**$82,969**	$151
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$57,635	$1,205	$23,822	$0	$0	**$82,662**	$7,564	$0	$15,116	**$105,342**	$192
	SUBTOTAL 8	**$115,895**	**$1,205**	**$31,389**	**$0**	**$0**	**$148,489**	**$13,872**	**$3,291**	**$22,659**	**$188,312**	**$342**
9	COOLING WATER SYSTEM	$19,633	$9,493	$17,535	$0	$0	**$46,661**	$4,392	$0	$6,881	**$57,934**	$105
10	ASH/SPENT SORBENT HANDLING SYS	$8,539	$272	$11,417	$0	$0	**$20,228**	$1,945	$0	$2,282	**$24,455**	$44
11	ACCESSORY ELECTRIC PLANT	$25,493	$10,812	$30,628	$0	$0	**$66,933**	$5,920	$0	$9,151	**$82,004**	$149
12	INSTRUMENTATION & CONTROL	$9,969	$0	$10,108	$0	$0	**$20,077**	$1,820	$1,004	$2,813	**$25,714**	$47
13	IMPROVEMENTS TO SITE	$3,330	$1,914	$6,711	$0	$0	**$11,955**	$1,179	$0	$2,627	**$15,761**	$29
14	BUILDINGS & STRUCTURES	$0	$26,555	$25,060	$0	$0	**$51,615**	$4,655	$0	$8,441	**$64,711**	$118
	TOTAL COST	**$989,303**	**$59,838**	**$456,991**	**$0**	**$0**	**$1,506,133**	**$142,627**	**$84,589**	**$240,210**	**$1,973,559**	**$3,588**

Exhibit 4-82 Case L13B Total Plant Cost Details

	Client:	USDOE/NETL								**Report Date:**	2009-Oct-19	
	Project:	Low Rank (Western) Coal Baseline Study										
		TOTAL PLANT COST SUMMARY										
	Case:	Case L13B - 1x550 MWnet USC PC w/ CO2 Capture										
	Plant Size:	550.1 MW,net		**Estimate Type:**		Conceptual				**Cost Base (June)** 2007	($x1000)	
Acct No.	**Item/Description**	**Equipment Cost**	**Material Cost**	**Labor Direct**	**Labor Indirect**	**Sales Tax**	**Bare Erected Cost $**	**Eng'g CM H.O.& Fee**	**Contingencies Process**	**Contingencies Project**	**TOTAL PLANT COST $**	**TOTAL PLANT COST $/kW**
1	COAL & SORBENT HANDLING											
1.1	Coal Receive & Unload	$6,016	$0	$2,748	$0	$0	$8,764	$783	$0	$1,432	$10,979	$20
1.2	Coal Stackout & Reclaim	$7,775	$0	$1,761	$0	$0	$9,536	$834	$0	$1,556	$11,926	$22
1.3	Coal Conveyors	$7,228	$0	$1,743	$0	$0	$8,971	$786	$0	$1,464	$11,221	$20
1.4	Other Coal Handling	$1,891	$0	$403	$0	$0	$2,294	$200	$0	$374	$2,869	$5
1.5	Sorbent Receive & Unload	$67	$0	$20	$0	$0	$87	$8	$0	$14	$109	$0
1.6	Sorbent Stackout & Reclaim	$1,079	$0	$198	$0	$0	$1,277	$111	$0	$208	$1,596	$3
1.7	Sorbent Conveyors	$385	$83	$94	$0	$0	$563	$49	$0	$92	$703	$1
1.8	Other Sorbent Handling	$233	$55	$122	$0	$0	$409	$36	$0	$67	$512	$1
1.9	Coal & Sorbent Hnd.Foundations	$0	$7,389	$9,321	$0	$0	$16,709	$1,569	$0	$2,742	$21,021	$38
	SUBTOTAL 1.	**$24,673**	**$7,526**	**$16,410**	**$0**	**$0**	**$48,610**	**$4,377**	**$0**	**$7,948**	**$60,935**	**$111**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$3,577	$0	$697	$0	$0	$4,274	$373	$0	$697	$5,344	$10
2.2	Coal Conveyor to Storage	$9,158	$0	$1,999	$0	$0	$11,158	$975	$0	$1,820	$13,953	$25
2.3	Coal Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.4	Misc.Coal Prep & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.5	Sorbent Prep Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.6	Sorbent Storage & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.7	Sorbent Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.8	Booster Air Supply System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.9	Coal & Sorbent Feed Foundation	$0	$1,023	$859	$0	$0	$1,882	$174	$0	$308	$2,364	$4
	SUBTOTAL 2.	**$12,735**	**$1,023**	**$3,555**	**$0**	**$0**	**$17,313**	**$1,522**	**$0**	**$2,825**	**$21,661**	**$39**
3	FEEDWATER & MISC. BOP SYSTEMS											
3.1	FeedwaterSystem	$25,440	$0	$8,218	$0	$0	$33,658	$2,941	$0	$5,490	$42,089	$77
3.2	Water Makeup & Pretreating	$6,238	$0	$2,008	$0	$0	$8,246	$780	$0	$1,805	$10,831	$20
3.3	Other Feedwater Subsystems	$7,788	$0	$3,291	$0	$0	$11,080	$993	$0	$1,811	$13,883	$25
3.4	Service Water Systems	$1,223	$0	$665	$0	$0	$1,888	$178	$0	$413	$2,479	$5
3.5	Other Boiler Plant Systems	$11,055	$0	$10,914	$0	$0	$21,969	$2,087	$0	$3,608	$27,664	$50
3.6	FO Supply Sys & Nat Gas	$277	$0	$346	$0	$0	$623	$59	$0	$102	$784	$1
3.7	Waste Treatment Equipment	$4,229	$0	$2,411	$0	$0	$6,640	$646	$0	$1,457	$8,744	$16
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	$2,940	$0	$898	$0	$0	$3,838	$369	$0	$841	$5,048	$9
	SUBTOTAL 3.	**$59,190**	**$0**	**$28,752**	**$0**	**$0**	**$87,942**	**$8,052**	**$0**	**$15,528**	**$111,522**	**$203**
4	PC BOILER											
4.1	PC Boiler & Accessories	$307,732	$0	$139,322	$0	$0	$447,054	$43,440	$22,353	$51,285	$564,131	$1,026
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.3	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.4	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.5	Primary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.6	Secondary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.8	Major Component Rigging	$0	w/4.1	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.9	Boiler Foundations	$0	w/14.1	w/14.1	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 4.	**$307,732**	**$0**	**$139,322**	**$0**	**$0**	**$447,054**	**$43,440**	**$22,353**	**$51,285**	**$564,131**	**$1,026**

Exhibit 4-82 Case L13B Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 2009-Oct-19
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case L13B - 1x550 MWnet USC PC w/ CO2 Capture
Plant Size: 550.1 MW,net **Estimate Type:** Conceptual **Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$104,982	$0	$28,597	$0	$0	$133,579	$12,759	$0	$14,634	$160,972	$293
5.2	Other FGD	$1,355	$0	$879	$0	$0	$2,234	$215	$0	$245	$2,694	$5
5.3	Bag House & Accessories	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.4	Other Particulate Removal Materials	$25,082	$0	$17,113	$0	$0	$42,195	$4,070	$0	$4,626	$50,891	$93
5.5	Gypsum Dewatering System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.6	Mercury Removal System	w/5.1	$0	w/5.1	$0	$0	$0	$0	$0	$0	$0	$0
5.9	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 5.	**$131,420**	**$0**	**$46,589**	**$0**	**$0**	**$178,008**	**$17,044**	**$0**	**$19,505**	**$214,558**	**$390**
5B	CO_2 REMOVAL & COMPRESSION											
5B.1	CO_2 Removal System	$222,267	$0	$67,439	$0	$0	$289,706	$27,698	$57,941	$75,069	$450,415	$819
5B.2	CO_2 Compression & Drying	$29,496	$0	$9,253	$0	$0	$38,749	$3,706	$0	$8,491	$50,946	$93
	SUBTOTAL 5.	**$251,763**	**$0**	**$76,692**	**$0**	**$0**	**$328,455**	**$31,404**	**$57,941**	**$83,560**	**$501,361**	**$911**
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
6.2	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.3	Compressed Air Piping	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.9	Combustion Turbine Foundations	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
7.2	HRSG Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7.3	Ductwork	$9,892	$0	$6,356	$0	$0	$16,248	$1,417	$0	$2,650	$20,314	$37
7.4	Stack	$9,040	$0	$5,290	$0	$0	$14,330	$1,380	$0	$1,571	$17,280	$31
7.9	Duct & Stack Foundations	$0	$1,037	$1,178	$0	$0	$2,215	$207	$0	$484	$2,907	$5
	SUBTOTAL 7.	**$18,932**	**$1,037**	**$12,823**	**$0**	**$0**	**$32,792**	**$3,004**	**$0**	**$4,705**	**$40,501**	**$74**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$58,260	$0	$7,567	$0	$0	$65,827	$6,308	$3,291	$7,543	$82,969	$151
8.2	Turbine Plant Auxiliaries	$384	$0	$823	$0	$0	$1,207	$118	$0	$132	$1,457	$3
8.3a	Condenser & Auxiliaries	$2,890	$0	$2,039	$0	$0	$4,929	$476	$0	$540	$5,945	$11
8.3b	Air Cooled Condenser	$26,481	$0	$5,309	$0	$0	$31,790	$3,179	$0	$6,994	$41,963	$76
8.4	Steam Piping	$27,880	$0	$13,747	$0	$0	$41,627	$3,497	$0	$6,769	$51,893	$94
8.9	TG Foundations	$0	$1,205	$1,904	$0	$0	$3,109	$294	$0	$681	$4,084	$7
	SUBTOTAL 8.	**$115,895**	**$1,205**	**$31,389**	**$0**	**$0**	**$148,489**	**$13,872**	**$3,291**	**$22,659**	**$188,312**	**$342**
9	COOLING WATER SYSTEM											
9.1	Cooling Towers	$14,655	$0	$4,564	$0	$0	$19,218	$1,838	$0	$2,106	$23,162	$42
9.2	Circulating Water Pumps	$3,049	$0	$229	$0	$0	$3,278	$277	$0	$356	$3,911	$7
9.3	Circ.Water System Auxiliaries	$752	$0	$100	$0	$0	$852	$81	$0	$93	$1,026	$2
9.4	Circ.Water Piping	$0	$5,959	$5,775	$0	$0	$11,734	$1,098	$0	$1,925	$14,757	$27
9.5	Make-up Water System	$582	$0	$777	$0	$0	$1,359	$130	$0	$223	$1,713	$3
9.6	Component Cooling Water Sys	$595	$0	$474	$0	$0	$1,069	$102	$0	$176	$1,346	$2
9.9	Circ.Water System Foundations& Structures	$0	$3,535	$5,616	$0	$0	$9,150	$866	$0	$2,003	$12,019	$22
	SUBTOTAL 9.	**$19,633**	**$9,493**	**$17,535**	**$0**	**$0**	**$46,661**	**$4,392**	**$0**	**$6,881**	**$57,934**	**$105**

Exhibit 4-82 Case L13B Total Plant Cost Details (Continued)

Client:	USDOE/NETL	**Report Date:**	2009-Oct-19
Project:	Low Rank (Western) Coal Baseline Study		

TOTAL PLANT COST SUMMARY

Case:	Case L13B - 1x550 MWnet USC PC w/ CO2 Capture						
Plant Size:	550.1 MW,net	**Estimate Type:**	Conceptual	**Cost Base (June)**	2007	($x1000)	

Acct		Equipment	Material	Labor		Sales	Bare Erected	Eng'g CM	Contingencies		TOTAL PLANT COST	
No.	Item/Description	Cost	Cost	Direct	Indirect	Tax	Cost $	H.O.& Fee	Process	Project	$	$/kW
10	ASH/SPENT SORBENT HANDLING SYS											
10.1	Ash Coolers	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.2	Cyclone Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.3	HGCU Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.4	High Temperature Ash Piping	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.5	Other Ash Recovery Equipment	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.6	Ash Storage Silos	$1,143	$0	$3,521	$0	$0	$4,663	$458	$0	$512	$5,633	$10
10.7	Ash Transport & Feed Equipment	$7,397	$0	$7,577	$0	$0	$14,973	$1,432	$0	$1,641	$18,046	$33
10.8	Misc. Ash Handling Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.9	Ash/Spent Sorbent Foundation	$0	$272	$320	$0	$0	$591	$55	$0	$129	$776	$1
	SUBTOTAL 10.	**$8,539**	**$272**	**$11,417**	**$0**	**$0**	**$20,228**	**$1,945**	**$0**	**$2,282**	**$24,455**	**$44**
11	ACCESSORY ELECTRIC PLANT											
11.1	Generator Equipment	$1,733	$0	$281	$0	$0	$2,015	$187	$0	$165	$2,366	$4
11.2	Station Service Equipment	$5,031	$0	$1,653	$0	$0	$6,684	$625	$0	$548	$7,857	$14
11.3	Switchgear & Motor Control	$5,784	$0	$983	$0	$0	$6,767	$627	$0	$739	$8,134	$15
11.4	Conduit & Cable Tray	$0	$3,626	$12,539	$0	$0	$16,166	$1,565	$0	$2,660	$20,390	$37
11.5	Wire & Cable	$0	$6,843	$13,210	$0	$0	$20,053	$1,689	$0	$3,261	$25,003	$45
11.6	Protective Equipment	$265	$0	$900	$0	$0	$1,165	$114	$0	$128	$1,406	$3
11.7	Standby Equipment	$1,364	$0	$31	$0	$0	$1,395	$128	$0	$152	$1,675	$3
11.8	Main Power Transformers	$11,316	$0	$189	$0	$0	$11,505	$872	$0	$1,238	$13,615	$25
11.9	Electrical Foundations	$0	$343	$841	$0	$0	$1,184	$113	$0	$259	$1,556	$3
	SUBTOTAL 11.	**$25,493**	**$10,812**	**$30,628**	**$0**	**$0**	**$66,933**	**$5,920**	**$0**	**$9,151**	**$82,004**	**$149**
12	INSTRUMENTATION & CONTROL											
12.1	PC Control Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.2	Combustion Turbine Control	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
12.3	Steam Turbine Control	w/8.1	$0	w/8.1	$0	$0	$0	$0	$0	$0	$0	$0
12.4	Other Major Component Control	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.5	Signal Processing Equipment	W/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.6	Control Boards,Panels & Racks	$513	$0	$307	$0	$0	$821	$78	$41	$141	$1,080	$2
12.7	Distributed Control System Equipment	$5,182	$0	$906	$0	$0	$6,088	$564	$304	$696	$7,652	$14
12.8	Instrument Wiring & Tubing	$2,809	$0	$5,572	$0	$0	$8,382	$714	$419	$1,427	$10,942	$20
12.9	Other I & C Equipment	$1,464	$0	$3,323	$0	$0	$4,787	$464	$239	$549	$6,040	$11
	SUBTOTAL 12.	**$9,969**	**$0**	**$10,108**	**$0**	**$0**	**$20,077**	**$1,820**	**$1,004**	**$2,813**	**$25,714**	**$47**

Exhibit 4-82 Case L13B Total Plant Cost Details (Continued)

Client:	USDOE/NETL	Report Date:	2009-Oct-19
Project:	Low Rank (Western) Coal Baseline Study		
	TOTAL PLANT COST SUMMARY		
Case:	Case L13B - 1x550 MWnet USC PC w/ CO2 Capture		
Plant Size:	550.1 MW,net Estimate Type: Conceptual	Cost Base (June)	2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
13	IMPROVEMENTS TO SITE											
13.1	Site Preparation	$0	$56	$1,119	$0	$0	$1,175	$117	$0	$258	$1,550	$3
13.2	Site Improvements	$0	$1,858	$2,308	$0	$0	$4,166	$411	$0	$915	$5,492	$10
13.3	Site Facilities	$3,330	$0	$3,284	$0	$0	$6,614	$652	$0	$1,453	$8,718	$16
	SUBTOTAL 13.	**$3,330**	**$1,914**	**$6,711**	**$0**	**$0**	**$11,955**	**$1,179**	**$0**	**$2,627**	**$15,761**	**$29**
14	BUILDINGS & STRUCTURES											
14.1	Boiler Building	$0	$10,726	$9,433	$0	$0	$20,159	$1,812	$0	$3,296	$25,267	$46
14.2	Turbine Building	$0	$12,678	$11,816	$0	$0	$24,495	$2,208	$0	$4,005	$30,708	$56
14.3	Administration Building	$0	$645	$682	$0	$0	$1,326	$120	$0	$217	$1,663	$3
14.4	Circulation Water Pumphouse	$0	$296	$235	$0	$0	$531	$47	$0	$87	$665	$1
14.5	Water Treatment Buildings	$0	$791	$721	$0	$0	$1,513	$136	$0	$247	$1,896	$3
14.6	Machine Shop	$0	$431	$290	$0	$0	$721	$64	$0	$118	$902	$2
14.7	Warehouse	$0	$292	$293	$0	$0	$585	$53	$0	$96	$734	$1
14.8	Other Buildings & Structures	$0	$239	$203	$0	$0	$442	$40	$0	$72	$554	$1
14.9	Waste Treating Building & Str.	$0	$457	$1,387	$0	$0	$1,844	$175	$0	$303	$2,322	$4
	SUBTOTAL 14.	**$0**	**$26,555**	**$25,060**	**$0**	**$0**	**$51,615**	**$4,655**	**$0**	**$8,441**	**$64,711**	**$118**
	TOTAL COST	**$989,303**	**$59,838**	**$456,991**	**$0**	**$0**	**$1,506,133**	**$142,627**	**$84,589**	**$240,210**	**$1,973,559**	**$3,588**

Exhibit 4-83 Case L13B Owner's Costs

Owner's Costs	$x1000	$/kW
Preproduction Costs		
6 Months Fixed O&M	$12,590	$23
1 Month Variable O&M	$4,130	$8
25% of 1 Months Fuel Cost at 100% CF	$1,040	$2
2% of TPC	$39,471	$72
Total	**$57,231**	**$104**
Inventory Capital		
60 day supply of fuel and consumables at 100% CF	$10,853	$20
0.5% of TPC (spare parts)	$9,868	$18
Total	**$20,721**	**$38**
Initial Cost for Catalyst and Chemicals	**$2,776**	**$5**
Land	**$900**	**$2**
Other Owner's Costs	**$296,034**	**$538**
Financing Costs	**$53,286**	**$97**
Total Owner's Costs	**$430,947**	**$783**
Total Overnight Cost (TOC)	**$2,404,506**	**$4,372**
TASC Multiplier	1.140	
Total As-Spent Cost (TASC)	**$2,741,137**	**$4,984**

Exhibit 4-84 Case L13B Initial and Annual O&M Costs

INITIAL & ANNUAL O&M EXPENSES					Cost Base (June)	2007
Case L13B - 1x550 MWnet USC PC w/ CO2 Capture					Heat Rate-net(Btu/kWh):	12,558
					MWe-net:	550
					Capacity Factor: (%):	85
OPERATING & MAINTENANCE LABOR						
Operating Labor						
Operating Labor Rate(base):	34.65	$/hour				
Operating Labor Burden:	30.00	% of base				
Labor O-H Charge Rate:	25.00	% of labor				
			Total			
Skilled Operator	2.0		2.0			
Operator	11.3		11.3			
Foreman	1.0		1.0			
Lab Tech's, etc.	2.0		2.0			
TOTAL-O.J.'s	16.3		16.3			
					Annual Cost	Annual Unit Cost
					$	$/kW-net
Annual Operating Labor Cost					$6,444,907	$11.717
Maintenance Labor Cost					$13,698,600	$24.903
Administrative & Support Labor					$5,035,877	$9.155
Property Taxes and Insurance					$39,471,181	$71.757
TOTAL FIXED OPERATING COSTS					**$64,650,564**	**$117.532**
VARIABLE OPERATING COSTS						
						$/kWh-net
Maintenance Material Cost					**$20,547,899**	**$0.00502**
Consumables	Consumption Initial	Consumption /Day	Unit Cost	Initial Cost		
Water(/1000 gallons)	0	6,323	1.08	**$0**	**$2,121,935**	**$0.00052**
Chemicals						
MU & WT Chem.(lb)	0	3,096	0.17	$0	$166,238	$0.00004
Lime (ton)	0	163	75.00	$0	$3,792,901	$0.00093
Carbon (Mercury Removal) (lb)	0	4,764	1.05	$0	$1,552,185	$0.00038
MEA Solvent (ton)	1,144	1.65	2,249.89	$2,573,869	$1,151,744	$0.00028
NaOH (tons)	77	12.97	433.68	$33,393	$1,745,370	$0.00043
H2SO4 (tons)	77	7.82	138.78	$10,686	$336,527	$0.00008
Corrosion Inhibitor	0	0	0.00	$158,267	$7,537	$0.00000
Activated Carbon(lb)	0	1,965	1.05	$0	$640,227	$0.00016
Ammonia (19% NH3) ton	0	31	129.80	$0	$1,248,552	$0.00030
Subtotal Chemicals				**$2,776,215**	**$10,641,280**	**$0.00260**
Other						
Supplemental Fuel(MBtu)	0	0	0.00	$0	$0	$0.00000
SCR Catalyst(m3)	w/equip.	0.51	5,775.94	$0	$918,085	$0.00022
Emission Penalties	0	0	0.00	$0	$0	$0.00000
Subtotal Other				**$0**	**$918,085**	**$0.00022**
Waste Disposal						
Flyash (ton)	0	1,321	16.23	$0	$6,649,723	$0.00162
Bottom Ash(ton)	0	247	16.23	$0	$1,243,350	$0.00030
Subtotal-Waste Disposal				**$0**	**$7,893,073**	**$0.00193**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	$0.00000
Subtotal By-Products				**$0**	**$0**	**$0.00000**
TOTAL VARIABLE OPERATING COSTS				**$2,776,215**	**$42,122,273**	**$0.01028**
Fuel(ton)	0	12,527	10.92	**$0**	**$42,441,720**	**$0.01036**

5. CIRCULATING FLUIDIZED BED COMBUSTION CASES

This section contains an evaluation of plant designs for Cases S22A, S22B, L22A, and L22B, which are based on SC CFB plants. All the designs have a nominal net output of 550 MWe. All four CFB plants use a single reheat 24.1 MPa/593°C/593°C (3,500 psig/1,100°F/1,100°F) cycle. Cases S22A and S22B are very similar in terms of process, equipment, scope, and arrangement, except that Case S22B employs CO_2 absorption/regeneration and compression/transport systems. Cases L22A and L22B differ from Cases S22A and S22B only through the use of a different coal type (NDL instead of PRB).

Section 5.1 covers the two non- CO_2 capture cases and Section 5.2 covers the two CO_2 capture cases. The sections are organized analogously to Section 4 as follows:

- Process and System Description provides an overview of the technology operation as applied to Cases S22A and L22A in Section 5.1.1 and S22B and L22B in Section 5.2.1.
- Key Assumptions is a summary of study and modeling assumptions relevant to Cases S22A and L22A in Section 5.1.2 and S22B and L22B in Section 5.2.2.
- Sparing Philosophy is provided for Cases S22A and L22A in Section 5.1.3 and S22B and L22B Section 5.2.3.
- Performance Results provide the main modeling results from Cases S22A and L22A in Section 5.1.4 and S22B and L22B in Section 5.2.4, including the performance summary, environmental performance, carbon balance, sulfur balance, water balance, mass and energy balance diagrams, and mass and energy balance tables.
- Equipment Lists provide an itemized list of major equipment for Cases S22A and L22A in Section 5.1.5 and S22B and L22B in Section 5.2.5 with account codes that correspond to the cost accounts in the Cost Estimates section.
- Cost Estimates provide a summary of capital and operating costs for Cases S22A and L22A in Section 5.1.6 and S22B and L22B in Section 5.2.6.

If the information for the CO_2 capture cases is identical to that presented for the non-capture cases, a reference is made to the earlier section rather than repeating the information.

5.1 SC CFB NON-CAPTURE CASES (PRB AND LIGNITE)

5.1.1 Process Description

In this section the SC CFB process without CO_2 capture is described. The SC process descriptions follow the BFD in Exhibit 5-1 and stream numbers reference the same exhibit. The tables in Exhibit 5-2 and Exhibit 5-3 provide process data for the numbered streams in the BFD.

Coal (stream 8) and limestone (stream 9) are introduced into the combustor via pipes, and PA (stream 4) is introduced through bubble caps in a grid to fluidize the bed. Additional combustion air, including staged air for NOx and combustion control, is provided by the FD fans (stream 2). The combustor operates at a slight positive pressure so air leakage occurs in the solids collection/recycle zone, and the infiltration air is accounted for in stream 7. Ammonia is injected for additional NOx control using SNCR between the cyclone and the convective backpass.

Flue gas exits the combustor (stream 11) and is cooled to 127°C (260°F) in the combustion air preheater (not shown) before passing to the baghouse to collect the waste products and the fly ash. Flue gas exits the baghouse and enters the ID fan suction (stream 14). The flue gas passes to the plant stack and is discharged to the atmosphere.

Exhibit 5-1 Cases S22A and L22A Process Flow Diagram

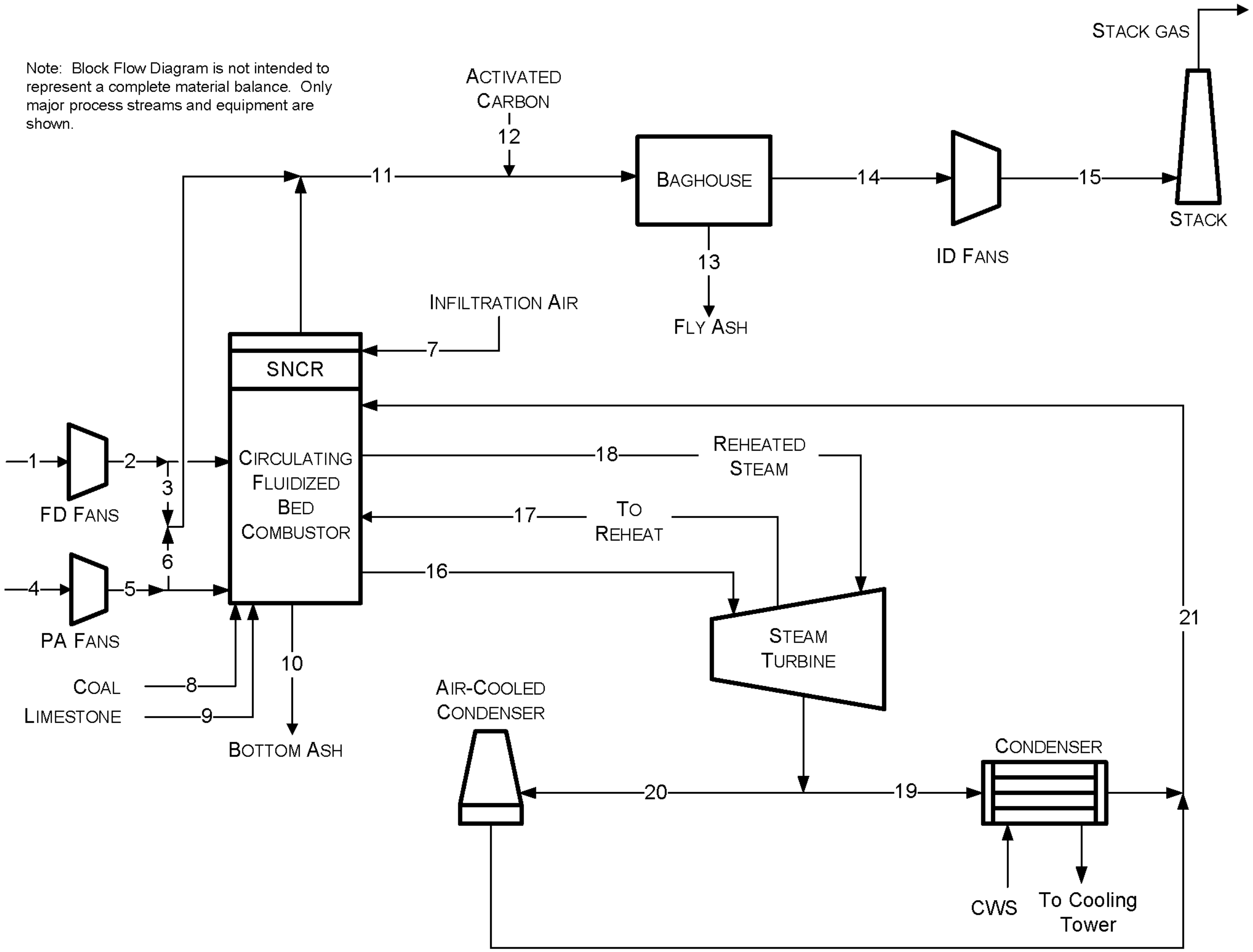

Exhibit 5-2 Case S22A Stream Table

	1	2	3	4	5	6	7	8	9	10	11
V-L Mole Fraction											
Ar	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0000	0.0000	0.0000	0.0085
CO_2	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0000	0.0000	0.0000	0.1412
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0000	0.0000	0.0000	0.1104
N_2	0.7759	0.7759	0.7759	0.7759	0.7759	0.7759	0.7759	0.0000	0.0000	0.0000	0.7082
O_2	0.2081	0.2081	0.2081	0.2081	0.2081	0.2081	0.2081	0.0000	0.0000	0.0000	0.0317
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	26,861	26,861	1,585	40,292	40,292	2,108	1,145	0	0	0	74,918
V-L Flowrate (kg/hr)	776,161	776,161	45,801	1,164,242	1,164,242	60,921	33,082	0	0	0	2,202,362
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	255,512	17,308	13,183	30,760
Temperature (°C)	6	10	10	6	18	18	6	6	6	149	127
Pressure (MPa, abs)	0.09	0.09	0.09	0.09	0.10	0.10	0.09	0.09	0.09	0.09	0.09
Enthalpy (kJ/kg)^A	15.26	20.24	20.24	15.26	27.31	27.31	15.26	---	---	---	258.99
Density (kg/m^3)	1.1	1.2	1.2	1.1	1.2	1.2	1.1	---	---	---	0.8
V-L Molecular Weight	28.895	28.895	28.895	28.895	28.895	28.895	28.895	---	---	---	29.397
V-L Flowrate (lb_{mol}/hr)	59,219	59,219	3,495	88,829	88,829	4,648	2,524	0	0	0	165,165
V-L Flowrate (lb/hr)	1,711,143	1,711,143	100,974	2,566,714	2,566,714	134,308	72,933	0	0	0	4,855,376
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	563,307	38,158	29,063	67,815
Temperature (°F)	42	51	51	42	64	64	42	42	42	300	260
Pressure (psia)	13.0	13.6	13.6	13.0	14.5	14.5	13.0	13.0	13.0	13.0	12.4
Enthalpy (Btu/lb)^A	6.6	8.7	8.7	6.6	11.7	11.7	6.6	---	---	---	111.3
Density (lb/ft^3)	0.070	0.072	0.072	0.070	0.075	0.075	0.070	---	---	---	0.047

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 5-2 Case S22A Stream Table (Continued)

	12	13	14	15	16	17	18	19	20	21
V-L Mole Fraction										
Ar	0.0000	0.0000	0.0085	0.0085	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.0000	0.0000	0.1412	0.1412	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0000	0.0000	0.1104	0.1104	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.0000	0.0000	0.7082	0.7082	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0000	0.0000	0.0317	0.0317	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	0	0	74,918	74,918	89,424	75,308	75,308	34,349	34,349	68,697
V-L Flowrate (kg/hr)	0	0	2,202,362	2,202,362	1,611,006	1,356,701	1,356,701	618,799	618,799	1,237,598
Solids Flowrate (kg/hr)	47	30,807	0	0	0	0	0	0	0	0
Temperature (°C)	6	127	127	137	593	354	593	32	32	32
Pressure (MPa, abs)	0.11	0.08	0.08	0.09	24.23	4.90	4.52	0.005	0.005	1.72
Enthalpy (kJ/kg)[A]	---	---	302.89	313.72	3,476.62	3,082.95	3,652.22	1,932.31	1,932.31	136.94
Density (kg/m^3)	---	---	0.7	0.8	69.2	18.7	11.6	0.05	0.05	995.7
V-L Molecular Weight	---	---	29.397	29.397	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	0	0	165,165	165,165	197,147	166,027	166,027	75,726	75,726	151,451
V-L Flowrate (lb/hr)	0	0	4,855,376	4,855,376	3,551,660	2,991,014	2,991,014	1,364,218	1,364,218	2,728,437
Solids Flowrate (lb/hr)	103	67,917	0	0	0	0	0	0	0	0
Temperature (°F)	42	260	260	279	1,100	669	1,100	90	90	90
Pressure (psia)	16.0	12.2	12.2	13.1	3,514.7	710.8	655.8	0.7	0.7	250.0
Enthalpy (Btu/lb)[A]	---	---	130.2	134.9	1,494.7	1,325.4	1,570.2	830.7	830.7	58.9
Density (lb/ft^3)	---	---	0.047	0.049	4.319	1.164	0.722	0.003	0.003	62.162

Exhibit 5-3 Case L22A Stream Table

	1	2	3	4	5	6	7	8	9	10	11
V-L Mole Fraction											
Ar	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0000	0.0000	0.0000	0.0081
CO_2	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0000	0.0000	0.0000	0.1359
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	0.0000	0.0000	0.0000	0.1429
N_2	0.7761	0.7761	0.7761	0.7761	0.7761	0.7761	0.7761	0.0000	0.0000	0.0000	0.6811
O_2	0.2082	0.2082	0.2082	0.2082	0.2082	0.2082	0.2082	0.0000	0.0000	0.0000	0.0319
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	28,220	28,220	1,665	42,330	42,330	2,215	1,186	0	0	0	81,847
V-L Flowrate (kg/hr)	815,499	815,499	48,123	1,223,249	1,223,249	64,009	34,285	0	0	0	2,372,318
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	338,379	19,758	17,655	41,196
Temperature (°C)	4	9	9	4	16	16	4	4	4	149	127
Pressure (MPa, abs)	0.10	0.10	0.10	0.10	0.11	0.11	0.10	0.10	0.10	0.10	0.09
Enthalpy (kJ/kg)[A]	13.75	18.42	18.42	13.75	25.07	25.07	13.75	---	---	---	322.94
Density (kg/m^3)	1.2	1.2	1.2	1.2	1.3	1.3	1.2	---	---	---	0.8
V-L Molecular Weight	28.898	28.898	28.898	28.898	28.898	28.898	28.898	---	---	---	28.985
V-L Flowrate (lb_{mol}/hr)	62,215	62,215	3,671	93,322	93,322	4,883	2,616	0	0	0	180,441
V-L Flowrate (lb/hr)	1,797,868	1,797,868	106,092	2,696,802	2,696,802	141,115	75,585	0	0	0	5,230,066
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	745,997	43,559	38,923	90,821
Temperature (°F)	40	48	48	40	60	60	40	40	40	300	261
Pressure (psia)	13.8	14.4	14.4	13.8	15.3	15.3	13.8	13.8	13.8	13.8	13.2
Enthalpy (Btu/lb)[A]	5.9	7.9	7.9	5.9	10.8	10.8	5.9	---	---	---	138.8
Density (lb/ft^3)	0.074	0.076	0.076	0.074	0.079	0.079	0.074	---	---	---	0.050

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 5-3 Case L22A Stream Table (Continued)

	12	13	14	15	16	17	18	19	20	21
V-L Mole Fraction										
Ar	0.0000	0.0000	0.0081	0.0081	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.0000	0.0000	0.1359	0.1359	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0000	0.0000	0.1429	0.1429	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.0000	0.0000	0.6811	0.6811	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0000	0.0000	0.0319	0.0319	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	0	0	81,847	81,847	89,417	75,302	75,302	34,324	34,324	69,542
V-L Flowrate (kg/hr)	0	0	2,372,318	2,372,318	1,610,866	1,356,582	1,356,582	618,351	618,351	1,252,811
Solids Flowrate (kg/hr)	72	41,267	0	0	0	0	0	0	0	0
Temperature (°C)	6	127	127	137	593	354	593	32	32	32
Pressure (MPa, abs)	0.11	0.09	0.09	0.10	24.23	4.90	4.52	0.005	0.005	1.72
Enthalpy (kJ/kg)[A]	---	---	358.28	368.61	3,476.62	3,082.96	3,652.22	1,924.46	1,924.46	136.94
Density (kg/m^3)	---	---	0.8	0.8	69.2	18.7	11.6	0.05	0.05	995.7
V-L Molecular Weight	---	---	28.985	28.985	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	0	0	180,441	180,441	197,130	166,012	166,012	75,671	75,671	153,313
V-L Flowrate (lb/hr)	0	0	5,230,066	5,230,066	3,551,351	2,990,751	2,990,751	1,363,231	1,363,231	2,761,976
Solids Flowrate (lb/hr)	158	90,979	0	0	0	0	0	0	0	0
Temperature (°F)	42	261	261	278	1,100	669	1,100	90	90	90
Pressure (psia)	16.0	13.0	13.0	13.9	3,514.7	710.8	655.8	0.7	0.7	250.0
Enthalpy (Btu/lb)[A]	---	---	154.0	158.5	1,494.7	1,325.4	1,570.2	827.4	827.4	58.9
Density (lb/ft^3)	---	---	0.049	0.051	4.319	1.164	0.722	0.003	0.003	62.162

5.1.2 Key System Assumptions

System assumptions for Cases S22A and L22A, SC CFB without CO_2 capture, are compiled in Exhibit 5-4.

Exhibit 5-4 CFB Cases without CO_2 Capture Study Configuration Matrix

	Case S22A w/o CO_2 Capture	Case L22A w/o CO_2 Capture
Steam Cycle, MPa/°C/°C (psig/°F/°F)	24.1/593/593 (3,500/1,100/1,100)	24.1/593/593 (3,500/1,100/1,100)
Coal	Subbituminous	Lignite
Carbon Conversion, %	98.6	99.1
Ca/S Mole Ratio	2.4	2.4
Condenser pressure, mm Hg (in Hg)	36 (1.4)	36 (1.4)
Combustion Air Preheater Flue Gas Exit Temp, °C (ºF)	127 (260)	127 (260)
Cooling water to condenser, °C (ºF)	9 (48)	8 (47)
Cooling water from condenser, °C (ºF)	20 (68)	19 (67)
SO_2 Control	in-bed Limestone injection	in-bed Limestone injection
SO_2 Reduction Efficiency, % (A)	94	94
NOx Control	Combustion temperature control w/OFA and SNCR	Combustion temperature control w/OFA and SNCR
SNCR Efficiency, % [1]	46	46
Ammonia Slip, ppmv	2	2
Particulate Control	Fabric Filter	Fabric Filter
Fabric Filter efficiency, % [1]	99.9	99.9
Ash Distribution, Fly/Bottom	70% / 30%	70% / 30%
Mercury Control	Co-benefit Capture	Co-benefit Capture
Mercury removal efficiency, % [1]	57	57
CO_2 Control	N/A	N/A
CO_2 Capture, % [1]	N/A	N/A
CO_2 Sequestration	N/A	N/A

[1] Equipment removal efficiencies

Balance of Plant – Cases S22A and L22A

The balance of plant assumptions are common to all cases and were presented previously in Section 3.1.6.

5.1.3 Sparing Philosophy

Single trains are used throughout the design with exceptions where equipment capacity requires an additional train. There is no redundancy other than normal sparing of rotating equipment. The plant design consists of the following major subsystems:

- One SC CFB combustor (1 x 100 percent) with SNCR
- Two single-stage, in-line, multi-compartment fabric filters (2 x 50 percent)
- One steam turbine (1 x 100 percent)

5.1.4 Cases S22A and L22A Performance Results

The non-capture SC CFB plant using PRB coal produces a net output of 550 MWe at a net plant efficiency of 38.9 percent (HHV basis). The same plant configuration using lignite coal produces a net output of 550 MWe at a net plant efficiency of 38.0 percent (HHV basis).

Overall performance for the two plants is summarized in Exhibit 5-5, which includes auxiliary power requirements. The cooling water system, including the CWPs, cooling tower fan, and the air-cooled condenser, account for about 30 percent of the auxiliary load in all cases; and the PA, FD and induced draft fans account for an additional 40 percent in all cases.

In the CFB cases boiler efficiencies are 85.7 percent for the PRB coal cases and 84.5 percent for the lignite cases. In each case the boiler heat loss is 1 percent of the heat input and carbon conversion is 98.6 percent and 99.1 percent for PRB and lignite coal, respectively.

Exhibit 5-5 CFB Cases without CO_2 Capture Plant Performance Summary

POWER SUMMARY (Gross Power at Generator Terminals, kWe)	S22A	L22A
Steam Turbine Power	**578,400**	**578,700**
AUXILIARY LOAD SUMMARY, kWe		
Coal Handling and Conveying	500	600
Pulverizers / Crushers	120	160
Sorbent Handling & Reagent Preparation	80	90
Ash Handling	1,300	1,740
PA Fans	4,040	3,990
FD Fans	1,110	1,100
ID Fans	6,870	7,050
SNCR	10	20
Baghouse	150	200
Steam Turbine Auxiliaries	400	400
Condensate Pumps	780	790
CWP	2,390	2,380
Ground Water Pumps	220	220
Cooling Tower Fans	1,560	1,460
Air-Cooled Condenser Fans	4,990	4,660
Miscellaneous Balance of Plant[1]	2,000	2,000
Transformer Loss	1,810	1,810
TOTAL AUXILIARIES, kWe	**28,330**	**28,670**
NET POWER, kWe	**550,070**	**550,030**
Plant CF, %	85%	85%
Net Plant Efficiency, % (HHV)	38.9%	38.0%
Net Plant Heat Rate, kJ/kWh (Btu/kWh)	9,253 (8,770)	9,469 (8,975)
CONDENSER COOLING DUTY GJ/hr (10^6 Btu/hr)	**2,225 (2,109)**	**2,211 (2,096)**
CONSUMABLES		
As-Received Coal Feed, kg/hr (lb/hr)	255,512 (563,307)	338,379 (745,997)
Thermal Input, kWt[2]	1,413,821	1,446,676
Raw Water Withdrawal, m^3/min (gpm)	9.1 (2,393)	9.0 (2,379)
Raw Water Consumption, m^3/min (gpm)	7.0 (1,839)	6.9 (1,828)

[1] Includes plant control systems, lighting, HVAC, and miscellaneous low voltage loads
[2] Thermal input based on as-received HHV of coal

Environmental Performance

The environmental targets for emissions of Hg, NOx, SO_2, and PM were presented in Section 2.3. A summary of the plant air emissions for Cases S22A and L22A is presented in Exhibit 5-6.

Exhibit 5-6 CFB Cases without CO_2 Capture Air Emissions

	kg/GJ ($lb/10^6$ Btu)		Tonne/year (ton/year) 85% capacity factor		kg/MWh (lb/MWh)	
	S22A	**L22A**	**S22A**	**L22A**	**S22A**	**L22A**
SO_2	0.044 (0.102)	0.049 (0.113)	1,659 (1,829)	1,892 (2,086)	0.385 (0.85)	0.439 (0.97)
NO_X	0.030 (0.070)	0.030 (0.070)	1,141 (1,257)	1,167 (1,286)	0.265 (0.584)	0.271 (0.597)
Particulates	0.006 (0.0130)	0.006 (0.0130)	212 (233)	217 (239)	0.049 (0.108)	0.050 (0.111)
Hg	1.3E-7 (3.02E-7)	2.07E-7 (4.82E-7)	0.005 (0.005)	0.008 (0.009)	1.14E-6 (2.52E-6)	1.85E-6 (4.11E-6)
CO_2	91.5 (212.8)	94.0 (218.7)	3,464,762 (3,821,451)	3,645,843 (4,018,854)	805 (1,775)	846 (1,865)
CO_2 [1]					846 (1,866)	890 (1,963)

[1] CO_2 emissions based on net power instead of gross power

SO_2 emissions are controlled using in-bed limestone injection that achieves a removal efficiency of 94 percent. The waste is collected in the baghouse.

NOx emissions from CFB combustors are inherently low because of the relatively low bed operating temperature of 1,600°F. NOx emissions are controlled to about 0.10-0.15 lb/MMBtu through the use of temperature controls, staging, and OFA. An SNCR unit then further reduces the NOx concentration by 46 percent to 0.07 lb/MMBtu.

Particulate emissions are controlled using a pulse jet fabric filter, which operates at an efficiency of 99.9 percent.

Co-benefit capture of mercury from a CFB with SNCR and a fabric filter is estimated to be 57 percent for either subbituminous or lignite coal [12]. Mercury emissions can be reduced to approximately 25 percent of NSPS limits without the use of carbon injection, however carbon injection was included since it is currently the generally accepted practice.

CO_2 emissions represent the uncontrolled discharge from the process.

The carbon balances for the two non-capture CFB cases are shown in Exhibit 5-7. The carbon input to the plant consists of carbon in the air and limestone in addition to carbon in the coal. Carbon leaves the plant as CO_2 in the stack gas and unburned carbon in the ash. The carbon conversion in the CFB is assumed to be 98.6 percent and 99.1 percent for PRB and lignite, respectively.

Exhibit 5-7 Cases S22A and L22A Carbon Balance

Carbon In, kg/hr (lb/hr)			Carbon Out, kg/hr (lb/hr)		
	S22A	**L22A**		**S22A**	**L22A**
Coal	127,930 (282,037)	133,841 (295,069)	**Ash**	2,935 (6,471)	2,570 (5,666)
Air (CO_2)	269 (593)	283 (623)	**Stack Gas**	127,066 (280,133)	133,630 (294,604)
Limestone	1,756 (3,872)	2,005 (4,420)			
Activated Carbon	47 (103)	72 (158)			
Total	**130,002 (286,605)**	**136,200 (300,270)**	**Total**	**130,002 (286,605)**	**136,200 (300,270)**

Exhibit 5-8 shows the sulfur balances for the two non-capture CFB cases. Sulfur input comes solely from the sulfur in the coal. Sulfur output is the sulfur combined with limestone in the ash, and the sulfur emitted in the stack gas.

Exhibit 5-8 Cases S22A and L22A Sulfur Balance

Sulfur In, kg/hr (lb/hr)			Sulfur Out, kg/hr (lb/hr)		
	S22A	**L22A**		**S22A**	**L22A**
Coal	1,859 (4,098)	2,120 (4,673)	**Ash**	1,747 (3,852)	1,992 (4,393)
			Stack Gas	112 (246)	127 (280)
Total	**1,859 (4,098)**	**2,120 (4,673)**	**Total**	**1,859 (4,098)**	**2,120 (4,673)**

Exhibit 5-9 and Exhibit 5-10 show the overall water balances for the plants. Raw water withdrawal is obtained from groundwater (50 percent) and from municipal sources (50 percent). Water demand represents the total amount of water required for a particular process. Some water is recovered within the process and that water is re-used as internal recycle. Raw water withdrawal is the difference between water demand and internal recycle. Some water is discharged from the process to a permitted outfall. The difference between the withdrawal and discharge is the consumption.

Exhibit 5-9 Case S22A Water Balance

Water Use	Water Demand, m^3/min (gpm)	Internal Recycle, m^3/min (gpm)	Raw Water Withdrawal, m^3/min (gpm)	Process Water Discharge, m^3/min (gpm)	Raw Water Consumption, m^3/min (gpm)
BFW Makeup	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cooling Tower Makeup	9.3 (2,464)	0.27 (71)	9.1 (2,393)	2.10 (554)	6.96 (1,839)
Total	**9.3 (2,464)**	**0.27 (71)**	**9.1 (2,393)**	**2.10 (554)**	**6.96 (1,839)**

Exhibit 5-10 Case L22A Water Balance

Water Use	Water Demand, m^3/min (gpm)	Internal Recycle, m^3/min (gpm)	Raw Water Withdrawal, m^3/min (gpm)	Process Water Discharge, m^3/min (gpm)	Raw Water Consumption, m^3/min (gpm)
BFW Makeup	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cooling Tower Makeup	9.3 (2,450)	0.27 (71)	9.0 (2,379)	2.09 (551)	6.92 (1,828)
Total	**9.3 (2,450)**	**0.27 (71)**	**9.0 (2,379)**	**2.09 (551)**	**6.92 (1,828)**

Heat and Mass Balance Diagrams

Heat and mass balance diagrams are shown for the following subsystems in Exhibit 5-11 through Exhibit 5-14:

- Combustor and flue gas cleanup
- Steam and FW

Overall plant energy balances are provided in tabular form in Exhibit 5-15 for the two CFB non-capture cases. The power out is the steam turbine power after generator losses.

Exhibit 5-11 Case S22A Combustor and Gas Cleanup System Heat and Mass Balance Diagram

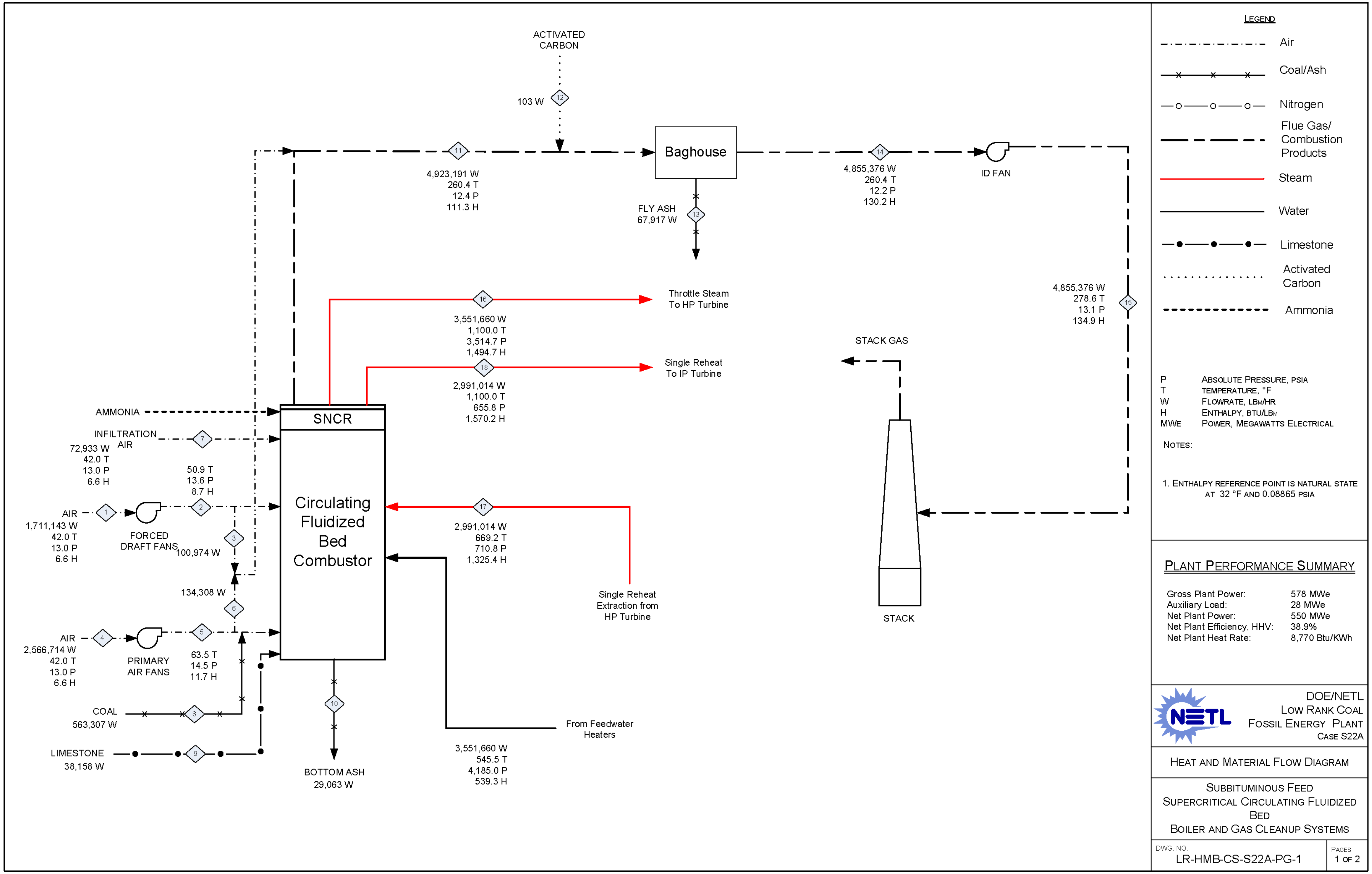

Exhibit 5-12 Case S22A Power Block System Heat and Mass Balance Diagram

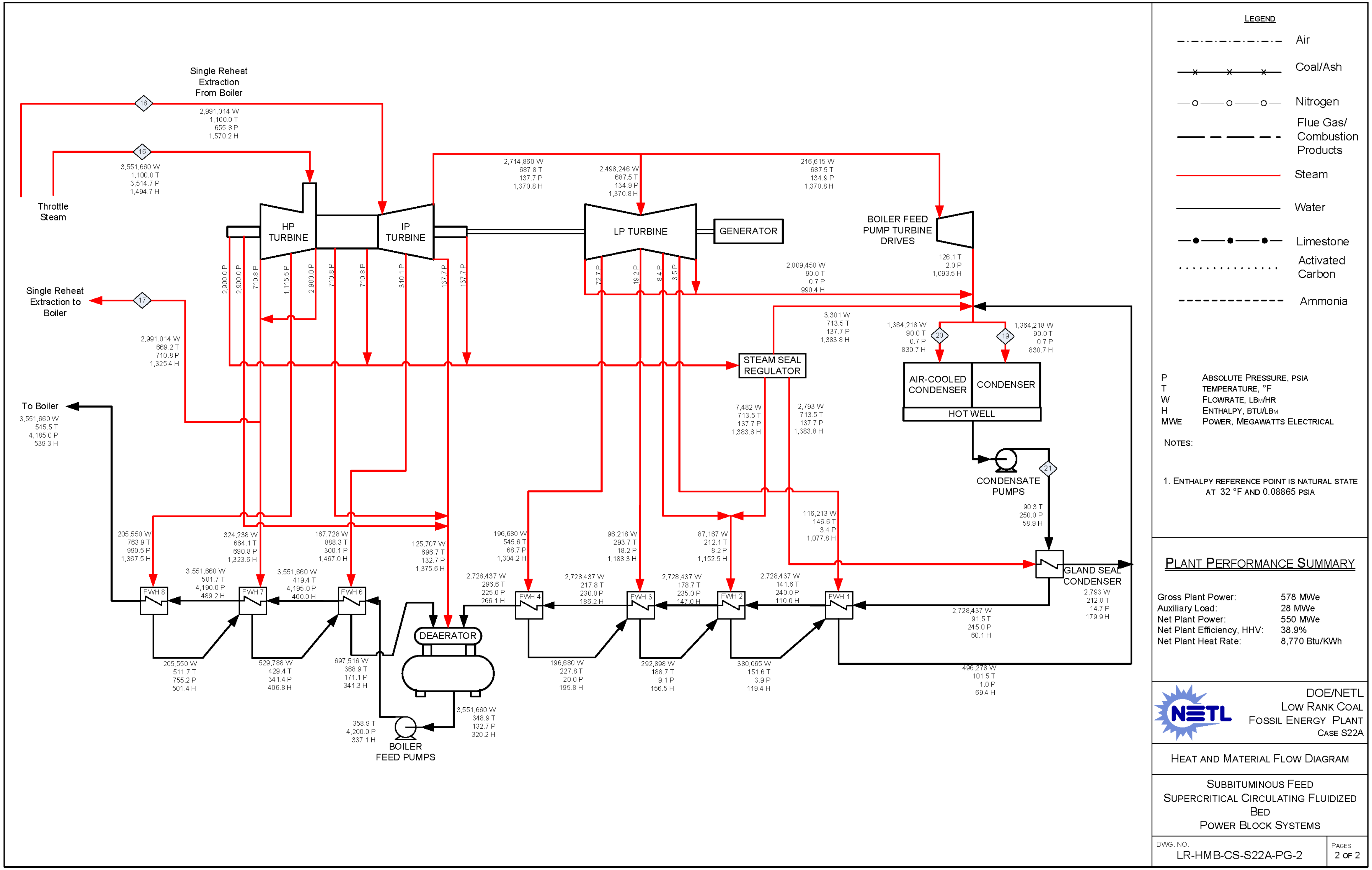

Exhibit 5-13 Case L22A Combustor and Gas Cleanup System Heat and Mass Balance Diagram

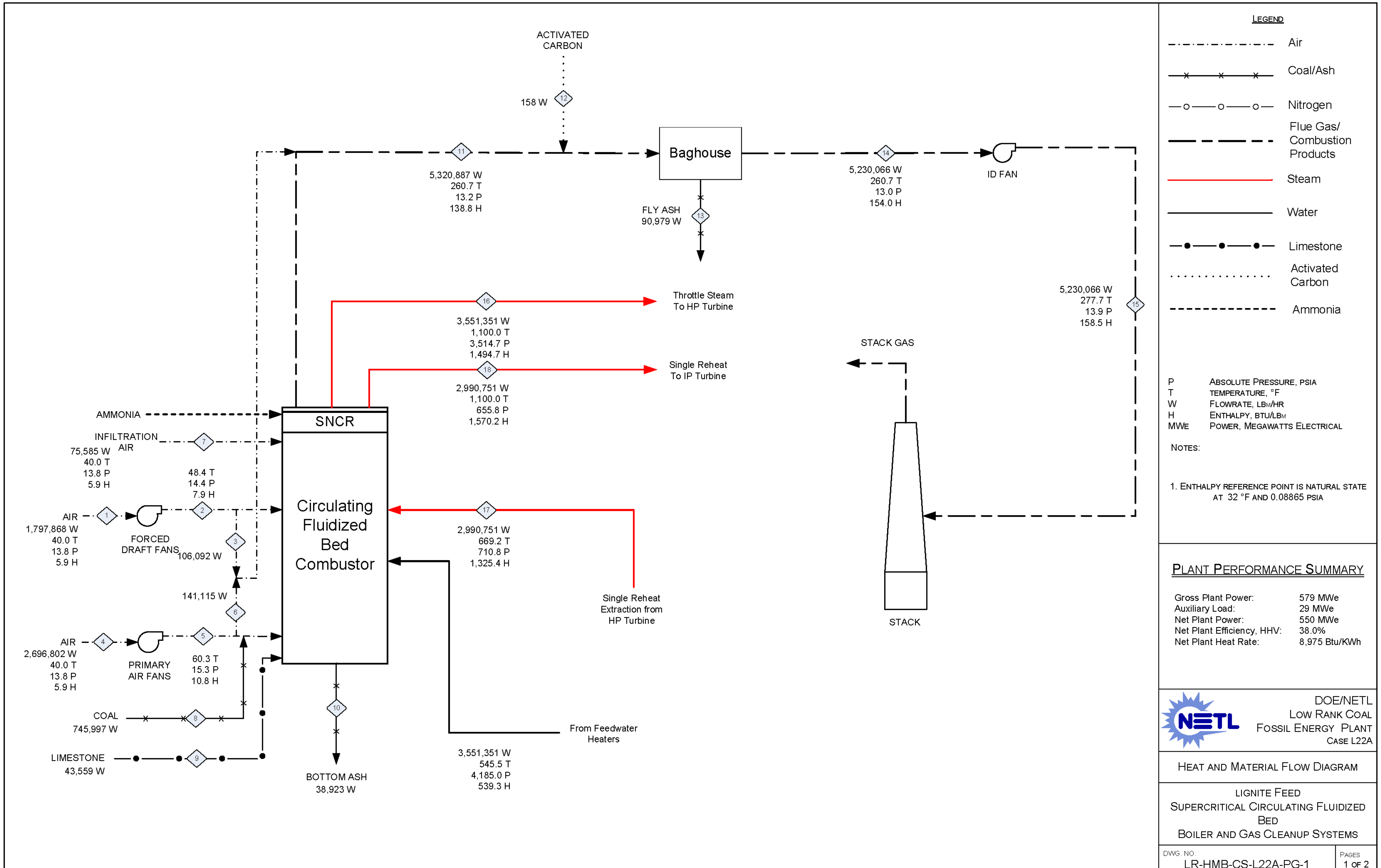

Exhibit 5-14 Case L22A Power Block System Heat and Mass Balance Diagram

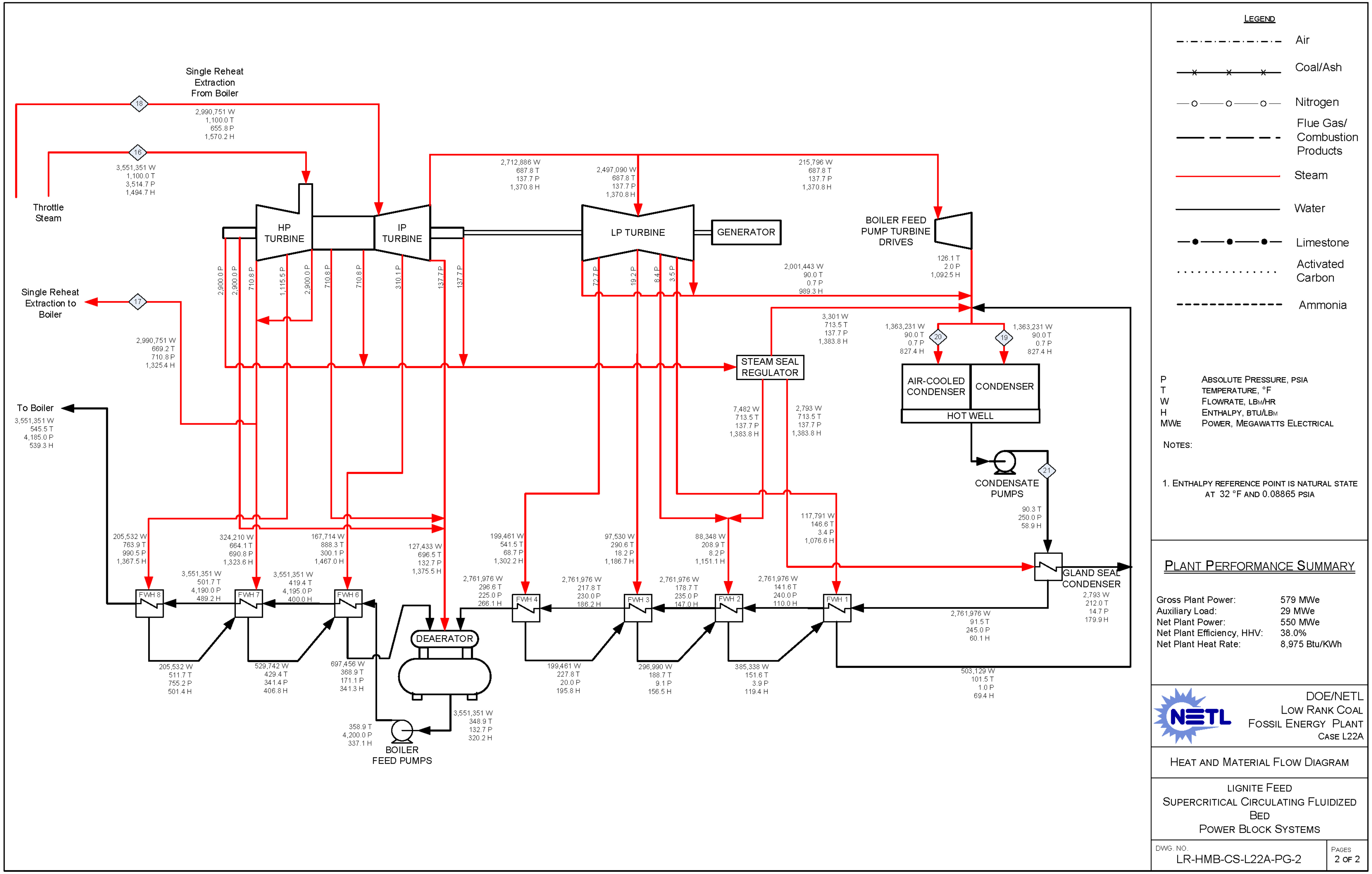

Exhibit 5-15 Cases S22A and L22A Energy Balance (0°C [32°F] Reference)

	HHV		Sensible + Latent		Power		Total	
	S22A	L22A	S22A	L22A	S22A	L22A	S22A	L22A
Heat In, GJ/hr (MMBtu/hr)								
Coal	5,090 (4,824)	5,208 (4,936)	2.6 (2.5)	3.0 (2.9)			5,092 (4,827)	5,211 (4,939)
Combustion Air			30.1 (28.5)	28.5 (27.0)			30.1 (28.5)	28.5 (27.0)
Raw Water Makeup			12.6 (12.0)	10.0 (9.5)			12.6 (12.0)	10.0 (9.5)
Limestone			0.14 (0.13)	0.12 (0.12)			0.14 (0.13)	0.12 (0.12)
Auxiliary Power					102 (97)	103 (98)	102 (97)	103 (98)
Totals	**5,090 (4,824)**	**5,208 (4,936)**	**45.5 (43.1)**	**41.7 (39.5)**	**102 (97)**	**103 (98)**	**5,237 (4,964)**	**5,353 (5,074)**
Heat Out, GJ/hr (MMBtu/hr)								
Bottom Ash			11.7 (11.0)	14.8 (14.0)			11.7 (11.0)	14.8 (14.0)
Fly Ash + Sorbent			3.6 (3.5)	4.7 (4.4)			3.6 (3.5)	4.7 (4.4)
Flue Gas			691 (655)	874 (829)			691 (655)	874 (829)
Condenser			2,225 (2,109)	2,211 (2,096)			2,225 (2,109)	2,211 (2,096)
Cooling Tower Blowdown			11.7 (11.1)	11.3 (10.7)			11.7 (11.1)	11.3 (10.7)
Process Losses*			212 (201)	153 (145)			212 (201)	153 (145)
Power					2,082 (1,974)	2,083 (1,975)	2,082 (1,974)	2,083 (1,975)
Totals	**0 (0)**	**0 (0)**	**3,155 (2,990)**	**3,270 (3,099)**	**2,082 (1,974)**	**2,083 (1,975)**	**5,237 (4,964)**	**5,353 (5,074)**

* Process losses including steam turbine, combustion reactions, and gas cooling are estimated to match the heat input to the plant.

5.1.5 CFB Cases without CO_2 Capture Equipment Lists

Major equipment items for the SC CFB Cases with no CO_2 capture using PRB or lignite coal are shown in the following tables. The equipment lists are not meant to be comprehensive, but rather representative. The accounts used in the equipment list correspond to the account numbers used in the cost estimates in Section 5.1.6. In general, the design conditions include a 10 percent contingency for flows and heat duties and a 21 percent contingency for heads on pumps and fans.

ACCOUNT 1 FUEL AND SORBENT HANDLING

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
1	Bottom Trestle Dumper and Receiving Hoppers	N/A	2(0)	181 tonne (200 ton)	181 tonne (200 ton)
2	Feeder	Belt	2(0)	572 tonne/hr (630 tph)	572 tonne/hr (630 tph)
3	Conveyor No. 1	Belt	1(0)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)
4	Transfer Tower No. 1	Enclosed	1(0)	N/A	N/A
5	Conveyor No. 2	Belt	1(0)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)
6	As-Received Coal Sampling System	Two-stage	1(0)	N/A	N/A
7	Stacker/Reclaimer	Traveling, linear	1(0)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)
8	Reclaim Hopper	N/A	2(1)	54 tonne (60 ton)	73 tonne (80 ton)
9	Feeder	Vibratory	2(1)	209 tonne/hr (230 tph)	281 tonne/hr (310 tph)
10	Conveyor No. 3	Belt w/ tripper	1(0)	417 tonne/hr (460 tph)	553 tonne/hr (610 tph)
11	Crusher Tower	N/A	1(0)	N/A	N/A
12	Coal Surge Bin w/ Vent Filter	Dual outlet	2(0)	209 tonne (230 ton)	281 tonne (310 ton)
13	Crusher	Impactor reduction	2(0)	8cm x 0 - 3cm x 0 (3 x 0 - 3/4" x 0)	8cm x 0 - 3cm x 0 (3" x 0 - 3/4" x 0)
14	As-Fired Coal Sampling System	Swing hammer	1(0)	N/A	N/A
15	Conveyor No. 4	Belt w/tripper	1(0)	417 tonne/hr (460 tph)	553 tonne/hr (610 tph)
16	Transfer Tower No. 2	Enclosed	1(0)	N/A	N/A
17	Conveyor No. 5	Belt w/ tripper	1(0)	426 tonne/hr (470 tph)	553 tonne/hr (610 tph)
18	Coal Silo w/ Vent Filter and Slide Gates	Field erected	6(0)	454 tonne (500 ton)	635 tonne (700 ton)
19	Limestone Truck Unloading Hopper	N/A	1(0)	36 tonne/hr (40 tph)	36 tonne/hr (40 tph)

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
20	Limestone Feeder	Belt	1(0)	73 tonne (80 ton)	82 tonne (90 ton)
21	Limestone Conveyor No. L1	Belt	1(0)	73 tonne (80 ton)	82 tonne (90 ton)
22	Limestone Reclaim Hopper	N/A	1(0)	18 tonne (20 ton)	18 tonne (20 ton)
23	Limestone Reclaim Feeder	Belt	1(0)	54 tonne (60 ton)	64 tonne (70 ton)
24	Limestone Conveyor No. L2	Belt	1(0)	54 tonne (60 ton)	64 tonne (70 ton)
25	Limestone Day Bin	w/ actuator	2(0)	227 tonne (250 ton)	263 tonne (290 ton)
26	Activated Carbon Storage Silo and Feeder System with Vent Filter	Shop assembled	1(0)	Silo - 36 tonne (40 ton) Feeder - 50 kg/hr (110 lb/hr)	Silo - 54 tonne (60 ton) Feeder - 77 kg/hr (170 lb/hr)

ACCOUNT 2 COAL AND SORBENT PREPARATION AND FEED

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
1	Coal Feeder	Gravimetric	6(0)	45 tonne/hr (50 tph)	64 tonne/hr (70 tph)
2	Limestone Bin Activator	N/A	1(1)	19 tonne/hr (21 tph)	22 tonne/hr (24 tph)
3	Limestone Weigh Feeder	N/A	1(1)	19 tonne/hr (21 tph)	22 tonne/hr (24 tph)
4	Limestone Rod Mill – Top size 1/16”	Field Erected	1(1)	19 tonne/hr (21 tph)	22 tonne/hr (24 tph)
5	Blower	Horizontal centrifugal	1(1)	31 m^3/min @ 0.2 MPa (1,090 scfm @ 24 psi)	41 m^3/min @ 0.2 MPa (1,450 scfm @ 24 psi)

ACCOUNT 3 FW AND MISCELLANEOUS SYSTEMS AND EQUIPMENT

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
1	Demineralized Water Storage Tank	Vertical, cylindrical, outdoor	2(0)	1,067,486 liters (282,000 gal)	1,063,701 liters (281,000 gal)
2	Condensate Pumps	Vertical canned	1(1)	23,091 lpm @ 213 m H_2O (6,100 gpm @ 700 ft H_2O)	23,091 lpm @ 213 m H_2O (6,100 gpm @ 700 ft H_2O)
3	Deaerator and Storage Tank	Horizontal spray type	1(0)	1,774,000 kg/hr (3,911,000 lb/hr), 5 min. tank	1,771,732 kg/hr (3,906,000 lb/hr), 5 min. tank

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
4	Boiler Feed Pump/Turbine	Barrel type, multi-stage, centrifugal	1(1)	29,905 lpm @ 3,475 m H_2O (7,900 gpm @ 11,400 ft H_2O)	29,905 lpm @ 3,475 m H_2O (7,900 gpm @ 11,400 ft H_2O)
5	Startup Boiler Feed Pump, Electric Motor Driven	Barrel type, multi-stage, centrifugal	1(0)	8,706 lpm @ 3,475 m H_2O (2,300 gpm @ 11,400 ft H_2O)	8,706 lpm @ 3,475 m H_2O (2,300 gpm @ 11,400 ft H_2O)
6	LP Feedwater Heater 1A/1B	Horizontal U-tube	2(0)	689,460 kg/hr (1,520,000 lb/hr)	689,460 kg/hr (1,520,000 lb/hr)
7	LP Feedwater Heater 2A/2B	Horizontal U-tube	2(0)	689,460 kg/hr (1,520,000 lb/hr)	689,460 kg/hr (1,520,000 lb/hr)
8	LP Feedwater Heater 3A/3B	Horizontal U-tube	2(0)	689,460 kg/hr (1,520,000 lb/hr)	689,460 kg/hr (1,520,000 lb/hr)
9	LP Feedwater Heater 4A/4B	Horizontal U-tube	2(0)	689,460 kg/hr (1,520,000 lb/hr)	689,460 kg/hr (1,520,000 lb/hr)
10	HP Feedwater Heater 6	Horizontal U-tube	1(0)	1,773,546 kg/hr (3,910,000 lb/hr)	1,773,546 kg/hr (3,910,000 lb/hr)
11	HP Feedwater Heater 7	Horizontal U-tube	1(0)	1,773,546 kg/hr (3,910,000 lb/hr)	1,773,546 kg/hr (3,910,000 lb/hr)
12	HP Feedwater heater 8	Horizontal U-tube	1(0)	1,773,546 kg/hr (3,910,000 lb/hr)	1,773,546 kg/hr (3,910,000 lb/hr)
13	Auxiliary Boiler	Shop fabricated, water tube	1(0)	18,144 kg/hr, 2.8 MPa, 343°C (40,000 lb/hr, 400 psig, 650°F)	18,144 kg/hr, 2.8 MPa, 343°C (40,000 lb/hr, 400 psig, 650°F)
14	Fuel Oil System	No. 2 fuel oil for light off	1(0)	1,135,624 liter (300,000 gal)	1,135,624 liter (300,000 gal)
15	Service Air Compressors	Flooded Screw	2(1)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)
16	Instrument Air Dryers	Duplex, regenerative	2(1)	28 m^3/min (1,000 scfm)	28 m^3/min (1,000 scfm)
17	Closed Cycle Cooling Heat Exchangers	Shell and tube	2(0)	53 GJ/hr (50 MMBtu/hr) each	53 GJ/hr (50 MMBtu/hr) each
18	Closed Cycle Cooling Water Pumps	Horizontal centrifugal	2(1)	20,820 lpm @ 30 m H_2O (5,500 gpm @ 100 ft H_2O)	20,820 lpm @ 30 m H_2O (5,500 gpm @ 100 ft H_2O)
19	Engine-Driven Fire Pump	Vertical turbine, diesel engine	1(1)	3,785 lpm @ 88 m H_2O (1,000 gpm @ 290 ft H_2O)	3,785 lpm @ 88 m H_2O (1,000 gpm @ 290 ft H_2O)
20	Fire Service Booster Pump	Two-stage horizontal centrifugal	1(1)	2,650 lpm @ 64 m H_2O (700 gpm @ 210 ft H_2O)	2,650 lpm @ 64 m H_2O (700 gpm @ 210 ft H_2O)

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
21	Raw Water Pumps	Stainless steel, single suction	2(1)	2,612 lpm @ 18 m H_2O (690 gpm @ 60 ft H_2O)	2,612 lpm @ 18 m H_2O (690 gpm @ 60 ft H_2O)
22	Ground Water Pumps	Stainless steel, single suction	2(1)	2,612 lpm @ 268 m H_2O (690 gpm @ 880 ft H_2O)	2,612 lpm @ 268 m H_2O (690 gpm @ 880 ft H_2O)
23	Filtered Water Pumps	Stainless steel, single suction	2(1)	303 lpm @ 49 m H_2O (80 gpm @ 160 ft H_2O)	303 lpm @ 49 m H_2O (80 gpm @ 160 ft H_2O)
24	Filtered Water Tank	Vertical, cylindrical	1(0)	280,120 liter (74,000 gal)	280,120 liter (74,000 gal)
25	Makeup Water Demineralizer	Multi-media filter, cartridge filter, RO membrane assembly, electrodeionization unit	1(1)	606 lpm (160 gpm)	606 lpm (160 gpm)
26	Liquid Waste Treatment System	--	1(0)	10 years, 24-hour storm	10 years, 24-hour storm

ACCOUNT 4 BOILER AND ACCESSORIES

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
1	Boiler	Atm. Pressure CFB, Once-thru Supercritical Boiler with Air Heater	1(0)	1,773,546 kg/hr steam @ 25.5 MPa/602°C/602°C (3,910,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)	1,773,546 kg/hr steam @ 25.5 MPa/602°C/602°C (3,910,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)
2	Primary Air Fan	Centrifugal	2(0)	640,019 kg/hr, 9,534 m^3/min @ 129 cm WG (1,411,000 lb/hr, 336,700 acfm @ 51 in. WG)	668,142 kg/hr, 9,339 m^3/min @ 129 cm WG (1,473,000 lb/hr, 329,800 acfm @ 51 in. WG)
3	Forced Draft Fan	Centrifugal	2(0)	426,377 kg/hr, 6,357 m^3/min @ 52 cm WG (940,000 lb/hr, 224,500 acfm @ 21 in. WG)	445,428 kg/hr, 6,224 m^3/min @ 52 cm WG (982,000 lb/hr, 219,800 acfm @ 21 in. WG)
4	Induced Draft Fan	Centrifugal	2(0)	1,210,638 kg/hr, 27,037 m^3/min @ 77 cm WG (2,669,000 lb/hr, 954,800 acfm @ 30 in. WG)	1,295,460 kg/hr, 27,555 m^3/min @ 77 cm WG (2,856,000 lb/hr, 973,100 acfm @ 30 in. WG)
5	SNCR Lance		1(1)	17 lpm (5 gpm)	17 lpm (5 gpm)
6	Dilution Air Blower	Centrifugal	2(1)	42 m^3/min @ 108 cm WG (1,500 acfm @ 42 in. WG)	42 m^3/min @ 108 cm WG (1,500 acfm @ 42 in. WG)

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
7	Ammonia Storage	Horizontal tank	5(0)	45,425 liter (12,000 gal)	45,425 liter (12,000 gal)
8	Ammonia Feed Pump	Centrifugal	2(1)	9 lpm @ 91 m H_2O (2 gpm @ 300 ft H_2O)	9 lpm @ 91 m H_2O (2 gpm @ 300 ft H_2O)

ACCOUNT 5 FLUE GAS CLEANUP

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
1	Fabric Filter	Single stage, high-ratio with pulse-jet online cleaning system, air-to-cloth ratio - 3.5 ft/min	2(0)	1,210,638 kg/hr (2,669,000 lb/hr) 99.9% efficiency	1,295,460 kg/hr (2,856,000 lb/hr) 99.9% efficiency
2	Carbon Injectors	---	1(0)	50 kg/hr (110 lb/hr)	77 kg/hr (170 lb/hr)

ACCOUNT 6 COMBUSTION TURBINE/ACCESSORIES

N/A

ACCOUNT 7 HRSG, DUCTING & STACK

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
1	Stack	Reinforced concrete with FRP liner	1(0)	152 m (500 ft) high x 6.7 m (22 ft) diameter	152 m (500 ft) high x 6.8 m (22 ft) diameter

ACCOUNT 8 STEAM TURBINE GENERATOR AND AUXILIARIES

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
1	Steam Turbine	Commercially available advanced steam turbine	1(0)	609 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)	609 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)
2	Steam Turbine Generator	Hydrogen cooled, static excitation	1(0)	680 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	680 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
3	Surface Condenser	Single pass, divided waterbox including vacuum pumps	1(0)	1,220 GJ/hr (1,160 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 9°C (48°F), Water temperature rise 11°C (20°F)	1,210 GJ/hr (1,150 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 8°C (47°F), Water temperature rise 11°C (20°F)
4	Air-cooled Condenser	---	1(0)	1,220 GJ/hr (1,160 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 6°C (42°F)	1,210 GJ/hr (1,150 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 4°C (40°F)

ACCOUNT 9 COOLING WATER SYSTEM

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
1	Circulating Water Pumps	Vertical, wet pit	2(1)	238,500 lpm @ 30 m (63,000 gpm @ 100 ft)	238,500 lpm @ 30 m (63,000 gpm @ 100 ft)
2	Cooling Tower	Evaporative, mechanical draft, multi-cell	1(0)	3°C (37°F) wet bulb / 9°C (48°F) CWT / 20°C (68°F) HWT / 1,340 GJ/hr (1,270 MMBtu/hr) heat duty	2°C (36°F) wet bulb / 8°C (47°F) CWT / 19°C (67°F) HWT / 1,329 GJ/hr (1,260 MMBtu/hr) heat duty

ACCOUNT 10 ASH/SPENT SORBENT RECOVERY AND HANDLING

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
1	Economizer Hopper (part of boiler scope of supply)	--	4(0)	--	--
2	Bottom Ash Hopper (part of boiler scope of supply)	--	2(0)	--	--
3	Clinker Grinder	--	1(1)	14.5 tonne/hr (16 tph)	19.1 tonne/hr (21 tph)
4	Pyrites Hopper (part of pulverizer scope of supply included with boiler)	--	6(0)	--	--
5	Hydroejectors	--	12(0)	--	--
6	Economizer /Pyrites Transfer Tank	--	1(0)	--	--
7	Ash Sluice Pumps	Vertical, wet pit	1(1)	568 lpm @ 17 m H_2O (150 gpm @ 56 ft H_2O)	757 lpm @ 17 m H_2O (200 gpm @ 56 ft H_2O)

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
8	Ash Seal Water Pumps	Vertical, wet pit	1(1)	7,571 lpm @ 9 m H_2O (2,000 gpm @ 28 ft H_2O)	7,571 lpm @ 9 m H_2O (2,000 gpm @ 28 ft H_2O)
9	Hydrobins	--	1(1)	568 lpm (150 gpm)	757 lpm (200 gpm)
10	Baghouse Hopper (part of baghouse scope of supply)	--	24(0)	--	--
11	Air Heater Hopper (part of boiler scope of supply)	--	10(0)	--	--
12	Air Blower	--	1(1)	31 m^3/min @ 0.2 MPa (1,090 scfm @ 24 psi)	41 m^3/min @ 0.2 MPa (1,450 scfm @ 24 psi)
13	Fly Ash Silo	Reinforced concrete	2(0)	1,996 tonne (2,200 ton)	2,722 tonne (3,000 ton)
14	Slide Gate Valves	--	2(0)	--	--
15	Unloader	--	1(0)	--	--
16	Telescoping Unloading Chute	--	1(0)	191 tonne/hr (210 tph)	254 tonne/hr (280 tph)

ACCOUNT 11 ACCESSORY ELECTRIC PLANT

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
1	STG Transformer	Oil-filled	1(0)	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz
2	Auxiliary Transformer	Oil-filled	1(1)	24 kV/4.16 kV, 29 MVA, 3-ph, 60 Hz	24 kV/4.16 kV, 30 MVA, 3-ph, 60 Hz
3	Low Voltage Transformer	Dry ventilated	1(1)	4.16 kV/480 V, 4 MVA, 3-ph, 60 Hz	4.16 kV/480 V, 4 MVA, 3-ph, 60 Hz
4	STG Isolated Phase Bus Duct and Tap Bus	Aluminum, self-cooled	1(0)	24 kV, 3-ph, 60 Hz	24 kV, 3-ph, 60 Hz
5	Medium Voltage Switchgear	Metal clad	1(1)	4.16 kV, 3-ph, 60 Hz	4.16 kV, 3-ph, 60 Hz
6	Low Voltage Switchgear	Metal enclosed	1(1)	480 V, 3-ph, 60 Hz	480 V, 3-ph, 60 Hz
7	Emergency Diesel Generator	Sized for emergency shutdown	1(0)	750 kW, 480 V, 3-ph, 60 Hz	750 kW, 480 V, 3-ph, 60 Hz

ACCOUNT 12 INSTRUMENTATION AND CONTROL

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
1	DCS - Main Control	Monitor/keyboard, Operator printer, Engineering printer	1(0)	Operator stations/printers and engineering stations/printers	Operator stations/printers and engineering stations/printers
2	DCS - Processor	Microprocessor with redundant input/output	1(0)	N/A	N/A
3	DCS - Data Highway	Fiber optic	1(0)	Fully redundant, 25% spare	Fully redundant, 25% spare

5.1.6 CFB Cases without CO_2 Capture – Cost Estimating

Costs Results

The cost estimating methodology was described previously in Section 2.6. The TPC summary organized by cost account, detailed breakdown of capital costs, owner's costs, and initial and annual O&M costs for the CFB PRB case without CO_2 capture (S22A) are shown in Exhibit 5-16, Exhibit 5-17, Exhibit 5-18, and Exhibit 5-19 respectively. The same data for the CFB lignite case without CO_2 capture (L22A) are shown in Exhibit 5-20, Exhibit 5-21, Exhibit 5-22, and Exhibit 5-23.

The estimated TOC of the CFB plant without CO_2 capture using PRB coal is $2,357/kW and using lignite coal is $2,490/kW. Project and process contingencies represent 8.9 and 4.4 percent respectively in both cases. The COE is 61.5 mills/kWh for the PRB case and 64.6 mills/kWh for the lignite case.

Exhibit 5-16 Case S22A Total Plant Cost Summary

Client:	USDOE/NETL
Project:	Low Rank (Western) Coal Baseline Study
Report Date:	2009-Oct-15
Case:	Case S22A - 1x550 MWnet SuperCritical CFB
Plant Size:	550.1 MW,net
Estimate Type:	Conceptual
Cost Base (June)	2007
	($x1000)

TOTAL PLANT COST SUMMARY

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor		Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies		TOTAL PLANT COST	
				Direct	Indirect				Process	Project	$	$/kW
1	COAL & SORBENT HANDLING	$20,581	$5,455	$12,324	$0	$0	**$38,361**	$3,443	$0	$6,271	**$48,074**	$87
2	COAL & SORBENT PREP & FEED	$9,713	$701	$3,410	$0	$0	**$13,823**	$1,585	$0	$2,281	**$17,690**	$32
3	FEEDWATER & MISC. BOP SYSTEMS	$40,705	$0	$20,497	$0	$0	**$61,202**	$5,595	$0	$10,589	**$77,385**	$141
4	CFB BOILER											
4.1	CFB Boiler & Accesories	$271,115	$0	$101,904	$0	$0	**$373,018**	$36,201	$55,953	$46,517	**$511,689**	$930
4.2	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.3	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.4-4.9	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 4	**$271,115**	**$0**	**$101,904**	**$0**	**$0**	**$373,018**	**$36,201**	**$55,953**	**$46,517**	**$511,689**	**$930**
5	FLUE GAS CLEANUP	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
6.2-6.9	Combustion Turbine Accessories	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 6	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
7.2-7.9	HRSG Accessories, Ductwork, and Stack	$22,469	$1,292	$15,258	$0	$0	**$39,020**	$3,582	$0	$5,563	**$48,164**	$88
	SUBTOTAL 7	**$22,469**	**$1,292**	**$15,258**	**$0**	**$0**	**$39,020**	**$3,582**	**$0**	**$5,563**	**$48,164**	**$88**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$51,514	$0	$6,851	$0	$0	**$58,365**	$5,594	$0	$6,396	**$70,354**	$128
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$58,200	$1,086	$20,458	$0	$0	**$79,744**	$7,531	$0	$15,280	**$102,556**	$186
	SUBTOTAL 8	**$109,715**	**$1,086**	**$27,308**	**$0**	**$0**	**$138,109**	**$13,125**	**$0**	**$21,676**	**$172,910**	**$314**
9	COOLING WATER SYSTEM	$7,672	$4,178	$7,446	$0	$0	**$19,296**	$1,816	$0	$2,896	**$24,008**	$44
10	ASH/SPENT SORBENT HANDLING SYS	$7,231	$230	$9,668	$0	$0	**$17,129**	$1,647	$0	$1,932	**$20,708**	$38
11	ACCESSORY ELECTRIC PLANT	$17,240	$6,017	$17,584	$0	$0	**$40,841**	$3,599	$0	$5,487	**$49,928**	$91
12	INSTRUMENTATION & CONTROL	$8,717	$0	$8,839	$0	$0	**$17,556**	$1,592	$0	$2,352	**$21,500**	$39
13	IMPROVEMENTS TO SITE	$2,964	$1,704	$5,974	$0	$0	**$10,642**	$1,050	$0	$2,338	**$14,030**	$26
14	BUILDINGS & STRUCTURES	$0	$23,254	$22,011	$0	$0	**$45,265**	$4,083	$0	$7,402	**$56,750**	$103
	TOTAL COST	**$518,121**	**$43,917**	**$252,224**	**$0**	**$0**	**$814,262**	**$77,318**	**$55,953**	**$115,303**	**$1,062,836**	**$1,932**

Exhibit 5-17 Case S22A Total Plant Cost Details

Client: USDOE/NETL **Report Date:** 2009-Oct-15
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case S22A - 1x550 MWnet SuperCritical CFB
Plant Size: 550.1 MW,net **Estimate Type:** Conceptual **Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING											
1.1	Coal Receive & Unload	$4,102	$0	$1,873	$0	$0	$5,975	$534	$0	$976	$7,485	$14
1.2	Coal Stackout & Reclaim	$5,301	$0	$1,201	$0	$0	$6,502	$569	$0	$1,061	$8,131	$15
1.3	Coal Conveyors	$4,928	$0	$1,188	$0	$0	$6,117	$536	$0	$998	$7,650	$14
1.4	Other Coal Handling	$1,289	$0	$275	$0	$0	$1,564	$137	$0	$255	$1,956	$4
1.5	Sorbent Receive & Unload	$129	$0	$39	$0	$0	$168	$15	$0	$27	$211	$0
1.6	Sorbent Stackout & Reclaim	$3,636	$0	$783	$0	$0	$4,419	$386	$0	$721	$5,526	$10
1.7	Sorbent Conveyors	$746	$161	$183	$0	$0	$1,090	$94	$0	$178	$1,362	$2
1.8	Other Sorbent Handling	$450	$106	$236	$0	$0	$792	$70	$0	$129	$992	$2
1.9	Coal & Sorbent Hnd.Foundations	$0	$5,189	$6,545	$0	$0	$11,734	$1,102	$0	$1,925	$14,762	$27
	SUBTOTAL 1.	**$20,581**	**$5,455**	**$12,324**	**$0**	**$0**	**$38,361**	**$3,443**	**$0**	**$6,271**	**$48,074**	**$87**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$2,379	$0	$464	$0	$0	$2,843	$248	$0	$464	$3,554	$6
2.2	Coal Conveyor to Storage	$6,092	$0	$1,330	$0	$0	$7,421	$649	$0	$1,211	$9,281	$17
2.3	Coal Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.4	Misc.Coal Prep & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.5	Sorbent Prep Equipment	$1,242	$0	$258	$0	$0	$1,499	$131	$0	$245	$1,875	$3
2.6	Sorbent Storage & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.7	Sorbent Injection System	$0	$0	$770	$0	$0	$770	$439	$0	$151	$1,360	$2
2.8	Booster Air Supply System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.9	Coal & Sorbent Feed Foundation	$0	$701	$588	$0	$0	$1,289	$119	$0	$211	$1,620	$3
	SUBTOTAL 2.	**$9,713**	**$701**	**$3,410**	**$0**	**$0**	**$13,823**	**$1,585**	**$0**	**$2,281**	**$17,690**	**$32**
3	FEEDWATER & MISC. BOP SYSTEMS											
3.1	FeedwaterSystem	$18,244	$0	$5,893	$0	$0	$24,138	$2,109	$0	$3,937	$30,184	$55
3.2	Water Makeup & Pretreating	$2,551	$0	$821	$0	$0	$3,372	$319	$0	$738	$4,429	$8
3.3	Other Feedwater Subsystems	$5,585	$0	$2,360	$0	$0	$7,946	$712	$0	$1,299	$9,956	$18
3.4	Service Water Systems	$500	$0	$272	$0	$0	$772	$73	$0	$169	$1,014	$2
3.5	Other Boiler Plant Systems	$9,136	$0	$9,020	$0	$0	$18,156	$1,725	$0	$2,982	$22,863	$42
3.6	FO Supply Sys & Nat Gas	$255	$0	$318	$0	$0	$573	$54	$0	$94	$721	$1
3.7	Waste Treatment Equipment	$1,730	$0	$986	$0	$0	$2,715	$264	$0	$596	$3,576	$7
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	$2,703	$0	$826	$0	$0	$3,529	$339	$0	$774	$4,642	$8
	SUBTOTAL 3.	**$40,705**	**$0**	**$20,497**	**$0**	**$0**	**$61,202**	**$5,595**	**$0**	**$10,589**	**$77,385**	**$141**

Exhibit 5-17 Case S22A Total Plant Cost Details (Continued)

Client:	USDOE/NETL
Project:	Low Rank (Western) Coal Baseline Study
Report Date:	2009-Oct-15
Case:	Case S22A - 1x550 MWnet SuperCritical CFB
Plant Size:	550.1 MW,net
Estimate Type:	Conceptual
Cost Base (June)	2007 ($x1000)

TOTAL PLANT COST SUMMARY

Acct		Equipment	Material	Labor		Sales	Bare Erected	Eng'g CM	Contingencies		TOTAL PLANT COST	
No.	Item/Description	Cost	Cost	Direct	Indirect	Tax	Cost $	H.O.& Fee	Process	Project	$	$/kW
4	CFB BOILER											
4.1	CFB Boiler & Accesories	$271,115	$0	$101,904	$0	$0	$373,018	$36,201	$55,953	$46,517	$511,689	$930
4.2	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.3	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.4	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.5	Primary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.6	Secondary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.8	Major Component Rigging	$0	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.9	CFB Foundations	$0	$0	w/14.1	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 4.	**$271,115**	**$0**	**$101,904**	**$0**	**$0**	**$373,018**	**$36,201**	**$55,953**	**$46,517**	**$511,689**	**$930**
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.2	Other FGD	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.3	Bag House & Accessories (Incl. w/ 4.1)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.4	Other Particulate Removal Materials	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.5	Gypsum Dewatering System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.6	Mercury Removal System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.9	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 5.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.2	Combustion Turbine Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.3	Compressed Air Piping	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.9	Combustion Turbine Foundations	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
7.2	HRSG Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7.3	Ductwork	$11,205	$0	$7,199	$0	$0	$18,404	$1,605	$0	$3,001	$23,011	$42
7.4	Stack	$11,264	$0	$6,591	$0	$0	$17,855	$1,719	$0	$1,957	$21,532	$39
7.9	Duct & Stack Foundations	$0	$1,292	$1,468	$0	$0	$2,760	$258	$0	$604	$3,622	$7
	SUBTOTAL 7.	**$22,469**	**$1,292**	**$15,258**	**$0**	**$0**	**$39,020**	**$3,582**	**$0**	**$5,563**	**$48,164**	**$88**

Exhibit 5-17 Case S22A Total Plant Cost Details (Continued)

	Client:	USDOE/NETL							**Report Date:**	2009-Oct-15			
	Project:	Low Rank (Western) Coal Baseline Study											
		TOTAL PLANT COST SUMMARY											
	Case:	Case S22A - 1x550 MWnet SuperCritical CFB											
	Plant Size:	550.1 MW,net		**Estimate Type:**		Conceptual			**Cost Base (June)**	2007	($x1000)		
Acct		**Equipment**	**Material**	**Labor**		**Sales**	**Bare Erected**	**Eng'g CM**	**Contingencies**		**TOTAL PLANT COST**		
No.	**Item/Description**	**Cost**	**Cost**	**Direct**	**Indirect**	**Tax**	**Cost $**	**H.O.& Fee**	**Process**	**Project**	**$**	**$/kW**	
8	STEAM TURBINE GENERATOR												
8.1	Steam TG & Accessories	$51,514	$0	$6,851	$0	$0	$58,365	$5,594	$0	$6,396	$70,354	$128	
8.2	Turbine Plant Auxiliaries	$346	$0	$742	$0	$0	$1,088	$106	$0	$119	$1,314	$2	
8.3a	Condenser & Auxiliaries	$4,035	$0	$2,282	$0	$0	$6,317	$608	$0	$692	$7,617	$14	
8.3b	Air Cooled Condenser	$36,976	$0	$7,413	$0	$0	$44,389	$4,439	$0	$9,766	$58,593	$107	
8.4	Steam Piping	$16,843	$0	$8,305	$0	$0	$25,148	$2,113	$0	$4,089	$31,350	$57	
8.9	TG Foundations	$0	$1,086	$1,716	$0	$0	$2,803	$265	$0	$614	$3,681	$7	
	SUBTOTAL 8.	**$109,715**	**$1,086**	**$27,308**	**$0**	**$0**	**$138,109**	**$13,125**	**$0**	**$21,676**	**$172,910**	**$314**	
9	COOLING WATER SYSTEM												
9.1	Cooling Towers	$5,639	$0	$1,756	$0	$0	$7,395	$707	$0	$810	$8,912	$16	
9.2	Circulating Water Pumps	$1,168	$0	$58	$0	$0	$1,227	$103	$0	$133	$1,463	$3	
9.3	Circ.Water System Auxiliaries	$330	$0	$44	$0	$0	$374	$36	$0	$41	$451	$1	
9.4	Circ.Water Piping	$0	$2,619	$2,538	$0	$0	$5,157	$483	$0	$846	$6,485	$12	
9.5	Make-up Water System	$273	$0	$365	$0	$0	$638	$61	$0	$105	$805	$1	
9.6	Component Cooling Water Sys	$262	$0	$208	$0	$0	$470	$45	$0	$77	$592	$1	
9.9	Circ.Water System Foundations& Structures	$0	$1,559	$2,477	$0	$0	$4,036	$382	$0	$883	$5,301	$10	
	SUBTOTAL 9.	**$7,672**	**$4,178**	**$7,446**	**$0**	**$0**	**$19,296**	**$1,816**	**$0**	**$2,896**	**$24,008**	**$44**	
10	ASH/SPENT SORBENT HANDLING SYS												
10.1	Ash Coolers	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0	
10.2	Cyclone Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0	
10.3	HGCU Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0	
10.4	High Temperature Ash Piping	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0	
10.5	Other Ash Recovery Equipment	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0	
10.6	Ash Storage Silos	$968	$0	$2,981	$0	$0	$3,949	$388	$0	$434	$4,770	$9	
10.7	Ash Transport & Feed Equipment	$6,263	$0	$6,416	$0	$0	$12,679	$1,212	$0	$1,389	$15,281	$28	
10.8	Misc. Ash Handling Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
10.9	Ash/Spent Sorbent Foundation	$0	$230	$271	$0	$0	$501	$47	$0	$110	$657	$1	
	SUBTOTAL 10.	**$7,231**	**$230**	**$9,668**	**$0**	**$0**	**$17,129**	**$1,647**	**$0**	**$1,932**	**$20,708**	**$38**	

Exhibit 5-17 Case S22A Total Plant Cost Details (Continued)

Client:	USDOE/NETL	**Report Date:**	2009-Oct-15
Project:	Low Rank (Western) Coal Baseline Study		

TOTAL PLANT COST SUMMARY

Case:	Case S22A - 1x550 MWnet SuperCritical CFB						
Plant Size:	550.1	MW,net	**Estimate Type:**	Conceptual	**Cost Base (June)**	2007	($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT											
11.1	Generator Equipment	$1,595	$0	$259	$0	$0	$1,854	$172	$0	$152	$2,177	$4
11.2	Station Service Equipment	$2,742	$0	$901	$0	$0	$3,644	$341	$0	$299	$4,283	$8
11.3	Switchgear & Motor Control	$3,153	$0	$536	$0	$0	$3,689	$342	$0	$403	$4,434	$8
11.4	Conduit & Cable Tray	$0	$1,977	$6,835	$0	$0	$8,812	$853	$0	$1,450	$11,115	$20
11.5	Wire & Cable	$0	$3,730	$7,200	$0	$0	$10,930	$921	$0	$1,778	$13,629	$25
11.6	Protective Equipment	$262	$0	$892	$0	$0	$1,154	$113	$0	$127	$1,393	$3
11.7	Standby Equipment	$1,275	$0	$29	$0	$0	$1,304	$120	$0	$142	$1,566	$3
11.8	Main Power Transformers	$8,213	$0	$171	$0	$0	$8,384	$637	$0	$902	$9,923	$18
11.9	Electrical Foundations	$0	$310	$761	$0	$0	$1,071	$102	$0	$235	$1,409	$3
	SUBTOTAL 11.	**$17,240**	**$6,017**	**$17,584**	**$0**	**$0**	**$40,841**	**$3,599**	**$0**	**$5,487**	**$49,928**	**$91**
12	INSTRUMENTATION & CONTROL											
12.1	PC Control Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.2	Combustion Turbine Control	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
12.3	Steam Turbine Control	w/8.1	$0	w/8.1	$0	$0	$0	$0	$0	$0	$0	$0
12.4	Other Major Component Control	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.5	Signal Processing Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.6	Control Boards,Panels & Racks	$449	$0	$269	$0	$0	$718	$68	$0	$118	$903	$2
12.7	Distributed Control System Equipment	$4,531	$0	$792	$0	$0	$5,323	$493	$0	$582	$6,398	$12
12.8	Instrument Wiring & Tubing	$2,456	$0	$4,873	$0	$0	$7,329	$625	$0	$1,193	$9,147	$17
12.9	Other I & C Equipment	$1,280	$0	$2,906	$0	$0	$4,186	$406	$0	$459	$5,051	$9
	SUBTOTAL 12.	**$8,717**	**$0**	**$8,839**	**$0**	**$0**	**$17,556**	**$1,592**	**$0**	**$2,352**	**$21,500**	**$39**
13	IMPROVEMENTS TO SITE											
13.1	Site Preparation	$0	$50	$996	$0	$0	$1,046	$104	$0	$230	$1,380	$3
13.2	Site Improvements	$0	$1,654	$2,054	$0	$0	$3,708	$366	$0	$815	$4,889	$9
13.3	Site Facilities	$2,964	$0	$2,923	$0	$0	$5,887	$580	$0	$1,293	$7,761	$14
	SUBTOTAL 13.	**$2,964**	**$1,704**	**$5,974**	**$0**	**$0**	**$10,642**	**$1,050**	**$0**	**$2,338**	**$14,030**	**$26**
14	BUILDINGS & STRUCTURES											
14.1	Boiler Building	$0	$9,090	$7,994	$0	$0	$17,084	$1,535	$0	$2,793	$21,412	$39
14.2	Turbine Building	$0	$11,797	$10,995	$0	$0	$22,792	$2,054	$0	$3,727	$28,573	$52
14.3	Administration Building	$0	$586	$619	$0	$0	$1,205	$109	$0	$197	$1,511	$3
14.4	Circulation Water Pumphouse	$0	$168	$133	$0	$0	$301	$27	$0	$49	$377	$1
14.5	Water Treatment Buildings	$0	$324	$295	$0	$0	$619	$56	$0	$101	$775	$1
14.6	Machine Shop	$0	$392	$263	$0	$0	$655	$58	$0	$107	$820	$1
14.7	Warehouse	$0	$265	$266	$0	$0	$532	$48	$0	$87	$667	$1
14.8	Other Buildings & Structures	$0	$217	$185	$0	$0	$402	$36	$0	$66	$503	$1
14.9	Waste Treating Building & Str.	$0	$415	$1,260	$0	$0	$1,676	$159	$0	$275	$2,110	$4
	SUBTOTAL 14.	**$0**	**$23,254**	**$22,011**	**$0**	**$0**	**$45,265**	**$4,083**	**$0**	**$7,402**	**$56,750**	**$103**
	TOTAL COST	**$518,121**	**$43,917**	**$252,224**	**$0**	**$0**	**$814,262**	**$77,318**	**$55,953**	**$115,303**	**$1,062,836**	**$1,932**

Exhibit 5-18 Case S22A Owner's Costs

Owner's Costs	$x1000	$/kW
Preproduction Costs		
6 Months Fixed O&M	$7,989	$15
1 Month Variable O&M	$2,132	$4
25% of 1 Months Fuel Cost at 100% CF	$782	$1
2% of TPC	$21,257	$39
Total	**$32,161**	**$58**
Inventory Capital		
60 day supply of fuel and consumables at 100% CF	$7,141	$13
0.5% of TPC (spare parts)	$5,314	$10
Total	**$12,455**	**$23**
Initial Cost for Catalyst and Chemicals	**$0**	**$0**
Land	**$900**	**$2**
Other Owner's Costs	**$159,425**	**$290**
Financing Costs	**$28,697**	**$52**
Total Owner's Costs	**$233,638**	**$425**
Total Overnight Cost (TOC)	**$1,296,474**	**$2,357**
TASC Multiplier	1.140	
Total As-Spent Cost (TASC)	**$1,477,980**	**$2,687**

Exhibit 5-19 Case S22A Initial and Annual O&M Costs

INITIAL & ANNUAL O&M EXPENSES					Cost Base (June)	2007
Case S22A - 1x550 MWnet SuperCritical CFB					Heat Rate-net(Btu/kWh):	8,770
					MWe-net:	550
					Capacity Factor: (%):	85
OPERATING & MAINTENANCE LABOR						
Operating Labor						
Operating Labor Rate(base):	34.65	$/hour				
Operating Labor Burden:	30.00	% of base				
Labor O-H Charge Rate:	25.00	% of labor				
			Total			
Skilled Operator	2.0		2.0			
Operator	9.0		9.0			
Foreman	1.0		1.0			
Lab Tech's, etc.	2.0		2.0			
TOTAL-O.J.'s	14.0		14.0			
					Annual Cost	Annual Unit Cost
					$	$/kW-net
Annual Operating Labor Cost					$5,524,319	$10.043
Maintenance Labor Cost					$7,258,531	$13.196
Administrative & Support Labor					$3,195,712	$5.810
Property Taxes and Insurance					$21,256,727	$38.645
TOTAL FIXED OPERATING COSTS					**$37,235,289**	**$67.694**

VARIABLE OPERATING COSTS						
						$/kWh-net
Maintenance Material Cost					**$10,887,797**	**$0.00266**
Consumables	Consumption Initial	Consumption /Day	Unit Cost	Initial Cost		
Water(/1000 gallons)	0	1,768	1.08	**$0**	**$593,430**	**$0.00014**
Chemicals						
MU & WT Chem.(lbs)	0	8,560	0.17	$0	$459,613	$0.00011
Limestone (ton)	0	458	21.63	$0	$3,074,030	$0.00075
Carbon (Mercury Removal) lb	0	0	1.05	$0	$0	$0.00000
MEA Solvent (ton)	0	0	2,249.89	$0	$0	$0.00000
NaOH (tons)	0	0	433.68	$0	$0	$0.00000
H2SO4 (tons)	0	0	138.78	$0	$0	$0.00000
Corrosion Inhibitor	0	0	0.00	$0	$0	$0.00000
Activated Carbon(lb)	0	0	1.05	$0	$0	$0.00000
Ammonia (19% NH3) ton	0	22	129.80	$0	$885,957	$0.00022
Subtotal Chemicals				**$0**	**$4,419,601**	**$0.00108**
Other						
Supplemental Fuel(MBtu)	0	0	0.00	$0	$0	$0.00000
SCR Catalyst(m3)	w/equip.	0.00	5,775.94	$0	$0	$0.00000
Emission Penalties	0	0	0.00	$0	$0	$0.00000
Subtotal Other				**$0**	**$0**	**$0.00000**
Waste Disposal						
Fly Ash (ton)	0	813	16.23	$0	$4,092,497	$0.00100
Bottom Ash (ton)	0	349	16.23	$0	$1,756,824	$0.00043
Subtotal-Waste Disposal				**$0**	**$5,849,321**	**$0.00143**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	$0.00000
Subtotal By-Products				**$0**	**$0**	**$0.00000**
TOTAL VARIABLE OPERATING COSTS				**$0**	**$21,750,148**	**$0.00531**
Fuel(ton)	0	6,754	15.22	**$0**	**$31,892,312**	**$0.00779**

Exhibit 5-20 Case L22A Total Plant Cost Summary

Client:	USDOE/NETL	**Report Date:**	2009-Oct-15
Project:	Low Rank (Western) Coal Baseline Study		

TOTAL PLANT COST SUMMARY

Case:	Case L22A - 1x550 MWnet SuperCritical CFB					
Plant Size:	550.0 MW,net	**Estimate Type:**	Conceptual	**Cost Base (June)**	2007	($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING	$23,894	$6,441	$14,485	$0	$0	**$44,820**	$4,024	$0	$7,327	**$56,171**	$102
2	COAL & SORBENT PREP & FEED	$11,501	$840	$3,970	$0	$0	**$16,312**	$1,836	$0	$2,689	**$20,836**	$38
3	FEEDWATER & MISC. BOP SYSTEMS	$41,674	$0	$21,471	$0	$0	**$63,145**	$5,780	$0	$10,907	**$79,832**	$145
4	CFB BOILER											
4.1	CFB Boiler & Accesories	$291,964	$0	$111,012	$0	$0	**$402,976**	$39,111	$60,446	$50,253	**$552,787**	$1,005
4.2	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.3	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.4-4.9	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 4	**$291,964**	**$0**	**$111,012**	**$0**	**$0**	**$402,976**	**$39,111**	**$60,446**	**$50,253**	**$552,787**	**$1,005**
5	FLUE GAS CLEANUP	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
6.2-6.9	Combustion Turbine Accessories	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 6	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
7.2-7.9	HRSG Accessories, Ductwork, and Stack	$22,563	$1,298	$15,322	$0	$0	**$39,183**	$3,597	$0	$5,586	**$48,366**	$88
	SUBTOTAL 7	**$22,563**	**$1,298**	**$15,322**	**$0**	**$0**	**$39,183**	**$3,597**	**$0**	**$5,586**	**$48,366**	**$88**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$51,515	$0	$6,851	$0	$0	**$58,365**	$5,594	$0	$6,396	**$70,355**	$128
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$57,952	$1,087	$20,414	$0	$0	**$79,453**	$7,502	$0	$15,219	**$102,173**	$186
	SUBTOTAL 8	**$109,467**	**$1,087**	**$27,265**	**$0**	**$0**	**$137,818**	**$13,096**	**$0**	**$21,614**	**$172,528**	**$314**
9	COOLING WATER SYSTEM	$7,641	$4,170	$7,424	$0	$0	**$19,235**	$1,810	$0	$2,887	**$23,933**	$44
10	ASH/SPENT SORBENT HANDLING SYS	$8,473	$269	$11,328	$0	$0	**$20,070**	$1,930	$0	$2,264	**$24,264**	$44
11	ACCESSORY ELECTRIC PLANT	$17,307	$6,035	$17,657	$0	$0	**$40,999**	$3,613	$0	$5,507	**$50,120**	$91
12	INSTRUMENTATION & CONTROL	$8,696	$0	$8,818	$0	$0	**$17,514**	$1,588	$0	$2,346	**$21,449**	$39
13	IMPROVEMENTS TO SITE	$2,965	$1,704	$5,975	$0	$0	**$10,643**	$1,050	$0	$2,339	**$14,032**	$26
14	BUILDINGS & STRUCTURES	$0	$24,249	$22,887	$0	$0	**$47,136**	$4,251	$0	$7,708	**$59,095**	$107
	TOTAL COST	**$546,145**	**$46,093**	**$267,614**	**$0**	**$0**	**$859,852**	**$81,686**	**$60,446**	**$121,428**	**$1,123,412**	**$2,042**

Exhibit 5-21 Case L22A Total Plant Cost Details

Client:	USDOE/NETL
Report Date:	2009-Oct-15
Project:	Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case:	Case L22A - 1x550 MWnet SuperCritical CFB
Plant Size:	550.0 MW,net
Estimate Type:	Conceptual
Cost Base (June)	2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING											
1.1	Coal Receive & Unload	$4,863	$0	$2,221	$0	$0	$7,084	$633	$0	$1,158	$8,875	$16
1.2	Coal Stackout & Reclaim	$6,285	$0	$1,424	$0	$0	$7,709	$674	$0	$1,257	$9,640	$18
1.3	Coal Conveyors	$5,843	$0	$1,409	$0	$0	$7,252	$635	$0	$1,183	$9,071	$16
1.4	Other Coal Handling	$1,529	$0	$326	$0	$0	$1,855	$162	$0	$303	$2,319	$4
1.5	Sorbent Receive & Unload	$140	$0	$42	$0	$0	$182	$16	$0	$30	$228	$0
1.6	Sorbent Stackout & Reclaim	$3,938	$0	$848	$0	$0	$4,787	$418	$0	$781	$5,986	$11
1.7	Sorbent Conveyors	$808	$175	$198	$0	$0	$1,181	$102	$0	$192	$1,475	$3
1.8	Other Sorbent Handling	$488	$114	$256	$0	$0	$858	$76	$0	$140	$1,074	$2
1.9	Coal & Sorbent Hnd.Foundations	$0	$6,152	$7,760	$0	$0	$13,912	$1,307	$0	$2,283	$17,502	$32
	SUBTOTAL 1.	**$23,894**	**$6,441**	**$14,485**	**$0**	**$0**	**$44,820**	**$4,024**	**$0**	**$7,327**	**$56,171**	**$102**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$2,852	$0	$556	$0	$0	$3,408	$297	$0	$556	$4,261	$8
2.2	Coal Conveyor to Storage	$7,302	$0	$1,594	$0	$0	$8,896	$778	$0	$1,451	$11,125	$20
2.3	Coal Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.4	Misc.Coal Prep & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.5	Sorbent Prep Equipment	$1,347	$0	$280	$0	$0	$1,626	$142	$0	$265	$2,034	$4
2.6	Sorbent Storage & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.7	Sorbent Injection System	$0	$0	$836	$0	$0	$836	$476	$0	$164	$1,475	$3
2.8	Booster Air Supply System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.9	Coal & Sorbent Feed Foundation	$0	$840	$705	$0	$0	$1,545	$143	$0	$253	$1,942	$4
	SUBTOTAL 2.	**$11,501**	**$840**	**$3,970**	**$0**	**$0**	**$16,312**	**$1,836**	**$0**	**$2,689**	**$20,836**	**$38**
3	FEEDWATER & MISC. BOP SYSTEMS											
3.1	FeedwaterSystem	$18,230	$0	$5,889	$0	$0	$24,119	$2,108	$0	$3,934	$30,160	$55
3.2	Water Makeup & Pretreating	$2,547	$0	$820	$0	$0	$3,366	$318	$0	$737	$4,422	$8
3.3	Other Feedwater Subsystems	$5,581	$0	$2,359	$0	$0	$7,940	$711	$0	$1,298	$9,949	$18
3.4	Service Water Systems	$499	$0	$272	$0	$0	$771	$72	$0	$169	$1,012	$2
3.5	Other Boiler Plant Systems	$10,133	$0	$10,004	$0	$0	$20,136	$1,913	$0	$3,307	$25,356	$46
3.6	FO Supply Sys & Nat Gas	$255	$0	$318	$0	$0	$573	$54	$0	$94	$721	$1
3.7	Waste Treatment Equipment	$1,727	$0	$984	$0	$0	$2,711	$264	$0	$595	$3,570	$6
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	$2,704	$0	$826	$0	$0	$3,530	$339	$0	$774	$4,643	$8
	SUBTOTAL 3.	**$41,674**	**$0**	**$21,471**	**$0**	**$0**	**$63,145**	**$5,780**	**$0**	**$10,907**	**$79,832**	**$145**

Exhibit 5-21 Case L22A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 2009-Oct-15
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case L22A - 1x550 MWnet SuperCritical CFB
Plant Size: 550.0 MW,net **Estimate Type:** Conceptual **Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
4	CFB BOILER											
4.1	CFB Boiler & Accesories	$291,964	$0	$111,012	$0	$0	$402,976	$39,111	$60,446	$50,253	$552,787	$1,005
4.2	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.3	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.4	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.5	Primary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.6	Secondary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.8	Major Component Rigging	$0	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.9	CFB Foundations	$0	$0	w/14.1	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 4.	**$291,964**	**$0**	**$111,012**	**$0**	**$0**	**$402,976**	**$39,111**	**$60,446**	**$50,253**	**$552,787**	**$1,005**
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.2	Other FGD	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.3	Bag House & Accessories (Incl. w/4.1)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.4	Other Particulate Removal Materials	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.5	Gypsum Dewatering System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.6	Mercury Removal System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.9	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 5.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.2	Combustion Turbine Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.3	Compressed Air Piping	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.9	Combustion Turbine Foundations	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
7.2	HRSG Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7.3	Ductwork	$11,252	$0	$7,229	$0	$0	$18,482	$1,611	$0	$3,014	$23,107	$42
7.4	Stack	$11,311	$0	$6,619	$0	$0	$17,930	$1,726	$0	$1,966	$21,622	$39
7.9	Duct & Stack Foundations	$0	$1,298	$1,474	$0	$0	$2,772	$259	$0	$606	$3,637	$7
	SUBTOTAL 7.	**$22,563**	**$1,298**	**$15,322**	**$0**	**$0**	**$39,183**	**$3,597**	**$0**	**$5,586**	**$48,366**	**$88**

Exhibit 5-21 Case L22A Total Plant Cost Details (Continued)

	Client:	USDOE/NETL								Report Date:	2009-Oct-15		
	Project:	Low Rank (Western) Coal Baseline Study											
		TOTAL PLANT COST SUMMARY											
	Case:	Case L22A - 1x550 MWnet SuperCritical CFB											
	Plant Size:	550.0 MW,net		Estimate Type:		Conceptual				Cost Base (June)	2007	($x1000)	
Acct		Equipment	Material	Labor		Sales	Bare Erected	Eng'g CM	Contingencies		TOTAL PLANT COST		
No.	Item/Description	Cost	Cost	Direct	Indirect	Tax	Cost $	H.O.& Fee	Process	Project	$	$/kW	
8	STEAM TURBINE GENERATOR												
8.1	Steam TG & Accessories	$51,515	$0	$6,851	$0	$0	$58,365	$5,594	$0	$6,396	$70,355	$128	
8.2	Turbine Plant Auxiliaries	$346	$0	$742	$0	$0	$1,088	$106	$0	$119	$1,314	$2	
8.3a	Condenser & Auxiliaries	$4,010	$0	$2,283	$0	$0	$6,293	$606	$0	$690	$7,589	$14	
8.3b	Air Cooled Condenser	$36,752	$0	$7,368	$0	$0	$44,120	$4,412	$0	$9,706	$58,238	$106	
8.4	Steam Piping	$16,843	$0	$8,305	$0	$0	$25,148	$2,113	$0	$4,089	$31,350	$57	
8.9	TG Foundations	$0	$1,087	$1,717	$0	$0	$2,803	$265	$0	$614	$3,682	$7	
	SUBTOTAL 8.	**$109,467**	**$1,087**	**$27,265**	**$0**	**$0**	**$137,818**	**$13,096**	**$0**	**$21,614**	**$172,528**	**$314**	
9	COOLING WATER SYSTEM												
9.1	Cooling Towers	$5,608	$0	$1,746	$0	$0	$7,354	$703	$0	$806	$8,863	$16	
9.2	Circulating Water Pumps	$1,168	$0	$58	$0	$0	$1,227	$103	$0	$133	$1,463	$3	
9.3	Circ.Water System Auxiliaries	$330	$0	$44	$0	$0	$374	$36	$0	$41	$451	$1	
9.4	Circ.Water Piping	$0	$2,619	$2,538	$0	$0	$5,157	$483	$0	$846	$6,485	$12	
9.5	Make-up Water System	$273	$0	$365	$0	$0	$638	$61	$0	$105	$803	$1	
9.6	Component Cooling Water Sys	$262	$0	$208	$0	$0	$470	$45	$0	$77	$592	$1	
9.9	Circ.Water System Foundations& Structures	$0	$1,551	$2,465	$0	$0	$4,016	$380	$0	$879	$5,276	$10	
	SUBTOTAL 9.	**$7,641**	**$4,170**	**$7,424**	**$0**	**$0**	**$19,235**	**$1,810**	**$0**	**$2,887**	**$23,933**	**$44**	
10	ASH/SPENT SORBENT HANDLING SYS												
10.1	Ash Coolers	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0	
10.2	Cyclone Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0	
10.3	HGCU Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0	
10.4	High Temperature Ash Piping	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0	
10.5	Other Ash Recovery Equipment	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0	
10.6	Ash Storage Silos	$1,134	$0	$3,493	$0	$0	$4,627	$454	$0	$508	$5,589	$10	
10.7	Ash Transport & Feed Equipment	$7,339	$0	$7,518	$0	$0	$14,856	$1,421	$0	$1,628	$17,905	$33	
10.8	Misc. Ash Handling Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
10.9	Ash/Spent Sorbent Foundation	$0	$269	$317	$0	$0	$587	$55	$0	$128	$770	$1	
	SUBTOTAL 10.	**$8,473**	**$269**	**$11,328**	**$0**	**$0**	**$20,070**	**$1,930**	**$0**	**$2,264**	**$24,264**	**$44**	

Exhibit 5-21 Case L22A Total Plant Cost Details (Continued)

Client:	USDOE/NETL
Project:	Low Rank (Western) Coal Baseline Study
Report Date:	2009-Oct-15
Case:	Case L22A - 1x550 MWnet SuperCritical CFB
Plant Size:	550.0 MW,net
Estimate Type:	Conceptual
Cost Base (June)	2007 ($x1000)

TOTAL PLANT COST SUMMARY

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT											
11.1	Generator Equipment	$1,595	$0	$259	$0	$0	$1,854	$172	$0	$152	$2,178	$4
11.2	Station Service Equipment	$2,751	$0	$904	$0	$0	$3,655	$342	$0	$300	$4,296	$8
11.3	Switchgear & Motor Control	$3,163	$0	$538	$0	$0	$3,700	$343	$0	$404	$4,448	$8
11.4	Conduit & Cable Tray	$0	$1,983	$6,856	$0	$0	$8,839	$856	$0	$1,454	$11,149	$20
11.5	Wire & Cable	$0	$3,742	$7,223	$0	$0	$10,965	$924	$0	$1,783	$13,671	$25
11.6	Protective Equipment	$269	$0	$916	$0	$0	$1,185	$116	$0	$130	$1,431	$3
11.7	Standby Equipment	$1,275	$0	$29	$0	$0	$1,304	$120	$0	$142	$1,566	$3
11.8	Main Power Transformers	$8,254	$0	$171	$0	$0	$8,425	$640	$0	$906	$9,971	$18
11.9	Electrical Foundations	$0	$311	$761	$0	$0	$1,072	$102	$0	$235	$1,409	$3
	SUBTOTAL 11.	**$17,307**	**$6,035**	**$17,657**	**$0**	**$0**	**$40,999**	**$3,613**	**$0**	**$5,507**	**$50,120**	**$91**
12	INSTRUMENTATION & CONTROL											
12.1	PC Control Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.2	Combustion Turbine Control	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
12.3	Steam Turbine Control	w/8.1	$0	w/8.1	$0	$0	$0	$0	$0	$0	$0	$0
12.4	Other Major Component Control	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.5	Signal Processing Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.6	Control Boards,Panels & Racks	$448	$0	$268	$0	$0	$716	$68	$0	$118	$901	$2
12.7	Distributed Control System Equipment	$4,521	$0	$790	$0	$0	$5,311	$492	$0	$580	$6,383	$12
12.8	Instrument Wiring & Tubing	$2,451	$0	$4,861	$0	$0	$7,312	$623	$0	$1,190	$9,125	$17
12.9	Other I & C Equipment	$1,277	$0	$2,899	$0	$0	$4,176	$405	$0	$458	$5,039	$9
	SUBTOTAL 12.	**$8,696**	**$0**	**$8,818**	**$0**	**$0**	**$17,514**	**$1,588**	**$0**	**$2,346**	**$21,449**	**$39**
13	IMPROVEMENTS TO SITE											
13.1	Site Preparation	$0	$50	$996	$0	$0	$1,046	$104	$0	$230	$1,380	$3
13.2	Site Improvements	$0	$1,654	$2,055	$0	$0	$3,709	$366	$0	$815	$4,890	$9
13.3	Site Facilities	$2,965	$0	$2,924	$0	$0	$5,888	$580	$0	$1,294	$7,762	$14
	SUBTOTAL 13.	**$2,965**	**$1,704**	**$5,975**	**$0**	**$0**	**$10,643**	**$1,050**	**$0**	**$2,339**	**$14,032**	**$26**
14	BUILDINGS & STRUCTURES											
14.1	Boiler Building	$0	$10,083	$8,867	$0	$0	$18,951	$1,703	$0	$3,098	$23,752	$43
14.2	Turbine Building	$0	$11,800	$10,997	$0	$0	$22,797	$2,055	$0	$3,728	$28,579	$52
14.3	Administration Building	$0	$586	$619	$0	$0	$1,205	$109	$0	$197	$1,512	$3
14.4	Circulation Water Pumphouse	$0	$168	$133	$0	$0	$301	$27	$0	$49	$377	$1
14.5	Water Treatment Buildings	$0	$323	$295	$0	$0	$618	$56	$0	$101	$774	$1
14.6	Machine Shop	$0	$392	$263	$0	$0	$655	$58	$0	$107	$820	$1
14.7	Warehouse	$0	$265	$266	$0	$0	$532	$48	$0	$87	$667	$1
14.8	Other Buildings & Structures	$0	$217	$185	$0	$0	$402	$36	$0	$66	$503	$1
14.9	Waste Treating Building & Str.	$0	$415	$1,260	$0	$0	$1,676	$159	$0	$275	$2,110	$4
	SUBTOTAL 14.	**$0**	**$24,249**	**$22,887**	**$0**	**$0**	**$47,136**	**$4,251**	**$0**	**$7,708**	**$59,095**	**$107**
	TOTAL COST	**$546,145**	**$46,093**	**$267,614**	**$0**	**$0**	**$859,852**	**$81,686**	**$60,446**	**$121,428**	**$1,123,412**	**$2,042**

Exhibit 5-22 Case L22A Owner's Costs

Owner's Costs	$x1000	$/kW
Preproduction Costs		
6 Months Fixed O&M	$8,298	$15
1 Month Variable O&M	$2,438	$4
25% of 1 Months Fuel Cost at 100% CF	$743	$1
2% of TPC	$22,468	$41
Total	**$33,948**	**$62**
Inventory Capital		
60 day supply of fuel and consumables at 100% CF	$6,921	$13
0.5% of TPC (spare parts)	$5,617	$10
Total	**$12,538**	**$23**
Initial Cost for Catalyst and Chemicals	**$0**	**$0**
Land	**$900**	**$2**
Other Owner's Costs	**$168,512**	**$306**
Financing Costs	**$30,332**	**$55**
Total Owner's Costs	**$246,230**	**$448**
Total Overnight Cost (TOC)	**$1,369,642**	**$2,490**
TASC Multiplier	1.140	
Total As-Spent Cost (TASC)	**$1,561,392**	**$2,839**

Exhibit 5-23 Case L22A Initial and Annual O&M Costs

INITIAL & ANNUAL O&M EXPENSES					Cost Base (June)	2007
Case L22A - 1x550 MWnet SuperCritical CFB					Heat Rate-net(Btu/kWh):	8,975
					MWe-net:	550
					Capacity Factor: (%):	85
OPERATING & MAINTENANCE LABOR						
Operating Labor						
Operating Labor Rate(base):	34.65	$/hour				
Operating Labor Burden:	30.00	% of base				
Labor O-H Charge Rate:	25.00	% of labor				
			Total			
Skilled Operator	2.0		2.0			
Operator	9.0		9.0			
Foreman	1.0		1.0			
Lab Tech's, etc.	2.0		2.0			
TOTAL-O.J.'s	14.0		14.0			
					Annual Cost	Annual Unit Cost
					$	$/kW-net
Annual Operating Labor Cost					$5,524,319	$10.044
Maintenance Labor Cost					$7,752,734	$14.095
Administrative & Support Labor					$3,319,263	$6.035
Property Taxes and Insurance					$22,468,247	$40.849
TOTAL FIXED OPERATING COSTS					**$39,064,563**	**$71.023**
VARIABLE OPERATING COSTS						
						$/kWh-net
Maintenance Material Cost					**$11,629,100**	**$0.00284**
Consumables	Consumption Initial	/Day	Unit Cost	Initial Cost		
Water(/1000 gallons)	0	1,764	1.08	**$0**	**$591,981**	**$0.00014**
Chemicals						
MU & WT Chem.(lbs)	0	8,539	0.17	$0	$458,490	$0.00011
Limestone (ton)	0	519	21.63	$0	$3,483,396	$0.00085
Carbon (Mercury Removal) lb	0	0	1.05	$0	$0	$0.00000
MEA Solvent (ton)	0	0	2,249.89	$0	$0	$0.00000
NaOH (tons)	0	0	433.68	$0	$0	$0.00000
H2SO4 (tons)	0	0	138.78	$0	$0	$0.00000
Corrosion Inhibitor	0	0	0.00	$0	$0	$0.00000
Activated Carbon(lb)	0	0	1.05	$0	$0	$0.00000
Ammonia (19% NH3) ton	0	23	129.80	$0	$926,228	$0.00023
Subtotal Chemicals				**$0**	**$4,868,114**	**$0.00119**
Other						
Supplemental Fuel(MBtu)	0	0	0.00	$0	$0	$0.00000
SCR Catalyst(m3)	w/equip.	0.00	5,775.94	$0	$0	$0.00000
Emission Penalties	0	0	0.00	$0	$0	$0.00000
Subtotal Other				**$0**	**$0**	**$0.00000**
Waste Disposal						
Flyash (ton)	0	1,082	16.23	$0	$5,446,644	$0.00133
Bottom Ash(ton)	0	464	16.23	$0	$2,335,695	$0.00057
Subtotal-Waste Disposal				**$0**	**$7,782,339**	**$0.00190**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	$0.00000
Subtotal By-Products				**$0**	**$0**	**$0.00000**
TOTAL VARIABLE OPERATING COSTS				**$0**	**$24,871,534**	**$0.00607**
Fuel(ton)	0	8,889	10.92	**$0**	**$30,113,925**	**$0.00735**

5.2 SC CFB CO_2 CAPTURE CASES (PRB AND LIGNITE)

5.2.1 Process Description

In this section the SC CFB processes with CO_2 capture are described. The plant configurations are similar to the non-capture cases presented in Section 5.1 with the major difference being the use of an Econamine system for CO_2 capture and subsequent compression of the captured CO_2 stream. Since the CO_2 capture and compression process increases the auxiliary load on the plant, the coal feed rate is significantly increased and the overall efficiency is significantly reduced relative to the non-capture cases. A process BFD for the two CO_2 capture cases is shown in Exhibit 5-24 and stream tables for Cases S22B and L22B are shown in Exhibit 5-25 and Exhibit 5-26. The CO_2 removal system is described in Section 3.1.4.

Exhibit 5-24 Cases S22B and L22B Process Flow Diagram

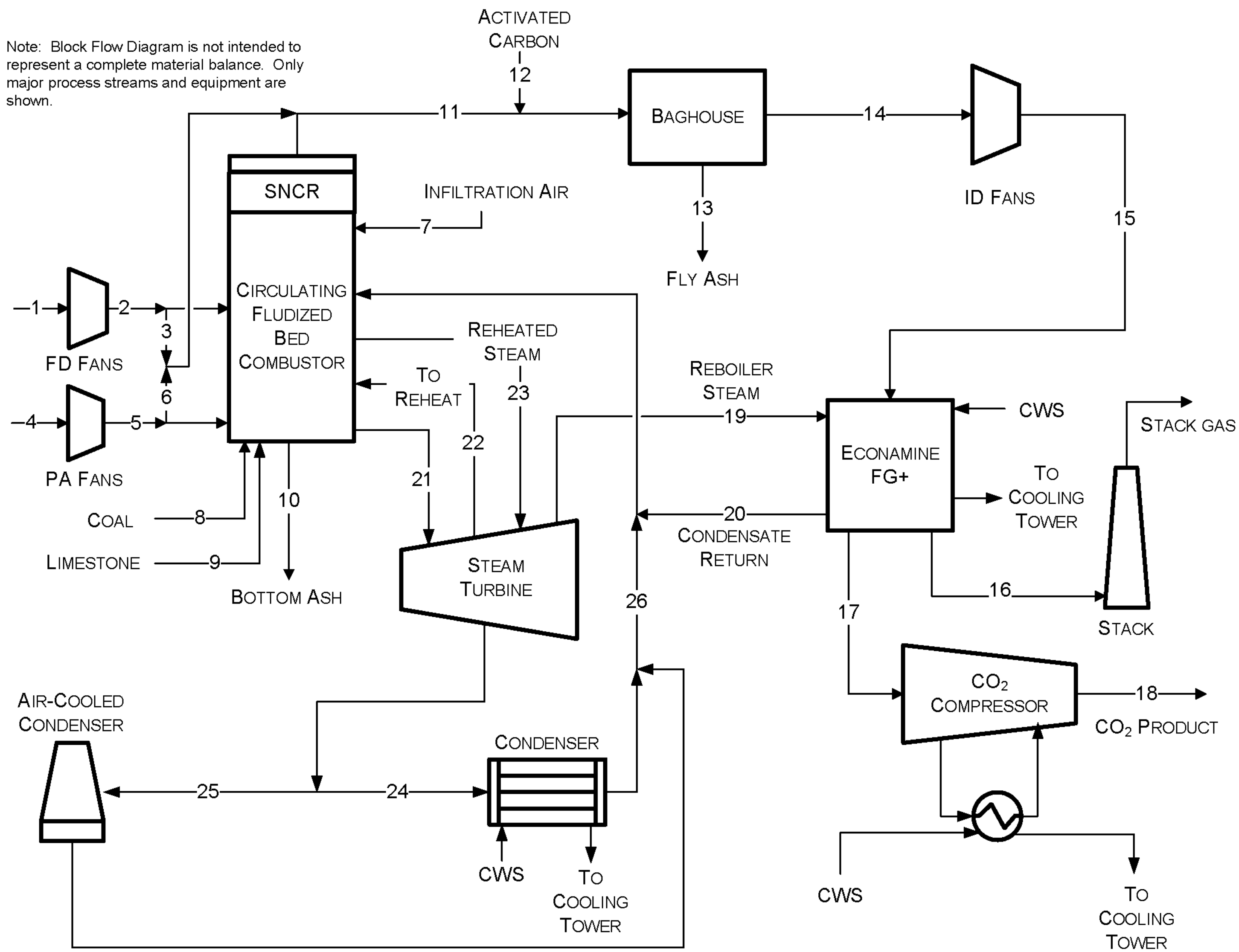

Exhibit 5-25 Case S22B Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13
V-L Mole Fraction													
Ar	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0000	0.0000	0.0000	0.0085	0.0000	0.0000
CO_2	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0000	0.0000	0.0000	0.1408	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0000	0.0000	0.0000	0.1101	0.0000	0.0000
N_2	0.7759	0.7759	0.7759	0.7759	0.7759	0.7759	0.7759	0.0000	0.0000	0.0000	0.7084	0.0000	0.0000
O_2	0.2081	0.2081	0.2081	0.2081	0.2081	0.2081	0.2081	0.0000	0.0000	0.0000	0.0322	0.0000	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000
V-L Flowrate (kg_{mol}/hr)	38,346	38,346	2,263	57,519	57,519	3,010	1,629	0	0	0	106,909	0	0
V-L Flowrate (kg/hr)	1,108,007	1,108,007	65,383	1,662,010	1,662,010	86,968	47,057	0	0	0	3,142,638	0	0
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	363,450	24,607	18,748	43,745	66	43,812
Temperature (°C)	6	10	10	6	18	18	6	6	6	149	127	6	127
Pressure (MPa, abs)	0.09	0.09	0.09	0.09	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.11	0.08
Enthalpy (kJ/kg)[A]	15.26	20.24	20.24	15.26	27.31	27.31	15.26	---	---	---	258.52	---	---
Density (kg/m^3)	1.1	1.2	1.2	1.1	1.2	1.2	1.1	---	---	---	0.8	---	---
V-L Molecular Weight	28.895	28.895	28.895	28.895	28.895	28.895	28.895	---	---	---	29.396	---	---
V-L Flowrate (lb_{mol}/hr)	84,538	84,538	4,989	126,807	126,807	6,635	3,590	0	0	0	235,694	0	0
V-L Flowrate (lb/hr)	2,442,737	2,442,737	144,146	3,664,106	3,664,106	191,731	103,742	0	0	0	6,928,330	0	0
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	801,270	54,248	41,332	96,442	146	96,588
Temperature (°F)	42	51	51	42	64	64	42	42	42	300	260	42	260
Pressure (psia)	13.0	13.6	13.6	13.0	14.5	14.5	13.0	13.0	13.0	13.0	12.4	16.0	12.2
Enthalpy (Btu/lb)[A]	6.6	8.7	8.7	6.6	11.7	11.7	6.6	---	---	---	111.1	---	---
Density (lb/ft^3)	0.070	0.072	0.072	0.070	0.075	0.075	0.070	---	---	---	0.047	---	---

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 5-25 Case S22B Stream Table (Continued)

	14	15	16	17	18	19	20	21	22	23	24	25	26
V-L Mole Fraction													
Ar	0.0085	0.0085	0.0106	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.1408	0.1408	0.0176	0.9955	0.9998	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.1101	0.1101	0.0431	0.0045	0.0002	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.7084	0.7084	0.8883	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0322	0.0322	0.0404	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	106,909	106,909	85,263	13,605	13,546	55,720	55,720	127,061	107,319	107,319	24,118	24,118	49,507
V-L Flowrate (kg/hr)	3,142,638	3,142,638	2,400,394	597,154	596,083	1,003,809	1,003,809	2,289,042	1,933,384	1,933,384	434,498	434,498	891,885
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	127	136	32	21	35	152	151	593	354	593	32	32	32
Pressure (MPa, abs)	0.08	0.09	0.09	0.16	15.27	0.51	0.49	24.23	4.90	4.52	0.00	0.00	1.72
Enthalpy (kJ/kg)[A]	302.37	312.40	101.55	20.14	-212.30	2,746.79	635.72	3,476.62	3,081.69	3,652.22	1,993.45	1,993.45	136.94
Density (kg/m^3)	0.7	0.8	1.0	2.9	794.5	2.7	915.8	69.2	18.7	11.6	0.0	0.0	995.7
V-L Molecular Weight	29.396	29.396	28.153	43.892	44.006	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	235,694	235,694	187,972	29,994	29,863	122,841	122,841	280,122	236,598	236,598	53,172	53,172	109,145
V-L Flowrate (lb/hr)	6,928,330	6,928,330	5,291,962	1,316,500	1,314,139	2,213,019	2,213,019	5,046,474	4,262,383	4,262,383	957,903	957,903	1,966,271
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	260	277	89	69	95	306	304	1,100	668	1,100	90	90	90
Pressure (psia)	12.2	13.1	13.1	23.5	2,215.0	73.5	71.0	3,514.7	710.8	655.8	0.7	0.7	250.0
Enthalpy (Btu/lb)[A]	130.0	134.3	43.7	8.7	-91.3	1,180.9	273.3	1,494.7	1,324.9	1,570.2	857.0	857.0	58.9
Density (lb/ft^3)	0.047	0.049	0.063	0.184	49.600	0.169	57.172	4.319	1.166	0.722	0.003	0.003	62.162

Exhibit 5-26 Case L22B Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13
V-L Mole Fraction													
Ar	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0000	0.0000	0.0000	0.0081	0.0000	0.0000
CO_2	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0000	0.0000	0.0000	0.1355	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	0.0000	0.0000	0.0000	0.1425	0.0000	0.0000
N_2	0.7761	0.7761	0.7761	0.7761	0.7761	0.7761	0.7761	0.0000	0.0000	0.0000	0.6814	0.0000	0.0000
O_2	0.2082	0.2082	0.2082	0.2082	0.2082	0.2082	0.2082	0.0000	0.0000	0.0000	0.0324	0.0000	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000
V-L Flowrate (kg_{mol}/hr)	41,598	41,598	2,455	62,397	62,397	3,265	1,743	0	0	0	120,589	0	0
V-L Flowrate (kg/hr)	1,202,087	1,202,087	70,935	1,803,130	1,803,130	94,352	50,361	0	0	0	3,495,206	0	0
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	497,052	28,912	25,901	60,435	106	60,541
Temperature (°C)	4	9	9	4	16	16	4	4	4	149	127	6	127
Pressure (MPa, abs)	0.10	0.10	0.10	0.10	0.11	0.11	0.10	0.10	0.10	0.10	0.09	0.11	0.09
Enthalpy (kJ/kg)[A]	13.75	18.42	18.42	13.75	25.07	25.07	13.75	---	---	---	322.44	---	---
Density (kg/m^3)	1.2	1.2	1.2	1.2	1.3	1.3	1.2	---	---	---	0.8	---	---
V-L Molecular Weight	28.898	28.898	28.898	28.898	28.898	28.898	28.898	---	---	---	28.985	---	---
V-L Flowrate (lb_{mol}/hr)	91,708	91,708	5,412	137,562	137,562	7,198	3,842	0	0	0	265,852	0	0
V-L Flowrate (lb/hr)	2,650,148	2,650,148	156,385	3,975,222	3,975,222	208,010	111,028	0	0	0	7,705,610	0	0
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	1,095,812	63,740	57,102	133,237	233	133,470
Temperature (°F)	40	48	48	40	60	60	40	40	40	300	261	42	261
Pressure (psia)	13.8	14.4	14.4	13.8	15.3	15.3	13.8	13.8	13.8	13.8	13.2	16.0	13.0
Enthalpy (Btu/lb)[A]	5.9	7.9	7.9	5.9	10.8	10.8	5.9	---	---	---	138.6	---	---
Density (lb/ft^3)	0.074	0.076	0.076	0.074	0.079	0.079	0.074	---	---	---	0.050	---	---

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 5-26 Case L22B Stream Table (Continued)

	14	15	16	17	18	19	20	21	22	23	24	25	26
V-L Mole Fraction													
Ar	0.0081	0.0081	0.0106	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.1355	0.1355	0.0177	0.9958	0.9998	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.1425	0.1425	0.0406	0.0042	0.0002	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.6814	0.6814	0.8889	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0324	0.0324	0.0422	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	120,589	120,589	92,443	14,771	14,711	60,513	60,513	130,387	110,149	110,149	23,354	23,354	46,709
V-L Flowrate (kg/hr)	3,495,206	3,495,206	2,605,558	648,450	647,360	1,090,158	1,090,158	2,348,967	1,984,364	1,984,364	420,736	420,736	841,472
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	127	136	32	21	35	152	151	593	354	593	32	32	32
Pressure (MPa, abs)	0.09	0.10	0.10	0.16	15.27	0.51	0.49	24.23	4.90	4.52	0.005	0.005	1.72
Enthalpy (kJ/kg)[A]	357.62	367.19	97.46	19.85	-212.30	2,746.79	635.72	3,476.62	3,081.61	3,652.22	2,005.39	2,005.39	136.94
Density (kg/m^3)	0.8	0.8	1.1	2.9	794.5	2.7	915.8	69.2	18.7	11.6	0.04	0.04	995.7
V-L Molecular Weight	28.985	28.985	28.185	43.899	44.006	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	265,852	265,852	203,803	32,565	32,432	133,408	133,408	287,455	242,837	242,837	51,488	51,488	102,975
V-L Flowrate (lb/hr)	7,705,610	7,705,610	5,744,271	1,429,587	1,427,183	2,403,388	2,403,388	5,178,585	4,374,775	4,374,775	927,564	927,564	1,855,129
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	261	276	89	69	95	306	304	1,100	668	1,100	90	90	90
Pressure (psia)	13.0	13.9	13.9	23.2	2,215.0	73.5	71.0	3,514.7	710.8	655.8	0.7	0.7	250.0
Enthalpy (Btu/lb)[A]	153.7	157.9	41.9	8.5	-91.3	1,180.9	273.3	1,494.7	1,324.9	1,570.2	862.2	862.2	58.9
Density (lb/ft^3)	0.049	0.051	0.066	0.181	49.600	0.169	57.172	4.319	1.166	0.722	0.003	0.003	62.162

5.2.2 Key System Assumptions

System assumptions for Cases S22B and L22B, SC CFB with CO_2 capture, are compiled in Exhibit 5-27.

Exhibit 5-27 CFB Cases with CO_2 Capture Study Configuration Matrix

	Case S22B w/ CO_2 Capture	Case L22B w/CO_2 Capture
Steam Cycle, MPa/°C/°C (psig/°F/°F)	24.1/593/593 (3,500/1,100/1,100)	24.1/593/593 (3,500/1,100/1,100)
Coal	Subbituminous	Lignite
Ca/S Mole Ratio	2.4	2.4
Condenser pressure, mm Hg (in Hg)	36 (1.4)	36 (1.4)
Combustion air preheater flue gas exit temp., °C (ºF)	127 (260)	127 (260)
Cooling water to condenser, °C (ºF)	9 (48)	8 (47)
Cooling water from condenser, °C (ºF)	20 (68)	19 (67)
SO_2 Control [2, 3]	in-bed Limestone injection	in-bed Limestone injection
SO_2 Reduction Efficiency, % [1]	94	94
NOx Control	Combustion temperature control w/OFA and SNCR	Combustion temperature control w/OFA and SNCR
SNCR Efficiency, % [1]	46	46
Ammonia Slip (end of catalyst life), ppmv	2	2
Particulate Control	Fabric Filter	Fabric Filter
Fabric Filter efficiency, % [1]	99.9	99.9
Ash Distribution, Fly/Bottom	70% / 30%	70% / 30%
Mercury Control	Co-benefit Capture	Co-benefit Capture
Mercury removal efficiency, % [1]	57	57
CO_2 Control	Econamine	Econamine
CO_2 Capture, % [1]	90	90
CO_2 Sequestration	Off-site Saline Formation	Off-site Saline Formation

[1] Equipment removal efficiencies

[2] An SO_2 polishing step is included to meet more stringent SOx content limits in the flue gas (< 10 ppmv) to reduce formation of amine HSS during the CO_2 absorption process

[3] SO_2 exiting the post-FGD polishing step is absorbed in the CO_2 capture process making stack emissions negligible

Balance of Plant – Cases S22B and L22B

The balance of plant assumptions are common to all cases and were presented previously in Section 3.1.6.

5.2.3 Sparing Philosophy

Single trains are used throughout the design with exceptions where equipment capacity requires an additional train. There is no redundancy other than normal sparing of rotating equipment. The plant design consists of the following major subsystems:

- One SC CFB combustor (1 x 100 percent) with SNCR
- Two single-stage, in-line, multi-compartment fabric filters (2 x 50 percent)
- One steam turbine (1 x 100 percent)
- Two parallel Econamine CO_2 absorption systems, with each system consisting of two absorbers, strippers, and ancillary equipment (2 x 50 percent)

5.2.4 Cases S22B and L22B Performance Results

The CO_2 capture SC CFB plant using PRB coal produces a net output of 550 MWe at a net plant efficiency of 27.3 percent (HHV basis). The same plant configuration using lignite coal produces a net output of 550 MWe at a net plant efficiency of 25.9 percent (HHV basis).

Overall performance for the two plants is summarized in Exhibit 5-28, which includes auxiliary power requirements. The cooling water system, including the CWPs and cooling tower fan, and the air-cooled condenser account for about 16 percent of the auxiliary load in all cases, and the PA, FD and induced draft fans account for an additional 14 percent. CO_2 compression accounts for about 42 percent and the Econamine process about 20 percent of the auxiliary load in all cases.

Exhibit 5-28 CFB Cases with CO_2 Capture Plant Performance Summary

POWER SUMMARY (Gross Power at Generator Terminals, kWe)	S22B	L22B
Steam Turbine Power	**664,000**	**672,900**
AUXILIARY LOAD SUMMARY, kWe		
Coal Handling and Conveying	620	760
Pulverizers / Crushers	170	240
Sorbent Handling & Reagent Preparation	110	130
Ash Handling	1,850	2,550
PA Fans	5,760	5,880
FD Fans	1,590	1,620
ID Fans	9,080	9,630
SNCR	20	20
Baghouse	210	290
Econamine Auxiliaries	22,410	24,310
CO_2 Compression	47,960	52,090
Steam Turbine Auxiliaries	400	400
Condensate Pumps	560	530
CWP	8,850	9,900
Ground Water Pumps	700	720
Cooling Tower Fans	5,780	6,080
Air-Cooled Condenser Fans	3,620	3,320
Miscellaneous Balance of Plant[1]	2,000	2,000
Transformer Loss	2,300	2,350
TOTAL AUXILIARIES, kWe	**113,990**	**122,820**
NET POWER, kWe	**550,010**	**550,080**
Plant CF, %	85%	85%
Net Plant Efficiency, % (HHV)	27.3%	25.9%
Net Plant Heat Rate, kJ/kWh (Btu/kWh)	13,163 (12,476)	13,907 (13,182)
CONDENSER COOLING DUTY GJ/hr (10^6 Btu/hr)	**1,614 (1,529)**	**1,574 (1,492)**
CONSUMABLES		
As-Received Coal Feed, kg/hr (lb/hr)	363,450 (801,270)	497,052 (1,095,812)
Thermal Input, kWt[2]	2,011,075	2,125,054
Raw Water Withdrawal, m^3/min (gpm)	29.4 (7,762)	30.3 (7,996)
Raw Water Consumption, m^3/min (gpm)	21.6 (5,713)	21.6 (5,704)

[1] Includes plant control systems, lighting, HVAC, and miscellaneous low voltage loads
[2] Thermal input based on as-received HHV of coal

Environmental Performance

The environmental targets for emissions of Hg, NOx, SO_2, and PM were presented in Section 2.3. A summary of the plant air emissions for Cases S22B and L22B is presented in Exhibit 5-29.

Exhibit 5-29 CFB Cases with CO_2 Capture Air Emissions

	kg/GJ ($lb/10^6$ Btu)		Tonne/year (ton/year) 85% capacity factor		kg/MWh (lb/MWh)	
	S22B	**L22B**	**S22B**	**L22B**	**S22B**	**L22B**
SO_2	0.001 (0.002)	0.001 (0.002)	41 (45)	44 (48)	0.008 (0.020)	0.009 (0.020)
NO_X	0.030 (0.070)	0.030 (0.070)	1,622 (1,788)	1,714 (1,890)	0.328 (0.723)	0.342 (0.754)
Particulates	0.006 (0.0130)	0.006 (0.0130)	301 (332)	318 (351)	0.061 (0.134)	0.064 (0.140)
Hg	1.30E-7 (3.02E-7)	2.07E-7 (4.82E-7)	0.007 (0.008)	0.012 (0.013)	1.41E-6 (3.12E-6)	2.36E-6 (5.19E-6)
CO_2	9.1 (21.3)	9.4 (21.9)	493,129 (542,582)	535,549 (590,342)	100 (220)	107 (236)
CO_2 [1]					120 (265)	131 (288)

[1] CO_2 emissions based on net power instead of gross power

SO_2 emissions are controlled using in-bed limestone injection that achieves a removal efficiency of 94 percent. The waste is collected in the baghouse. The CO_2 capture system includes a SO_2 polishing unit that reduces SO_2 emission to a negligible level.

NOx emissions from CFB combustors are inherently low because of the relatively low bed operating temperature of 1,600°F NOx emissions are controlled to about 0.10-0.15 lb/MMBtu through the use of temperature controls, staging, and OFA. An SNCR unit then further reduces the NOx concentration by 46 percent to 0.07 lb/MMBtu.

Particulate emissions are controlled using a pulse jet fabric filter, which operates at an efficiency of 99.9 percent.

Co-benefit capture of mercury from a CFB with SNCR and a fabric filter is estimated in an EPA report to be 57 percent for either subbituminous or lignite coal. Given the lack of mercury data on utility-scale CFB's, the EPA estimate is used for co-benefit capture levels in all CFB cases. Mercury emissions can be reduced to approximately 25 percent of NSPS limits without the use of carbon injection, however carbon injection was included since it is currently the generally accepted practice.

Ninety percent of the CO_2 from the flue gas is captured in the Econamine system and compressed for sequestration.

The carbon balances for the two CO_2 capture CFB cases are shown in Exhibit 5-30. The carbon input to the plant consists of carbon in the air and limestone in addition to carbon in the coal. Carbon leaves the plant as CO_2 in the stack gas, unburned carbon in the ash and CO_2 product. The carbon conversion in the CFB is assumed to be 98.6 percent and 99.1 percent for PRB and lignite respectively:

Percent Sequestered = (Carbon in Product for Sequestration)/ (Carbon in Coal + Carbon in Limestone - Carbon in Ash) or

358,628 / (401,181 + 5,505 – 9,202) * 100 = 90.2 percent (S22B)

389,478 / (433,434 + 6,468 – 8,299) * 100 = 90.2 percent (L22B)

Exhibit 5-30 Cases S22B and L22B Carbon Balance

Carbon In, kg/hr (lb/hr)			Carbon Out, kg/hr (lb/hr)		
	S22B	**L22B**		**S22B**	**L22B**
Coal	181,973 (401,181)	196,602 (433,434)	**Ash**	4,174 (9,202)	3,764 (8,299)
Air (CO_2)	384 (846)	417 (918)	**Stack Gas**	18,075 (39,848)	19,629 (43,275)
Limestone	2,497 (5,505)	2.934 (6,468)	**CO_2 Product**	162,671 (358,628)	176,664 (389,478)
Activated Carbon	66 (146)	106 (223)			
Total	**184,920 (407,678)**	**200,058 (441,053)**	**Total**	**184,920 (407,678)**	**200,058 (441,053)**

Exhibit 5-31 shows the sulfur balances for the two capture CFB cases. Sulfur input comes solely from the sulfur in the coal. Sulfur output is the sulfur combined with lime in the ash, the SO_2 from the polishing scrubber, and the sulfur emitted in the stack gas. The sulfur exits the Econamine system in the form of sodium sulfite and HSS.

Exhibit 5-31 Cases S22B and L22B Sulfur Balance

Sulfur In, kg/hr (lb/hr)			Sulfur Out, kg/hr (lb/hr)		
	S22B	**L22B**		**S22B**	**L22B**
Coal	2,644 (5,829)	3,114 (6,864)	**Ash**	2,485 (5,479)	2,927 (6,452)
			Polishing Scrubber / Econamine FG+	156 (344)	184 (405)
			Stack Gas	3 (6)	3 (6)
Total	**2,644 (5,829)**	**3,114 (6,864)**	**Total**	**2,644 (5,829)**	**3,114 (6,864)**

Exhibit 5-32 and Exhibit 5-33 shows the overall water balances for the plants. Raw water withdrawal is obtained from groundwater (50 percent) and from municipal sources (50 percent). Water demand represents the total amount of water required for a particular process. Some water is recovered within the process and that water is re-used as internal recycle. Raw water withdrawal is the difference between water demand and internal recycle. Some water is discharged from the process to a permitted outfall. The difference between the withdrawal and discharge is the consumption.

Exhibit 5-32 Case S22B Water Balance

Water Use	Water Demand, m^3/min (gpm)	Internal Recycle, m^3/min (gpm)	Raw Water Withdrawal, m^3/min (gpm)	Process Water Discharge, m^3/min (gpm)	Raw Water Consumption, m^3/min (gpm)
Econamine	0.15 (39)	0 (0)	0.15 (39)	0 (0)	0.15 (39)
BFW Makeup	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cooling Tower Makeup	34.5 (9,110)	5.25 (1,387)	29.2 (7,723)	7.76 (2,049)	21.48 (5,674)
Total	**34.6 (9,148)**	**5.25 (1,387)**	**29.4 (7,762)**	**7.76 (2,049)**	**21.63 (5,713)**

Exhibit 5-33 Case L22B Water Balance

Water Use	Water Demand, m^3/min (gpm)	Internal Recycle, m^3/min (gpm)	Raw Water Withdrawal, m^3/min (gpm)	Process Water Discharge, m^3/min (gpm)	Raw Water Consumption, m^3/min (gpm)
Econamine	0.16 (42)	0 (0)	0.16 (42)	0 (0)	0.16 (42)
BFW Makeup	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cooling Tower Makeup	38.6 (10,190)	8.47 (2,236)	30.1 (7,953)	8.67 (2,292)	21.43 (5,662)
Total	**38.7 (10,232)**	**8.47 (2,236)**	**30.3 (7,996)**	**8.67 (2,292)**	**21.59 (5,704)**

Heat and Mass Balance Diagrams

Heat and mass balance diagrams are shown for the following subsystems in Exhibit 5-34 through Exhibit 5-37:

- Combustor and flue gas cleanup
- Steam and FW

Overall plant energy balances are provided in tabular form in Exhibit 5-38 for the two SC CFB cases. The sulfur exits the Econamine FG+ system in the form of sodium sulfite and HSS, but is shown as SO_2. The power out is the steam turbine power after generator losses.

Exhibit 5-34 Case S22B Combustor and Gas Cleanup System Heat and Mass Balance Diagram

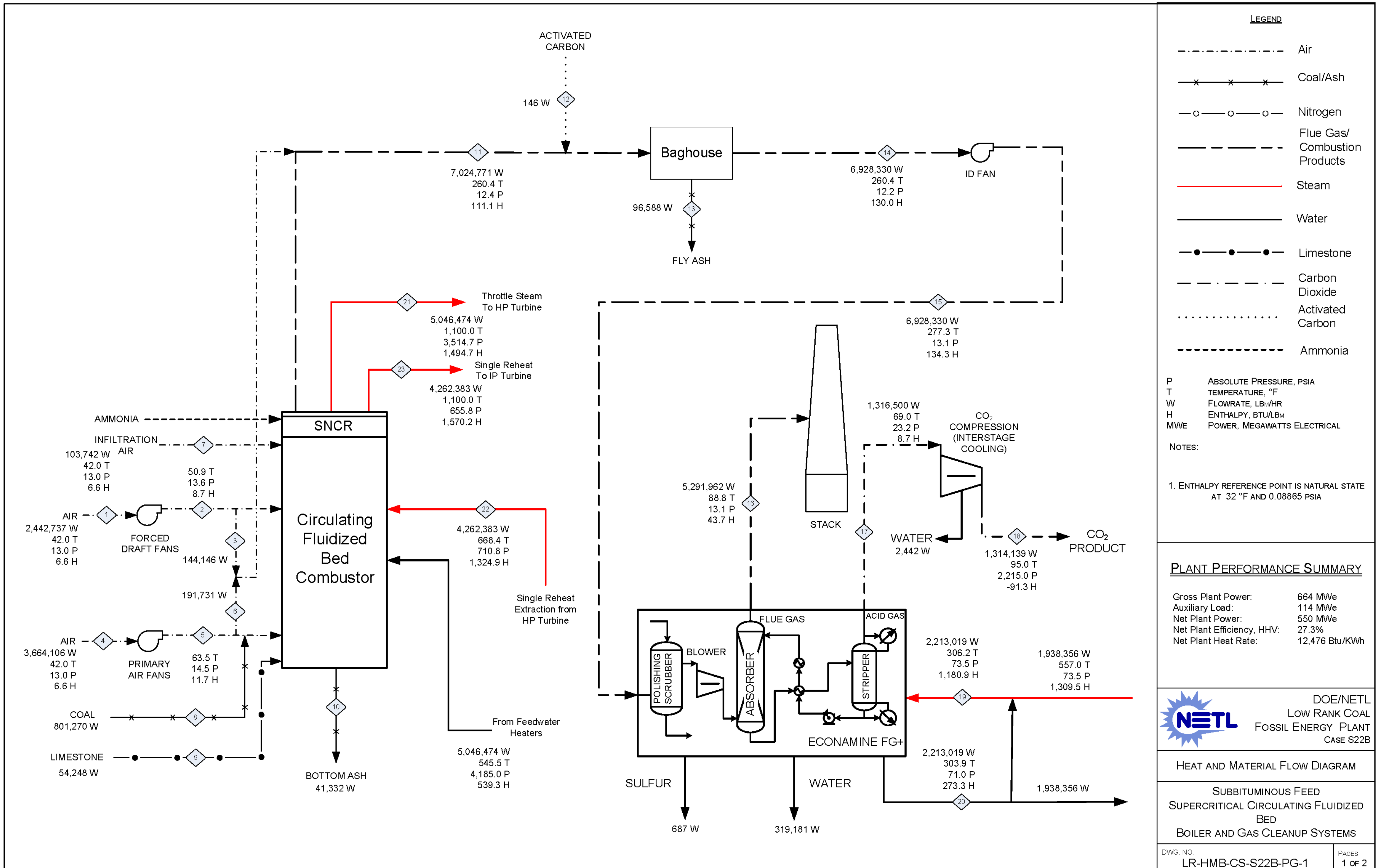

Exhibit 5-35 Case S22B Power Block System Heat and Mass Balance Diagram

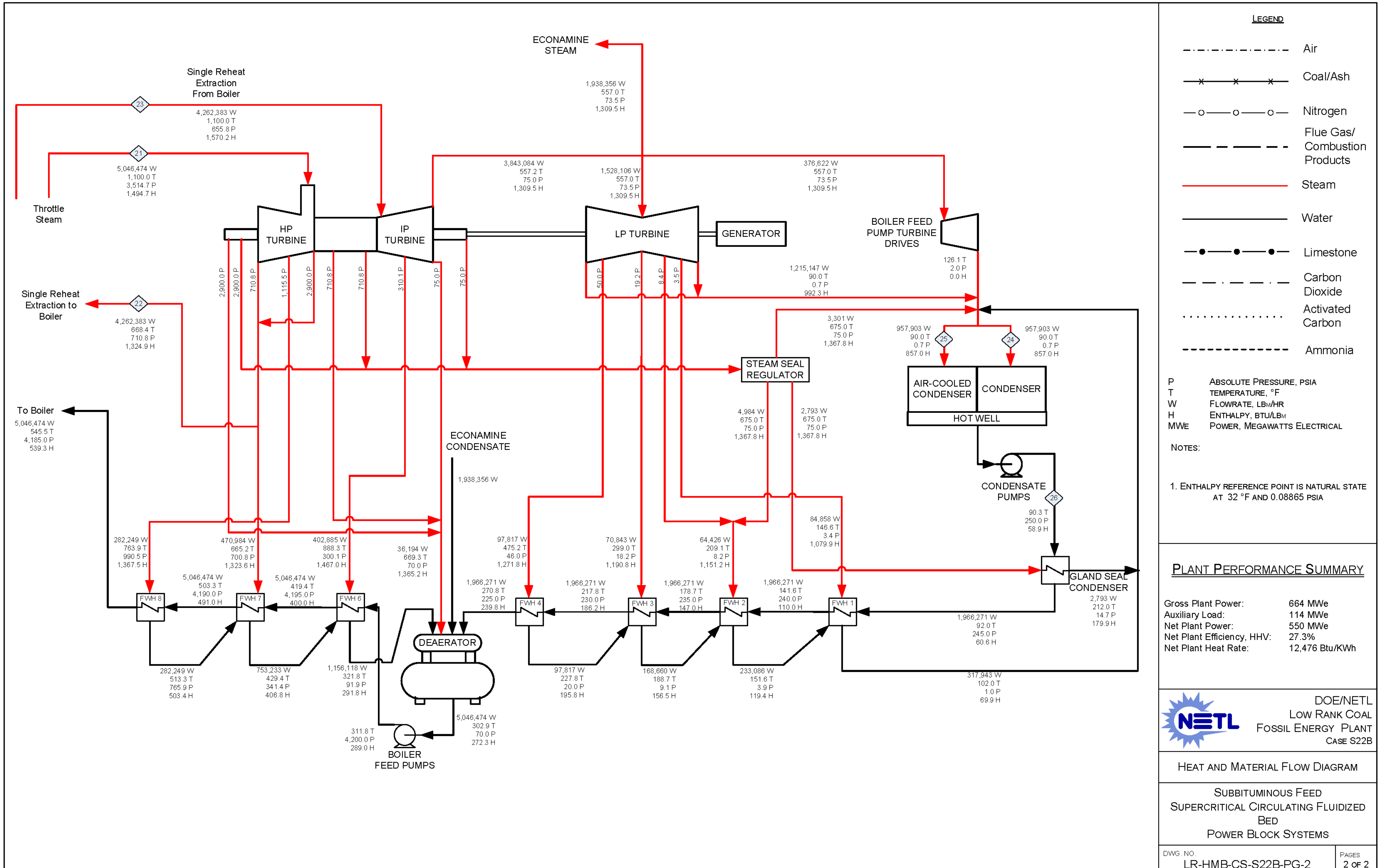

Exhibit 5-36 Case L22B Combustor and Gas Cleanup System Heat and Mass Balance Diagram

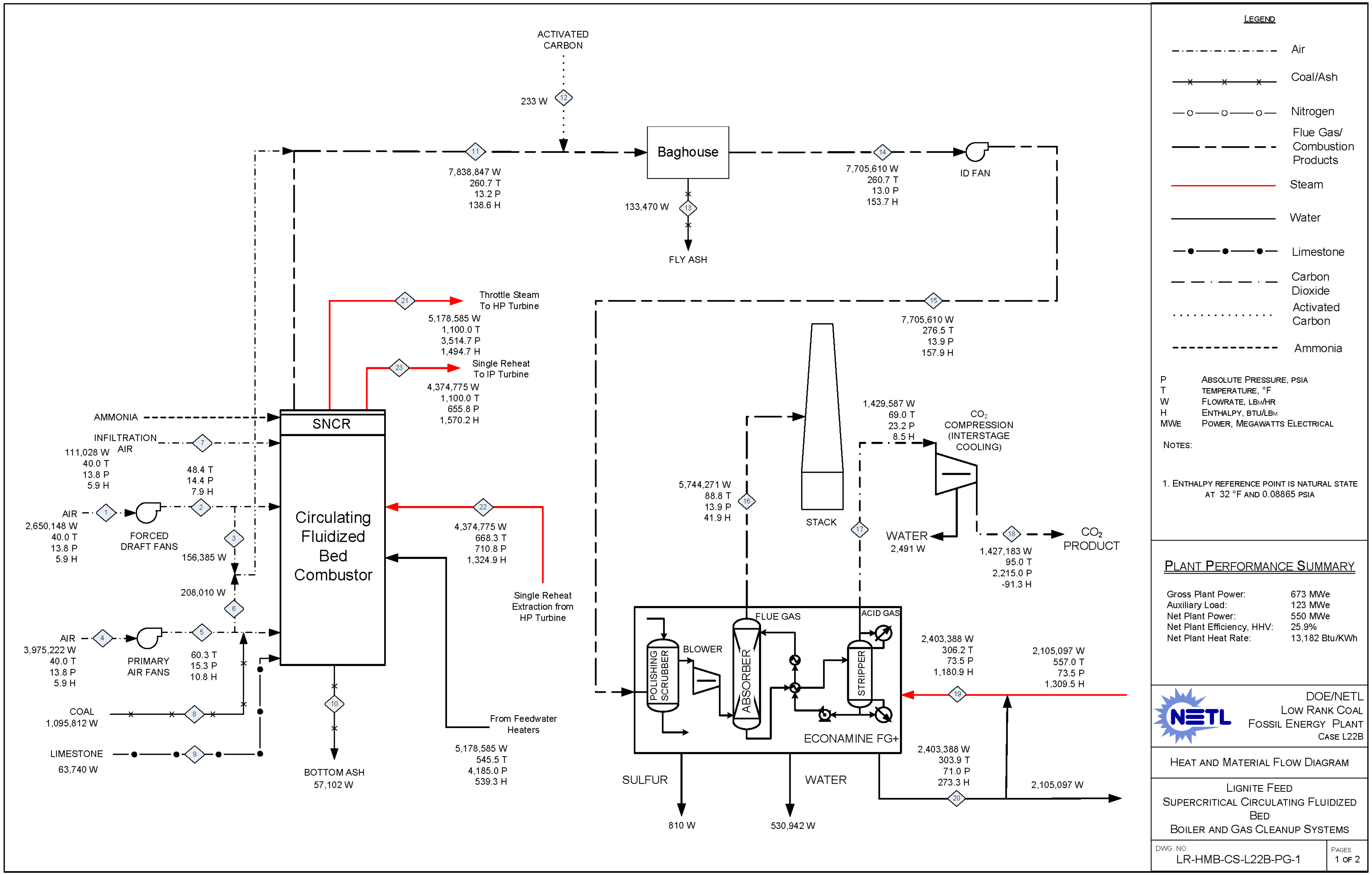

Exhibit 5-37 Case L22B Power Block System Heat and Mass Balance Diagram

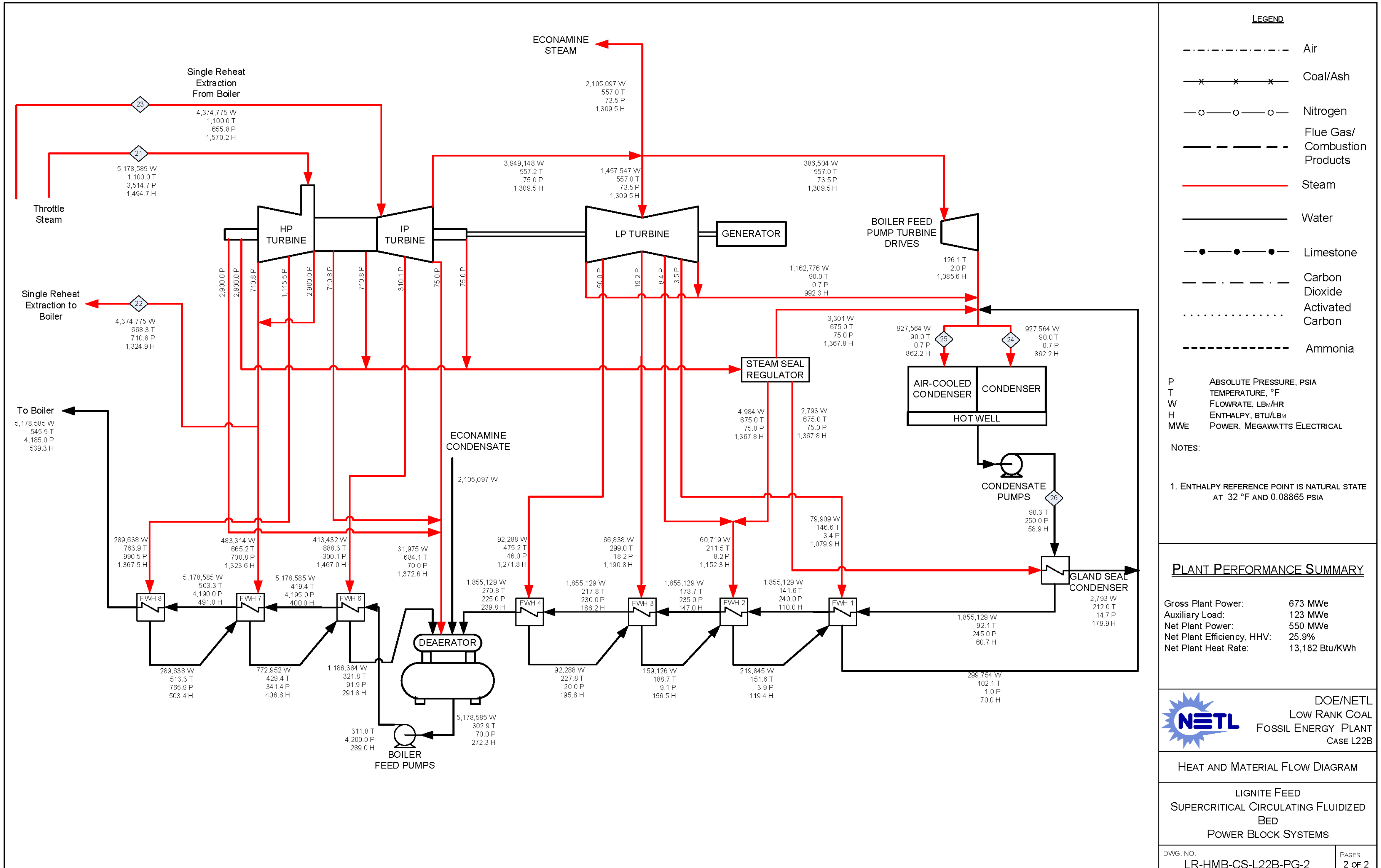

Exhibit 5-38 Cases S22B and L22B Energy Balance (0°C [32°F] Reference)

	HHV		Sensible + Latent		Power		Total	
	S22B	L22B	S22B	L22B	S22B	L22B	S22B	L22B
Heat In, GJ/hr (MMBtu/hr)								
Coal	7,240 (6,862)	7,650 (7,251)	3.7 (3.5)	4.4 (4.2)			7,244 (6,866)	7,655 (7,255)
Combustion Air			43.0 (40.7	42.0 (39.8)			43.0 (40.7)	42.0 (39.8)
Raw Water Makeup			40.9 (38.8)	33.7 (32.0)			40.9 (38.8)	33.7 (32.0)
Limestone			0.19 (0.18)	0.18 (0.17)			0.19 (0.18)	0.18 (0.17)
Auxiliary Power					410 (389)	442 (419)	410 (389)	442 (419)
Totals	**7,240 (6,862)**	**7,650 (7,251)**	**87.8 (83.3)**	**80.4 (76.2)**	**410 (389)**	**442 (419)**	**7,738 (7,334)**	**8,173 (7,746)**
Heat Out, GJ/hr (MMBtu/hr)								
Bottom Ash			16.6 (15.7)	21.7 (20.6)			16.6 (15.7)	21.7 (20.6)
Fly Ash + Sorbent			5.2 (4.9)	6.9 (6.5)			5.2 (4.9)	6.9 (6.5)
Flue Gas			244 (231)	254 (241)			244 (231)	254 (241)
Condenser			1,614 (1,529)	1,574 (1,492)			1,614 (1,529)	1,574 (1,492)
CO_2			-127 (-120)	-137 (-130)			-127 (-120)	-137 (-130)
Cooling Tower Blowdown			43.2 (41.0)	47.0 (44.5)			43.2 (41.0)	47.0 (44.5)
Econamine Losses			3,196 (3,029)	3,686 (3,494)			3,196 (3,029)	3,686 (3,494)
Process Losses*			356.0 (337.4)	297.8 (282.3)			356.0 (337.4)	297.8 (282.3)
Power					2,390 (2,266)	2,422 (2,296)	2,390 (2,266)	2,422 (2,296)
Totals	**0 (0)**	**0 (0)**	**5,348 (5,069)**	**5,750 (5,450)**	**2,390 (2,266)**	**2,422 (2,296)**	**7,738 (7,334)**	**8,173 (7,746)**

* Process losses including steam turbine, combustion reactions, and gas cooling are estimated to match the heat input to the plant.

5.2.5 CFB Cases with CO_2 Capture Equipment Lists

Major equipment items for SC CFB with CO_2 capture and using PRB or lignite coal are shown in the following tables. The equipment lists are not meant to be comprehensive, but rather representative. The accounts used in the equipment list correspond to the account numbers used in the cost estimates in Section 5.2.6. In general, the design conditions include a 10 percent contingency for flows and heat duties and a 21 percent contingency for heads on pumps and fans.

ACCOUNT 1 FUEL AND SORBENT HANDLING

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
1	Bottom Trestle Dumper and Receiving Hoppers	N/A	2(0)	181 tonne (200 ton)	181 tonne (200 ton)
2	Feeder	Belt	2(0)	572 tonne/hr (630 tph)	572 tonne/hr (630 tph)
3	Conveyor No. 1	Belt	1(0)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)
4	Transfer Tower No. 1	Enclosed	1(0)	N/A	N/A
5	Conveyor No. 2	Belt	1(0)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)
6	As-Received Coal Sampling System	Two-stage	1(0)	N/A	N/A
7	Stacker/Reclaimer	Traveling, linear	1(0)	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)
8	Reclaim Hopper	N/A	2(1)	73 tonne (80 ton)	100 tonne (110 ton)
9	Feeder	Vibratory	2(1)	299 tonne/hr (330 tph)	408 tonne/hr (450 tph)
10	Conveyor No. 3	Belt w/ tripper	1(0)	599 tonne/hr (660 tph)	816 tonne/hr (900 tph)
11	Crusher Tower	N/A	1(0)	N/A	N/A
12	Coal Surge Bin w/ Vent Filter	Dual outlet	2(0)	299 tonne (330 ton)	408 tonne (450 ton)
13	Crusher	Impactor reduction	2(0)	8cm x 0 - 3cm x 0 (3" x 0 - 3/4"x 0)	8cm x 0 - 3cm x 0 (3" x 0 – 3/4"x 0)
14	As-Fired Coal Sampling System	Swing hammer	1(1)	N/A	N/A
15	Conveyor No. 4	Belt w/tripper	1(0)	599 tonne/hr (660 tph)	816 tonne/hr (900 tph)
16	Transfer Tower No. 2	Enclosed	1(0)	N/A	N/A
17	Conveyor No. 5	Belt w/ tripper	1(0)	599 tonne/hr (660 tph)	816 tonne/hr (900 tph)
18	Coal Silo w/ Vent Filter and Slide Gates	Field erected	6(0)	635 tonne (700 ton)	907 tonne (1,000 ton)
19	Limestone Truck Unloading System	N/A	1(0)	36 tonne/hr (40 tph)	36 tonne/hr (40 tph)

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
20	Limestone Feeder	Belt	1(0)	100 tonne (110 ton)	118 tonne (130 ton)
21	Limestone Conveyor No. L1	Belt	1(0)	100 tonne/hr (110 tph)	118 tonne/hr (130 tph)
22	Limestone Reclaim Hopper	N/A	1(0)	18 tonne (20 ton)	27 tonne (30 ton)
23	Limestone Reclaim Feeder	Belt	1(0)	82 tonne/hr (90 tph)	100 tonne/hr (110 tph)
24	Limestone Conveyor No. L2	Belt	1(0)	82 tonne/hr (90 tph)	100 tonne/hr (110 tph)
25	Limestone Day Bin	w/ actuator	2(0)	327 tonne/hr (360 ton)	381 tonne/hr (420 ton)
26	Activated Carbon Storage Silo and Feeder System with Vent Filter	Shop assembled	1(0)	Silo - 54 tonne (60 ton) Feeder - 73 kg/hr (160 lb/hr)	Silo - 82 tonne (90 ton) Feeder - 118 kg/hr (260 lb/hr)

ACCOUNT 2 COAL AND SORBENT PREPARATION AND FEED

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
1	Coal Feeder	Gravimetric	6(0)	64 tonne/hr (70 tph)	91 tonne/hr (100 tph)
2	Limestone Bin Activator	N/A	1(1)	27 tonne/hr (30 tph)	32 tonne/hr (35 tph)
3	Limestone Weigh Feeder	N/A	1(1)	27 tonne/hr (30 tph)	32 tonne/hr (35 tph)
4	Limestone Rod Mill – Top size 1/16”	Field Erected	1(1)	27 tonne/hr (30 tph)	32 tonne/hr (35 tph)
5	Blower	Horizontal centrifugal	1(1)	44 m^3/min @ 0.2 MPa (1,550 scfm @ 24 psi)	60 m^3/min @ 0.2 MPa (2,130 scfm @ 24 psi)

ACCOUNT 3 FW AND MISCELLANEOUS SYSTEMS AND EQUIPMENT

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
1	Demineralized Water Storage Tank	Vertical, cylindrical, outdoor	2(0)	1,510,379 liters (399,000 gal)	1,578,233 liters (409,000 gal)
2	Condensate Pumps	Vertical canned	1(1)	16,656 lpm @ 213 m H_2O (4,400 gpm @ 700 ft H_2O)	15,899 lpm @ 213 m H_2O (4,200 gpm @ 700 ft H_2O)
3	Deaerator and Storage Tank	Horizontal spray type	1(0)	2,516,077 kg/hr (5,547,000 lb/hr), 5 min. tank	2,578,219 kg/hr (5,684,000 lb/hr), 5 min. tank

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
4	Boiler Feed Pump/Turbine	Barrel type, multi-stage, centrifugal	1(1)	42,397 lpm @ 3,505 m H_2O (11,200 gpm @ 11,500 ft H_2O)	43,154 lpm @ 3,505 m H_2O (11,400 gpm @ 11,500 ft H_2O)
5	Startup Boiler Feed Pump, Electric Motor Driven	Barrel type, multi-stage, centrifugal	1(0)	12,492 lpm @ 3,505 m H_2O (3,300 gpm @ 11,500 ft H_2O)	12,870 lpm @ 3,505 m H_2O (3,400 gpm @ 11,500 ft H_2O)
6	LP Feedwater Heater 1A/1B	Horizontal U-tube	2(0)	489,880 kg/hr (1,080,000 lb/hr)	476,272 kg/hr (1,050,000 lb/hr)
7	LP Feedwater Heater 2A/2B	Horizontal U-tube	2(0)	489,880 kg/hr (1,080,000 lb/hr)	476,272 kg/hr (1,050,000 lb/hr)
8	LP Feedwater Heater 3A/3B	Horizontal U-tube	2(0)	489,880 kg/hr (1,080,000 lb/hr)	476,272 kg/hr (1,050,000 lb/hr)
9	LP Feedwater Heater 4A/4B	Horizontal U-tube	2(0)	489,880 kg/hr (1,080,000 lb/hr)	476,272 kg/hr (1,050,000 lb/hr)
10	HP Feedwater Heater 6	Horizontal U-tube	1(0)	2,517,438 kg/hr (5,550,000 lb/hr)	2,576,405 kg/hr (5,680,000 lb/hr)
11	HP Feedwater Heater 7	Horizontal U-tube	1(0)	2,517,438 kg/hr (5,550,000 lb/hr)	2,576,405 kg/hr (5,680,000 lb/hr)
12	HP Feedwater heater 8	Horizontal U-tube	1(0)	2,517,438 kg/hr (5,550,000 lb/hr)	2,576,405 kg/hr (5,680,000 lb/hr)
13	Auxiliary Boiler	Shop fabricated, water tube	1(0)	18,144 kg/hr, 2.8 MPa, 343°C (40,000 lb/hr, 400 psig, 650°F)	18,144 kg/hr, 2.8 MPa, 343°C (40,000 lb/hr, 400 psig, 650°F)
14	Fuel Oil System	No. 2 fuel oil for light off	1(0)	1,135,624 liter (300,000 gal)	1,135,624 liter (300,000 gal)
15	Service Air Compressors	Flooded Screw	2(1)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)
16	Instrument Air Dryers	Duplex, regenerative	2(1)	28 m^3/min (1,000 scfm)	28 m^3/min (1,000 scfm)
17	Closed Cycle Cooling Heat Exchangers	Shell and tube	2(0)	53 GJ/hr (50 MMBtu/hr) each	53 GJ/hr (50 MMBtu/hr) each
18	Closed Cycle Cooling Water Pumps	Horizontal centrifugal	2(1)	20,820 lpm @ 30 m H_2O (5,500 gpm @ 100 ft H_2O)	20,820 lpm @ 30 m H_2O (5,500 gpm @ 100 ft H_2O)
19	Engine-Driven Fire Pump	Vertical turbine, diesel engine	1(1)	3,785 lpm @ 88 m H_2O (1,000 gpm @ 290 ft H_2O)	3,785 lpm @ 88 m H_2O (1,000 gpm @ 290 ft H_2O)
20	Fire Service Booster Pump	Two-stage horizontal centrifugal	1(1)	2,650 lpm @ 64 m H_2O (700 gpm @ 210 ft H_2O)	2,650 lpm @ 64 m H_2O (700 gpm @ 210 ft H_2O)

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
21	Raw Water Pumps	Stainless steel, single suction	2(1)	8,934 lpm @ 18 m H_2O (2,360 gpm @ 60 ft H_2O)	9,577 lpm @ 18 m H_2O (2,530 gpm @ 60 ft H_2O)
22	Ground Water Pumps	Stainless steel, single suction	2(1)	2,990 lpm @ 268 m H_2O (790 gpm @ 880 ft H_2O)	2,725 lpm @ 268 m H_2O (720 gpm @ 880 ft H_2O)
23	Filtered Water Pumps	Stainless steel, single suction	2(1)	492 lpm @ 49 m H_2O (130 gpm @ 160 ft H_2O)	530 lpm @ 49 m H_2O (140 gpm @ 160 ft H_2O)
24	Filtered Water Tank	Vertical, cylindrical	1(0)	480,747 liter (127,000 gal)	499,674 liter (132,000 gal)
25	Makeup Water Demineralizer	Multi-media filter, cartridge filter, RO membrane assembly, electrodeionization unit	1(1)	984 lpm (260 gpm)	1,022 lpm (270 gpm)
26	Liquid Waste Treatment System	--	1(0)	10 years, 24-hour storm	10 years, 24-hour storm

ACCOUNT 4 BOILER AND ACCESSORIES

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
1	Boiler	Atm. Pressure CFB, Once-thru Supercritical Boiler with Air Heater	1(0)	2,517,438 kg/hr steam @ 25.5 MPa/602°C/602°C (5,550,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)	2,576,405 kg/hr steam @ 25.5 MPa/602°C/602°C (5,680,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)
2	Primary Air Fan	Centrifugal	2(0)	911,721 kg/hr, 13,586 m^3/min @ 129 cm WG (2,010,000 lb/hr, 479,800 acfm @ 51 in. WG)	980,213 kg/hr, 13,703 m^3/min @ 129 cm WG (2,161,000 lb/hr, 483,900 acfm @ 51 in. WG)
3	Forced Draft Fan	Centrifugal	2(0)	607,814 kg/hr, 9,059 m^3/min @ 52 cm WG (1,340,000 lb/hr, 319,900 acfm @ 21 in. WG)	653,627 kg/hr, 9,135 m^3/min @ 52 cm WG (1,441,000 lb/hr, 322,600 acfm @ 21 in. WG)
4	Induced Draft Fan	Centrifugal	2(0)	1,724,105 kg/hr, 38,514 m^3/min @ 71 cm WG (3,801,000 lb/hr, 1,360,100 acfm @ 28 in. WG)	1,901,006 kg/hr, 40,434 m^3/min @ 71 cm WG (4,191,000 lb/hr, 1,427,900 acfm @ 28 in. WG)
5	SNCR Lance		1(1)	24 lpm (6 gpm)	25 lpm (7 gpm)

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
6	Dilution Air Blower	Centrifugal	2(1)	57 m^3/min @ 108 cm WG (2,000 acfm @ 42 in. WG)	59 m^3/min @ 108 cm WG (2,100 acfm @ 42 in. WG)
7	Ammonia Storage	Horizontal tank	5(0)	64,352 liter (17,000 gal)	68,137 liter (18,000 gal)
8	Ammonia Feed Pump	Centrifugal	2(1)	12 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)	13 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)

ACCOUNT 5 FLUE GAS CLEANUP

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
1	Fabric Filter	Single stage, high-ratio with pulse-jet online cleaning system, air-to-cloth ratio - 3.5 ft/min	2(0)	1,742,105 kg/hr (3,801,000 lb/hr) 99.9% efficiency	1,901,006 kg/hr (4,191,000 lb/hr) 99.9% efficiency
2	Carbon Injectors	---	1(0)	73 kg/hr (160 lb/hr)	118 kg/hr (260 lb/hr)

ACCOUNT 5B CARBON DIOXIDE RECOVERY

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
1	Econamine FG Plus	Amine-based CO_2 capture technology	2(0)	1,742,105 kg/h (3,801,000 lb/h) 21.1 wt % CO_2 concentration	1,901,006 kg/h (4,191,000 lb/h) 20.6 wt % CO_2 concentration
2	Econamine Condensate Pump	Centrifugal	1(1)	18,397 lpm @ 52 m H_2O (4,860 gpm @ 170 ft H_2O)	19,836 lpm @ 52 m H_2O (5,240 gpm @ 170 ft H_2O)
3	CO_2 Compressor	Integrally geared, multi-stage centrifugal	2(0)	327,062 kg/h @ 15.3 MPa (721,048 lb/h @ 2,215 psia)	353,030 kg/h @ 15.3 MPa (778,298 lb/h @ 2,215 psia)

ACCOUNT 6 COMBUSTION TURBINE/ACCESSORIES

N/A

ACCOUNT 7 DUCTING & STACK

Equipment No.	Description	Type	Operating Qty.	S22B Design Condition	L22B Design Condition
1	Stack	Reinforced concrete with FRP liner	1(0)	152 m (500 ft) high x 6.1 m (20 ft) diameter"	152 m (500 ft) high x 6.1 m (20 ft) diameter"

ACCOUNT 8 STEAM TURBINE GENERATOR AND AUXILIARIES

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
1	Steam Turbine	Commercially available advanced steam turbine	1(0)	699 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)	707 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)
2	Steam Turbine Generator	Hydrogen cooled, static excitation	1(0)	780 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	790 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase
3	Surface Condenser	Single pass, divided waterbox including vacuum pumps	1(0)	890 GJ/hr (840 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 9°C (48°F), Water temperature rise 11°C (20°F)	870 GJ/hr (820 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 8°C (47°F), Water temperature rise 11°C (20°F)
4	Air-cooled Condenser	---	1(0)	890 GJ/hr (840 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 6°C (42°F)	870 GJ/hr (820 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 4°C (40°F)

ACCOUNT 9 COOLING WATER SYSTEM

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
1	Circulating Water Pumps	Vertical, wet pit	2(1)	885,800 lpm @ 30 m (234,000 gpm @ 100 ft)	988,000 lpm @ 30 m (261,000 gpm @ 100 ft)
2	Cooling Tower	Evaporative, mechanical draft, multi-cell	1(0)	3°C (37°F) wet bulb / 9°C (48°F) CWT / 20°C (68°F) HWT / 4,948 GJ/hr (4,850 MMBtu/hr) heat duty	2°C (36°F) wet bulb / 8°C (47°F) CWT / 19°C (67°F) HWT / 5,497 GJ/hr (5,210 MMBtu/hr) heat duty

ACCOUNT 10 ASH/SPENT SORBENT RECOVERY AND HANDLING

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
1	Economizer Hopper (part of boiler scope of supply)	--	4(0)	--	--
2	Bottom Ash Hopper (part of boiler scope of supply)	--	2(0)	--	--
3	Clinker Grinder	--	1(1)	20.9 tonne/hr (23 tph)	28.1 tonne/hr (31 tph)
4	Pyrites Hopper (part of pulverizer scope of supply included with boiler)	--	6(0)	--	--
5	Hydroejectors	--	12(0)	--	--
6	Economizer /Pyrites Transfer Tank	--	1(0)	--	--
7	Ash Sluice Pumps	Vertical, wet pit	1(1)	833 lpm @ 17 m H_2O (220 gpm @ 56 ft H_2O)	1,136 lpm @ 17 m H_2O (300 gpm @ 56 ft H_2O)
8	Ash Seal Water Pumps	Vertical, wet pit	1(1)	7,571 lpm @ 9 m H_2O (2,000 gpm @ 28 ft H_2O)	7,571 lpm @ 9 m H_2O (2,000 gpm @ 28 ft H_2O)
9	Hydrobins	--	1(1)	833 lpm (220 gpm)	1,136 lpm (110 gpm)
10	Baghouse Hopper (part of baghouse scope of supply)	--	24(0)	--	--
11	Air Heater Hopper (part of boiler scope of supply)	--	10(0)	--	--
12	Air Blower	--	1(0)	44 m^3/min @ 0.2 MPa (1,550 scfm @ 24 psi)	60 m^3/min @ 0.2 MPa (2,130 scfm @ 24 psi)
13	Fly Ash Silo	Reinforced concrete	2(0)	2,900 tonne (3,200 ton)	3,990 tonne (4,400 ton)
14	Slide Gate Valves	--	2(0)	--	--
15	Unloader	--	1(0)	--	--
16	Telescoping Unloading Chute	--	1(0)	272 tonne/hr (300 tph)	372 tonne/hr (410 tph)

ACCOUNT 11 ACCESSORY ELECTRIC PLANT

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
1	STG Transformer	Oil-filled	1(0)	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz
2	Auxiliary Transformer	Oil-filled	1(1)	24 kV/4.16 kV, 124 MVA, 3-ph, 60 Hz	24 kV/4.16 kV, 133 MVA, 3-ph, 60 Hz
3	Low Voltage Transformer	Dry ventilated	1(1)	4.16 kV/480 V, 19 MVA, 3-ph, 60 Hz	4.16 kV/480 V, 20 MVA, 3-ph, 60 Hz

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
4	STG Isolated Phase Bus Duct and Tap Bus	Aluminum, self-cooled	1(0)	24 kV, 3-ph, 60 Hz	24 kV, 3-ph, 60 Hz
5	Medium Voltage Switchgear	Metal clad	1(1)	4.16 kV, 3-ph, 60 Hz	4.16 kV, 3-ph, 60 Hz
6	Low Voltage Switchgear	Metal enclosed	1(1)	480 V, 3-ph, 60 Hz	480 V, 3-ph, 60 Hz
7	Emergency Diesel Generator	Sized for emergency shutdown	1(0)	750 kW, 480 V, 3-ph, 60 Hz	750 kW, 480 V, 3-ph, 60 Hz

ACCOUNT 12 INSTRUMENTATION AND CONTROL

Equipment No.	Description	Type	Operating Qty. (Spares)	S22B Design Condition	L22B Design Condition
1	DCS - Main Control	Monitor/keyboard, Operator printer, Engineering printer	1(0)	Operator stations/printers and engineering stations/printers	Operator stations/printers and engineering stations/printers
2	DCS - Processor	Microprocessor with redundant input/output	1(0)	N/A	N/A
3	DCS - Data Highway	Fiber optic	1(0)	Fully redundant, 25% spare	Fully redundant, 25% spare

5.2.6 CFB Cases with CO_2 Capture – Cost Estimating

Costs Results

The cost estimating methodology was described previously in Section 2.6. The TPC summary organized by cost account, detailed breakdown of capital costs, owner's costs, and initial and annual O&M costs for the CFB PRB case with CO_2 capture (S22B) are shown in Exhibit 5-39, Exhibit 5-40, Exhibit 5-41, and Exhibit 5-42 respectively. The same data for the CFB lignite case with CO_2 capture (L22B) are shown in Exhibit 5-43, Exhibit 5-44, Exhibit 5-45, and Exhibit 5-46.

The estimated TOC of the CFB plant with CO_2 capture using PRB coal is $4,018/kW and using lignite coal is $4,307/kW. Project and process contingencies represent 10.1 and 5.8 percent respectively in both cases. The COE is 108.0 mills/kWh for the PRB case and 115.2 mills/kWh for the lignite case.

Exhibit 5-39 Case S22B Total Plant Cost Summary

Client: USDOE/NETL **Report Date:** 2009-Oct-15
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case S22B - 1x550 MWnet SuperCritical CFB w/ CO2 Capture
Plant Size: 550.0 MW,net **Estimate Type:** Conceptual **Cost Base (June)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING	$25,623	$6,783	$15,330	$0	$0	**$47,736**	$4,284	$0	$7,803	**$59,823**	$109
2	COAL & SORBENT PREP & FEED	$12,237	$883	$4,293	$0	$0	**$17,414**	$1,996	$0	$2,874	**$22,283**	$41
3	FEEDWATER & MISC. BOP SYSTEMS	$56,578	$0	$28,367	$0	$0	**$84,945**	$7,798	$0	$15,029	**$107,771**	$196
4	CFB BOILER											
4.1	CFB Boiler & Accesories	$346,916	$0	$126,165	$0	$0	**$473,081**	$45,902	$70,962	$58,994	**$648,939**	$1,180
4.2	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.3	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.4-4.9	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 4	**$346,916**	**$0**	**$126,165**	**$0**	**$0**	**$473,081**	**$45,902**	**$70,962**	**$58,994**	**$648,939**	**$1,180**
5	FLUE GAS CLEANUP	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
5B	CO2 REMOVAL & COMPRESSION	$244,840	$0	$74,586	$0	$0	**$319,426**	$30,541	$56,268	$81,247	**$487,482**	$886
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
6.2-6.9	Combustion Turbine Accessories	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 6	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
7.2-7.9	HRSG Accessories, Ductwork, and Stack	$20,327	$1,113	$13,768	$0	$0	**$35,209**	$3,225	$0	$5,052	**$43,486**	$79
	SUBTOTAL 7	**$20,327**	**$1,113**	**$13,768**	**$0**	**$0**	**$35,209**	**$3,225**	**$0**	**$5,052**	**$43,486**	**$79**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$56,847	$0	$7,545	$0	$0	**$64,391**	$6,171	$0	$7,056	**$77,619**	$141
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$54,623	$1,202	$21,278	$0	$0	**$77,102**	$7,158	$0	$14,402	**$98,663**	$179
	SUBTOTAL 8	**$111,469**	**$1,202**	**$28,822**	**$0**	**$0**	**$141,493**	**$13,329**	**$0**	**$21,459**	**$176,281**	**$321**
9	COOLING WATER SYSTEM	$18,876	$9,168	$16,922	$0	$0	**$44,967**	$4,232	$0	$6,637	**$55,836**	$102
10	ASH/SPENT SORBENT HANDLING SYS	$8,784	$279	$11,745	$0	$0	**$20,808**	$2,001	$0	$2,347	**$25,157**	$46
11	ACCESSORY ELECTRIC PLANT	$25,288	$10,700	$30,311	$0	$0	**$66,298**	$5,864	$0	$9,062	**$81,225**	$148
12	INSTRUMENTATION & CONTROL	$9,968	$0	$10,107	$0	$0	**$20,075**	$1,820	$1,004	$2,813	**$25,712**	$47
13	IMPROVEMENTS TO SITE	$3,323	$1,910	$6,697	$0	$0	**$11,931**	$1,177	$0	$2,622	**$15,729**	$29
14	BUILDINGS & STRUCTURES	$0	$25,694	$24,308	$0	$0	**$50,003**	$4,510	$0	$8,177	**$62,690**	$114
	TOTAL COST	**$884,229**	**$57,734**	**$391,423**	**$0**	**$0**	**$1,333,386**	**$126,679**	**$128,234**	**$224,115**	**$1,812,415**	**$3,295**

Exhibit 5-40 Case S22B Total Plant Cost Details

Client:	USDOE/NETL				**Report Date:**	2009-Oct-15	
Project:	Low Rank (Western) Coal Baseline Study						
	TOTAL PLANT COST SUMMARY						
Case:	Case S22B - 1x550 MWnet SuperCritical CFB w/ CO2 Capture						
Plant Size:	550.0	MW,net	**Estimate Type:**	Conceptual	**Cost Base (June)**	2007	($x1000)

Acct		Equipment	Material	Labor		Sales	Bare Erected	Eng'g CM	Contingencies		TOTAL PLANT COST	
No.	**Item/Description**	**Cost**	**Cost**	**Direct**	**Indirect**	**Tax**	**Cost $**	**H.O.& Fee**	**Process**	**Project**	**$**	**$/kW**
1	COAL & SORBENT HANDLING											
1.1	Coal Receive & Unload	$5,098	$0	$2,329	$0	$0	$7,427	$664	$0	$1,214	$9,304	$17
1.2	Coal Stackout & Reclaim	$6,589	$0	$1,493	$0	$0	$8,082	$707	$0	$1,318	$10,107	$18
1.3	Coal Conveyors	$6,126	$0	$1,477	$0	$0	$7,603	$666	$0	$1,240	$9,510	$17
1.4	Other Coal Handling	$1,603	$0	$342	$0	$0	$1,944	$170	$0	$317	$2,431	$4
1.5	Sorbent Receive & Unload	$162	$0	$49	$0	$0	$211	$19	$0	$34	$264	$0
1.6	Sorbent Stackout & Reclaim	$4,549	$0	$980	$0	$0	$5,529	$483	$0	$902	$6,913	$13
1.7	Sorbent Conveyors	$933	$202	$229	$0	$0	$1,364	$118	$0	$222	$1,704	$3
1.8	Other Sorbent Handling	$564	$132	$296	$0	$0	$991	$88	$0	$162	$1,241	$2
1.9	Coal & Sorbent Hnd.Foundations	$0	$6,450	$8,136	$0	$0	$14,586	$1,370	$0	$2,393	$18,349	$33
	SUBTOTAL 1.	**$25,623**	**$6,783**	**$15,330**	**$0**	**$0**	**$47,736**	**$4,284**	**$0**	**$7,803**	**$59,823**	**$109**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$2,999	$0	$584	$0	$0	$3,584	$312	$0	$584	$4,481	$8
2.2	Coal Conveyor to Storage	$7,679	$0	$1,676	$0	$0	$9,355	$818	$0	$1,526	$11,699	$21
2.3	Coal Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.4	Misc.Coal Prep & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.5	Sorbent Prep Equipment	$1,559	$0	$324	$0	$0	$1,883	$164	$0	$307	$2,354	$4
2.6	Sorbent Storage & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.7	Sorbent Injection System	$0	$0	$967	$0	$0	$967	$551	$0	$190	$1,708	$3
2.8	Booster Air Supply System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.9	Coal & Sorbent Feed Foundation	$0	$883	$742	$0	$0	$1,625	$151	$0	$266	$2,042	$4
	SUBTOTAL 2.	**$12,237**	**$883**	**$4,293**	**$0**	**$0**	**$17,414**	**$1,996**	**$0**	**$2,874**	**$22,283**	**$41**
3	FEEDWATER & MISC. BOP SYSTEMS											
3.1	FeedwaterSystem	$22,922	$0	$7,404	$0	$0	$30,326	$2,650	$0	$4,946	$37,922	$69
3.2	Water Makeup & Pretreating	$6,160	$0	$1,983	$0	$0	$8,143	$770	$0	$1,783	$10,695	$19
3.3	Other Feedwater Subsystems	$7,017	$0	$2,966	$0	$0	$9,983	$894	$0	$1,632	$12,509	$23
3.4	Service Water Systems	$1,208	$0	$657	$0	$0	$1,865	$175	$0	$408	$2,448	$4
3.5	Other Boiler Plant Systems	$11,887	$0	$11,735	$0	$0	$23,622	$2,244	$0	$3,880	$29,746	$54
3.6	FO Supply Sys & Nat Gas	$276	$0	$345	$0	$0	$621	$59	$0	$102	$782	$1
3.7	Waste Treatment Equipment	$4,176	$0	$2,381	$0	$0	$6,557	$638	$0	$1,439	$8,634	$16
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	$2,932	$0	$896	$0	$0	$3,828	$368	$0	$839	$5,036	$9
	SUBTOTAL 3.	**$56,578**	**$0**	**$28,367**	**$0**	**$0**	**$84,945**	**$7,798**	**$0**	**$15,029**	**$107,771**	**$196**

Exhibit 5-40 Case S22B Total Plant Cost Details (Continued)

Client:	USDOE/NETL		**Report Date:**	2009-Oct-15
Project:	Low Rank (Western) Coal Baseline Study			
	TOTAL PLANT COST SUMMARY			
Case:	Case S22B - 1x550 MWnet SuperCritical CFB w/ CO2 Capture			
Plant Size:	550.0 MW,net	**Estimate Type:** Conceptual	**Cost Base (June)** 2007	($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
4	CFB BOILER											
4.1	CFB Boiler & Accesories	$346,916	$0	$126,165	$0	$0	$473,081	$45,902	$70,962	$58,994	$648,939	$1,180
4.2	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.3	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.4	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.5	Primary Air System	$0	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.6	Secondary Air System	$0	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.8	Major Component Rigging	$0	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.9	CFB Foundations	$0	$0	w/14.1	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 4.	**$346,916**	**$0**	**$126,165**	**$0**	**$0**	**$473,081**	**$45,902**	**$70,962**	**$58,994**	**$648,939**	**$1,180**
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.2	Other FGD	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.3	Bag House & Accessories (Incl. w/ 4.1)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.4	Other Particulate Removal Materials	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.5	Gypsum Dewatering System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.6	Mercury Removal System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.9	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 5.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
5B	CO2 REMOVAL & COMPRESSION											
5B.1	CO2 Removal System	$215,848	$0	$65,491	$0	$0	$281,340	$26,898	$56,268	$72,901	$437,407	$795
5B.2	CO2 Compression & Drying	$28,992	$0	$9,095	$0	$0	$38,087	$3,643	$0	$8,346	$50,075	$91
	SUBTOTAL 5.	**$244,840**	**$0**	**$74,586**	**$0**	**$0**	**$319,426**	**$30,541**	**$56,268**	**$81,247**	**$487,482**	**$886**
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.2	Combustion Turbine Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.3	Compressed Air Piping	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.9	Combustion Turbine Foundations	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
7.2	HRSG Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7.3	Ductwork	$10,621	$0	$6,824	$0	$0	$17,445	$1,521	$0	$2,845	$21,811	$40
7.4	Stack	$9,706	$0	$5,680	$0	$0	$15,386	$1,481	$0	$1,687	$18,554	$34
7.9	Duct & Stack Foundations	$0	$1,113	$1,265	$0	$0	$2,378	$223	$0	$520	$3,121	$6
	SUBTOTAL 7.	**$20,327**	**$1,113**	**$13,768**	**$0**	**$0**	**$35,209**	**$3,225**	**$0**	**$5,052**	**$43,486**	**$79**

Exhibit 5-40 Case S22B Total Plant Cost Details (Continued)

Client:	USDOE/NETL	**Report Date:**	2009-Oct-15
Project:	Low Rank (Western) Coal Baseline Study		

TOTAL PLANT COST SUMMARY

Case:	Case S22B - 1x550 MWnet SuperCritical CFB w/ CO2 Capture						
Plant Size:	550.0 MW,net	**Estimate Type:**	Conceptual	**Cost Base (June)**	2007	($x1000)	

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$56,847	$0	$7,545	$0	$0	$64,391	$6,171	$0	$7,056	$77,619	$141
8.2	Turbine Plant Auxiliaries	$383	$0	$820	$0	$0	$1,203	$118	$0	$132	$1,453	$3
8.3a	Condenser & Auxiliaries	$3,219	$0	$2,033	$0	$0	$5,252	$506	$0	$576	$6,334	$12
8.3b	Air Cooled Condenser	$29,498	$0	$5,914	$0	$0	$35,412	$3,541	$0	$7,791	$46,744	$85
8.4	Steam Piping	$21,523	$0	$10,612	$0	$0	$32,135	$2,700	$0	$5,225	$40,060	$73
8.9	TG Foundations	$0	$1,202	$1,898	$0	$0	$3,100	$293	$0	$679	$4,072	$7
	SUBTOTAL 8.	**$111,469**	**$1,202**	**$28,822**	**$0**	**$0**	**$141,493**	**$13,329**	**$0**	**$21,459**	**$176,281**	**$321**
9	COOLING WATER SYSTEM											
9.1	Cooling Towers	$14,072	$0	$4,382	$0	$0	$18,454	$1,765	$0	$2,022	$22,240	$40
9.2	Circulating Water Pumps	$2,927	$0	$216	$0	$0	$3,144	$266	$0	$341	$3,750	$7
9.3	Circ.Water System Auxiliaries	$726	$0	$97	$0	$0	$823	$78	$0	$90	$991	$2
9.4	Circ.Water Piping	$0	$5,755	$5,577	$0	$0	$11,332	$1,061	$0	$1,859	$14,251	$26
9.5	Make-up Water System	$576	$0	$769	$0	$0	$1,345	$129	$0	$221	$1,695	$3
9.6	Component Cooling Water Sys	$575	$0	$457	$0	$0	$1,032	$98	$0	$170	$1,300	$2
9.9	Circ.Water System Foundations& Structures	$0	$3,414	$5,424	$0	$0	$8,837	$836	$0	$1,935	$11,608	$21
	SUBTOTAL 9.	**$18,876**	**$9,168**	**$16,922**	**$0**	**$0**	**$44,967**	**$4,232**	**$0**	**$6,637**	**$55,836**	**$102**
10	ASH/SPENT SORBENT HANDLING SYS											
10.1	Ash Coolers	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.2	Cyclone Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.3	HGCU Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.4	High Temperature Ash Piping	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.5	Other Ash Recovery Equipment	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.6	Ash Storage Silos	$1,175	$0	$3,622	$0	$0	$4,797	$471	$0	$527	$5,795	$11
10.7	Ash Transport & Feed Equipment	$7,609	$0	$7,794	$0	$0	$15,403	$1,473	$0	$1,688	$18,563	$34
10.8	Misc. Ash Handling Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.9	Ash/Spent Sorbent Foundation	$0	$279	$329	$0	$0	$608	$57	$0	$133	$798	$1
	SUBTOTAL 10.	**$8,784**	**$279**	**$11,745**	**$0**	**$0**	**$20,808**	**$2,001**	**$0**	**$2,347**	**$25,157**	**$46**

Exhibit 5-40 Case S22B Total Plant Cost Details (Continued)

Client:	USDOE/NETL	**Report Date:**	2009-Oct-15
Project:	Low Rank (Western) Coal Baseline Study		
	TOTAL PLANT COST SUMMARY		
Case:	Case S22B - 1x550 MWnet SuperCritical CFB w/ CO2 Capture		
Plant Size:	550.0 MW,net **Estimate Type:** Conceptual	**Cost Base (June)**	2007 ($x1000)

Acct		Equipment	Material	Labor		Sales	Bare Erected	Eng'g CM	Contingencies		TOTAL PLANT COST	
No.	Item/Description	Cost	Cost	Direct	Indirect	Tax	Cost $	H.O.& Fee	Process	Project	$	$/kW
11	ACCESSORY ELECTRIC PLANT											
11.1	Generator Equipment	$1,729	$0	$281	$0	$0	$2,010	$186	$0	$165	$2,361	$4
11.2	Station Service Equipment	$4,978	$0	$1,635	$0	$0	$6,613	$618	$0	$542	$7,774	$14
11.3	Switchgear & Motor Control	$5,723	$0	$973	$0	$0	$6,695	$621	$0	$732	$8,047	$15
11.4	Conduit & Cable Tray	$0	$3,588	$12,405	$0	$0	$15,993	$1,548	$0	$2,631	$20,173	$37
11.5	Wire & Cable	$0	$6,770	$13,069	$0	$0	$19,839	$1,671	$0	$3,227	$24,737	$45
11.6	Protective Equipment	$262	$0	$892	$0	$0	$1,154	$113	$0	$127	$1,393	$3
11.7	Standby Equipment	$1,361	$0	$31	$0	$0	$1,392	$128	$0	$152	$1,672	$3
11.8	Main Power Transformers	$11,236	$0	$187	$0	$0	$11,423	$866	$0	$1,229	$13,518	$25
11.9	Electrical Foundations	$0	$342	$838	$0	$0	$1,180	$113	$0	$259	$1,552	$3
	SUBTOTAL 11.	**$25,288**	**$10,700**	**$30,311**	**$0**	**$0**	**$66,298**	**$5,864**	**$0**	**$9,062**	**$81,225**	**$148**
12	INSTRUMENTATION & CONTROL											
12.1	PC Control Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.2	Combustion Turbine Control	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
12.3	Steam Turbine Control	w/8.1	$0	w/8.1	$0	$0	$0	$0	$0	$0	$0	$0
12.4	Other Major Component Control	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.5	Signal Processing Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.6	Control Boards,Panels & Racks	$513	$0	$307	$0	$0	$821	$78	$41	$141	$1,080	$2
12.7	Distributed Control System Equipment	$5,181	$0	$906	$0	$0	$6,087	$564	$304	$696	$7,651	$14
12.8	Instrument Wiring & Tubing	$2,809	$0	$5,572	$0	$0	$8,381	$714	$419	$1,427	$10,941	$20
12.9	Other I & C Equipment	$1,464	$0	$3,323	$0	$0	$4,787	$464	$239	$549	$6,039	$11
	SUBTOTAL 12.	**$9,968**	**$0**	**$10,107**	**$0**	**$0**	**$20,075**	**$1,820**	**$1,004**	**$2,813**	**$25,712**	**$47**
13	IMPROVEMENTS TO SITE											
13.1	Site Preparation	$0	$56	$1,117	$0	$0	$1,173	$116	$0	$258	$1,547	$3
13.2	Site Improvements	$0	$1,854	$2,303	$0	$0	$4,158	$410	$0	$914	$5,481	$10
13.3	Site Facilities	$3,323	$0	$3,277	$0	$0	$6,600	$651	$0	$1,450	$8,701	$16
	SUBTOTAL 13.	**$3,323**	**$1,910**	**$6,697**	**$0**	**$0**	**$11,931**	**$1,177**	**$0**	**$2,622**	**$15,729**	**$29**
14	BUILDINGS & STRUCTURES											
14.1	Boiler Building	$0	$9,741	$8,567	$0	$0	$18,308	$1,645	$0	$2,993	$22,946	$42
14.2	Turbine Building	$0	$12,816	$11,944	$0	$0	$24,760	$2,232	$0	$4,049	$31,041	$56
14.3	Administration Building	$0	$644	$681	$0	$0	$1,324	$120	$0	$217	$1,661	$3
14.4	Circulation Water Pumphouse	$0	$295	$235	$0	$0	$530	$47	$0	$87	$664	$1
14.5	Water Treatment Buildings	$0	$781	$712	$0	$0	$1,494	$134	$0	$244	$1,872	$3
14.6	Machine Shop	$0	$430	$289	$0	$0	$720	$64	$0	$118	$901	$2
14.7	Warehouse	$0	$292	$293	$0	$0	$584	$53	$0	$96	$733	$1
14.8	Other Buildings & Structures	$0	$238	$203	$0	$0	$441	$40	$0	$72	$553	$1
14.9	Waste Treating Building & Str.	$0	$456	$1,385	$0	$0	$1,841	$175	$0	$302	$2,319	$4
	SUBTOTAL 14.	**$0**	**$25,694**	**$24,308**	**$0**	**$0**	**$50,003**	**$4,510**	**$0**	**$8,177**	**$62,690**	**$114**
	TOTAL COST	**$884,229**	**$57,734**	**$391,423**	**$0**	**$0**	**$1,333,386**	**$126,679**	**$128,234**	**$224,115**	**$1,812,415**	**$3,295**

Exhibit 5-41 Case S22B Owner's Costs

Owner's Costs	$x1000	$/kW
Preproduction Costs		
6 Months Fixed O&M	$11,499	$21
1 Month Variable O&M	$3,808	$7
25% of 1 Months Fuel Cost at 100% CF	$1,113	$2
2% of TPC	$36,248	$66
Total	**$52,667**	**$96**
Inventory Capital		
60 day supply of fuel and consumables at 100% CF	$11,216	$20
0.5% of TPC (spare parts)	$9,062	$16
Total	**$20,278**	**$37**
Initial Cost for Catalyst and Chemicals	**$2,707**	**$5**
Land	**$900**	**$2**
Other Owner's Costs	**$271,862**	**$494**
Financing Costs	**$48,935**	**$89**
Total Owner's Costs	**$397,350**	**$722**
Total Overnight Cost (TOC)	**$2,209,764**	**$4,018**
TASC Multiplier	1.140	
Total As-Spent Cost (TASC)	**$2,519,131**	**$4,580**

Exhibit 5-42 Case S22B Initial and Annual O&M Costs

INITIAL & ANNUAL O&M EXPENSES					Cost Base (June)	2007
Case S22B - 1x550 MWnet SuperCritical CFB w/ CO2 Capture					Heat Rate-net(Btu/kWh):	12,476
					MWe-net:	550
					Capacity Factor: (%):	85
OPERATING & MAINTENANCE LABOR						
Operating Labor						
Operating Labor Rate(base):	34.65	$/hour				
Operating Labor Burden:	30.00	% of base				
Labor O-H Charge Rate:	25.00	% of labor				
			Total			
Skilled Operator	2.0		2.0			
Operator	11.3		11.3			
Foreman	1.0		1.0			
Lab Tech's, etc.	2.0		2.0			
TOTAL-O.J.'s	16.3		16.3			
					Annual Cost	Annual Unit Cost
					$	$/kW-net
Annual Operating Labor Cost					$6,444,907	$11.718
Maintenance Labor Cost					$11,953,029	$21.732
Administrative & Support Labor					$4,599,484	$8.363
Property Taxes and Insurance					$36,248,290	$65.905
TOTAL FIXED OPERATING COSTS					**$59,245,711**	**$107.718**
VARIABLE OPERATING COSTS						
						$/kWh-net
Maintenance Material Cost					**$17,929,544**	**$0.00438**
Consumables	Consumption Initial	Consumption /Day	Unit Cost	Initial Cost		
Water(/1000 gallons)	0	6,110	1.08	**$0**	**$2,050,454**	**$0.00050**
Chemicals						
MU & WT Chem. (lbs)	0	29,576	0.17	$0	$1,588,081	$0.00039
Limestone (ton)	0	650	21.63	$0	$4,362,695	$0.00107
Carbon (Mercury Removal) lb	0	0	1.05	$0	$0	$0.00000
MEA Solvent (ton)	1,116	1.58	2,249.89	$2,510,872	$1,102,882	$0.00027
NaOH (tons)	72	9.41	433.68	$31,225	$1,266,103	$0.00031
H2SO4 (tons)	75	7.51	138.78	$10,409	$323,354	$0.00008
Corrosion Inhibitor	0	0	0.00	$154,398	$7,352	$0.00000
Activated Carbon (lb)	0	1,887	1.05	$0	$614,814	$0.00015
Ammonia (19% NH3) ton	0	32	129.80	$0	$1,288,665	$0.00031
Subtotal Chemicals				**$2,706,903**	**$10,553,948**	**$0.00258**
Other						
Supplemental Fuel(MBtu)	0	0	0.00	$0	$0	$0.00000
SCR Catalyst(m3)	w/equip.	0.00	5,775.94	$0	$0	$0.00000
Emission Penalties	0	0	0.00	$0	$0	$0.00000
Subtotal Other				**$0**	**$0**	**$0.00000**
Waste Disposal						
Fly Ash (ton)	0	1,155	16.23	$0	$5,814,084	$0.00142
Bottom Ash (ton)	0	495	16.23	$0	$2,491,776	$0.00061
Subtotal-Waste Disposal				**$0**	**$8,305,860**	**$0.00203**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	$0.00000
Subtotal By-Products				**$0**	**$0**	**$0.00000**
TOTAL VARIABLE OPERATING COSTS				**$2,706,903**	**$38,839,805**	**$0.00948**
Fuel(ton)	0	9,593	15.22	**$0**	**$45,296,673**	**$0.01106**

Exhibit 5-43 Case L22B Total Plant Cost Summary

Client: USDOE/NETL   **Report Date:** 2009-Oct-15
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case L22B - 1x550 MWnet SuperCritical CFB w/ CO2 Capture
Plant Size: 550.1 MW,net   **Estimate Type:** Conceptual   **Cost Base (June)** 2007   ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING	$30,352	$8,171	$18,383	$0	$0	**$56,906**	$5,109	$0	$9,302	**$71,317**	$130
2	COAL & SORBENT PREP & FEED	$14,804	$1,082	$5,107	$0	$0	**$20,992**	$2,361	$0	$3,461	**$26,814**	$49
3	FEEDWATER & MISC. BOP SYSTEMS	$62,312	$0	$31,443	$0	$0	**$93,755**	$8,602	$0	$16,518	**$118,875**	$216
4	CFB BOILER											
4.1	CFB Boiler & Accesories	$379,938	$0	$141,045	$0	$0	**$520,983**	$50,556	$78,148	$64,969	**$714,656**	$1,299
4.2	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.3	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.4-4.9	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 4	**$379,938**	**$0**	**$141,045**	**$0**	**$0**	**$520,983**	**$50,556**	**$78,148**	**$64,969**	**$714,656**	**$1,299**
5	FLUE GAS CLEANUP	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
5B	CO2 REMOVAL & COMPRESSION	$256,554	$0	$78,155	$0	$0	**$334,709**	$32,002	$58,967	$85,136	**$510,814**	$929
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
6.2-6.9	Combustion Turbine Accessories	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 6	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
7.2-7.9	HRSG Accessories, Ductwork, and Stack	$20,511	$1,123	$13,893	$0	$0	**$35,527**	$3,254	$0	$5,097	**$43,878**	$80
	SUBTOTAL 7	**$20,511**	**$1,123**	**$13,893**	**$0**	**$0**	**$35,527**	**$3,254**	**$0**	**$5,097**	**$43,878**	**$80**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$57,269	$0	$7,605	$0	$0	**$64,874**	$6,217	$0	$7,109	**$78,200**	$142
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$54,457	$1,212	$21,408	$0	$0	**$77,077**	$7,147	$0	$14,367	**$98,591**	$179
	SUBTOTAL 8	**$111,726**	**$1,212**	**$29,013**	**$0**	**$0**	**$141,951**	**$13,364**	**$0**	**$21,476**	**$176,791**	**$321**
9	COOLING WATER SYSTEM	$20,295	$9,780	$18,083	$0	$0	**$48,159**	$4,533	$0	$7,098	**$59,789**	$109
10	ASH/SPENT SORBENT HANDLING SYS	$10,478	$333	$14,009	$0	$0	**$24,821**	$2,386	$0	$2,800	**$30,007**	$55
11	ACCESSORY ELECTRIC PLANT	$25,888	$11,026	$31,224	$0	$0	**$68,138**	$6,027	$0	$9,319	**$83,484**	$152
12	INSTRUMENTATION & CONTROL	$9,936	$0	$10,075	$0	$0	**$20,011**	$1,814	$1,001	$2,804	**$25,629**	$47
13	IMPROVEMENTS TO SITE	$3,342	$1,921	$6,736	$0	$0	**$12,000**	$1,184	$0	$2,637	**$15,820**	$29
14	BUILDINGS & STRUCTURES	$0	$26,965	$25,436	$0	$0	**$52,401**	$4,726	$0	$8,569	**$65,697**	$119
	TOTAL COST	**$946,136**	**$61,615**	**$422,601**	**$0**	**$0**	**$1,430,352**	**$135,919**	**$138,115**	**$239,185**	**$1,943,572**	**$3,533**

Exhibit 5-44 Case L22B Total Plant Cost Details

Client: USDOE/NETL **Report Date:** 2009-Oct-15
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case L22B - 1x550 MWnet SuperCritical CFB w/ CO2 Capture
Plant Size: 550.1 MW,net **Estimate Type:** Conceptual **Cost Base (June)** 2007 ($x1000)

Acct		Equipment	Material	Labor		Sales	Bare Erected	Eng'g CM	Contingencies		TOTAL PLANT COST	
No.	Item/Description	Cost	Cost	Direct	Indirect	Tax	Cost $	H.O.& Fee	Process	Project	$	$/kW
1	COAL & SORBENT HANDLING											
1.1	Coal Receive & Unload	$6,167	$0	$2,817	$0	$0	$8,984	$803	$0	$1,468	$11,255	$20
1.2	Coal Stackout & Reclaim	$7,970	$0	$1,806	$0	$0	$9,776	$855	$0	$1,595	$12,226	$22
1.3	Coal Conveyors	$7,410	$0	$1,787	$0	$0	$9,197	$806	$0	$1,500	$11,503	$21
1.4	Other Coal Handling	$1,939	$0	$413	$0	$0	$2,352	$205	$0	$384	$2,941	$5
1.5	Sorbent Receive & Unload	$179	$0	$54	$0	$0	$233	$21	$0	$38	$292	$1
1.6	Sorbent Stackout & Reclaim	$5,032	$0	$1,084	$0	$0	$6,116	$534	$0	$997	$7,647	$14
1.7	Sorbent Conveyors	$1,032	$223	$253	$0	$0	$1,508	$130	$0	$246	$1,885	$3
1.8	Other Sorbent Handling	$623	$146	$327	$0	$0	$1,096	$97	$0	$179	$1,372	$2
1.9	Coal & Sorbent Hnd.Foundations	$0	$7,802	$9,842	$0	$0	$17,643	$1,657	$0	$2,895	$22,196	$40
	SUBTOTAL 1.	**$30,352**	**$8,171**	**$18,383**	**$0**	**$0**	**$56,906**	**$5,109**	**$0**	**$9,302**	**$71,317**	**$130**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$3,673	$0	$716	$0	$0	$4,389	$383	$0	$716	$5,487	$10
2.2	Coal Conveyor to Storage	$9,404	$0	$2,053	$0	$0	$11,456	$1,001	$0	$1,869	$14,327	$26
2.3	Coal Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.4	Misc.Coal Prep & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.5	Sorbent Prep Equipment	$1,727	$0	$359	$0	$0	$2,086	$182	$0	$340	$2,608	$5
2.6	Sorbent Storage & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.7	Sorbent Injection System	$0	$0	$1,072	$0	$0	$1,072	$610	$0	$210	$1,892	$3
2.8	Booster Air Supply System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.9	Coal & Sorbent Feed Foundation	$0	$1,082	$908	$0	$0	$1,990	$184	$0	$326	$2,501	$5
	SUBTOTAL 2.	**$14,804**	**$1,082**	**$5,107**	**$0**	**$0**	**$20,992**	**$2,361**	**$0**	**$3,461**	**$26,814**	**$49**
3	FEEDWATER & MISC. BOP SYSTEMS											
3.1	FeedwaterSystem	$25,613	$0	$8,273	$0	$0	$33,886	$2,961	$0	$5,527	$42,374	$77
3.2	Water Makeup & Pretreating	$6,468	$0	$2,082	$0	$0	$8,549	$808	$0	$1,872	$11,229	$20
3.3	Other Feedwater Subsystems	$7,841	$0	$3,314	$0	$0	$11,155	$999	$0	$1,823	$13,977	$25
3.4	Service Water Systems	$1,268	$0	$690	$0	$0	$1,958	$184	$0	$428	$2,570	$5
3.5	Other Boiler Plant Systems	$13,506	$0	$13,335	$0	$0	$26,841	$2,550	$0	$4,409	$33,799	$61
3.6	FO Supply Sys & Nat Gas	$278	$0	$348	$0	$0	$626	$59	$0	$103	$788	$1
3.7	Waste Treatment Equipment	$4,385	$0	$2,500	$0	$0	$6,884	$670	$0	$1,511	$9,065	$16
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	$2,954	$0	$902	$0	$0	$3,856	$371	$0	$845	$5,072	$9
	SUBTOTAL 3.	**$62,312**	**$0**	**$31,443**	**$0**	**$0**	**$93,755**	**$8,602**	**$0**	**$16,518**	**$118,875**	**$216**

Exhibit 5-44 Case L22B Total Plant Cost Details (Continued)

Client:	USDOE/NETL	Report Date:	2009-Oct-15
Project:	Low Rank (Western) Coal Baseline Study		
	TOTAL PLANT COST SUMMARY		
Case:	Case L22B - 1x550 MWnet SuperCritical CFB w/ CO2 Capture		
Plant Size:	550.1 MW,net Estimate Type: Conceptual	Cost Base (June)	2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
4	CFB BOILER											
4.1	CFB Boiler & Accesories	$379,938	$0	$141,045	$0	$0	$520,983	$50,556	$78,148	$64,969	$714,656	$1,299
4.2	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.3	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.4	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.5	Primary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.6	Secondary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.8	Major Component Rigging	$0	w/4.1	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.9	CFB Foundations	$0	w/14.1	w/14.1	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 4.	**$379,938**	**$0**	**$141,045**	**$0**	**$0**	**$520,983**	**$50,556**	**$78,148**	**$64,969**	**$714,656**	**$1,299**
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.2	Other FGD	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.3	Bag House & Accessories (Incl. w/4.1)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.4	Other Particulate Removal Materials	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.5	Gypsum Dewatering System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.6	Mercury Removal System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.9	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 5.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
5B	CO2 REMOVAL & COMPRESSION											
5B.1	CO2 Removal System	$226,202	$0	$68,633	$0	$0	$294,835	$28,189	$58,967	$76,398	$458,389	$833
5B.2	CO2 Compression & Drying	$30,352	$0	$9,522	$0	$0	$39,874	$3,813	$0	$8,737	$52,424	$95
	SUBTOTAL 5.	**$256,554**	**$0**	**$78,155**	**$0**	**$0**	**$334,709**	**$32,002**	**$58,967**	**$85,136**	**$510,814**	**$929**
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.2	Combustion Turbine Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.3	Compressed Air Piping	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.9	Combustion Turbine Foundations	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
7.2	HRSG Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7.3	Ductwork	$10,717	$0	$6,886	$0	$0	$17,602	$1,535	$0	$2,871	$22,008	$40
7.4	Stack	$9,794	$0	$5,731	$0	$0	$15,525	$1,495	$0	$1,702	$18,721	$34
7.9	Duct & Stack Foundations	$0	$1,123	$1,276	$0	$0	$2,400	$225	$0	$525	$3,149	$6
	SUBTOTAL 7.	**$20,511**	**$1,123**	**$13,893**	**$0**	**$0**	**$35,527**	**$3,254**	**$0**	**$5,097**	**$43,878**	**$80**

Exhibit 5-44 Case L22B Total Plant Cost Details (Continued)

Client:	USDOE/NETL	**Report Date:**	2009-Oct-15
Project:	Low Rank (Western) Coal Baseline Study		
	TOTAL PLANT COST SUMMARY		
Case:	Case L22B - 1x550 MWnet SuperCritical CFB w/ CO2 Capture		
Plant Size:	550.1 MW,net **Estimate Type:** Conceptual	**Cost Base (June)**	2007 ($x1000)

Acct		Equipment	Material	Labor		Sales	Bare Erected	Eng'g CM	Contingencies		TOTAL PLANT COST	
No.	**Item/Description**	**Cost**	**Cost**	**Direct**	**Indirect**	**Tax**	**Cost $**	**H.O.& Fee**	**Process**	**Project**	**$**	**$/kW**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$57,269	$0	$7,605	$0	$0	$64,874	$6,217	$0	$7,109	$78,200	$142
8.2	Turbine Plant Auxiliaries	$386	$0	$828	$0	$0	$1,214	$119	$0	$133	$1,466	$3
8.3a	Condenser & Auxiliaries	$3,165	$0	$2,051	$0	$0	$5,216	$503	$0	$572	$6,291	$11
8.3b	Air Cooled Condenser	$29,004	$0	$5,815	$0	$0	$34,819	$3,482	$0	$7,660	$45,961	$84
8.4	Steam Piping	$21,902	$0	$10,799	$0	$0	$32,700	$2,747	$0	$5,317	$40,765	$74
8.9	TG Foundations	$0	$1,212	$1,915	$0	$0	$3,127	$296	$0	$685	$4,108	$7
	SUBTOTAL 8.	**$111,726**	**$1,212**	**$29,013**	**$0**	**$0**	**$141,951**	**$13,364**	**$0**	**$21,476**	**$176,791**	**$321**
9	COOLING WATER SYSTEM											
9.1	Cooling Towers	$15,147	$0	$4,717	$0	$0	$19,863	$1,900	$0	$2,176	$23,939	$44
9.2	Circulating Water Pumps	$3,160	$0	$241	$0	$0	$3,401	$287	$0	$369	$4,057	$7
9.3	Circ.Water System Auxiliaries	$775	$0	$103	$0	$0	$878	$83	$0	$96	$1,058	$2
9.4	Circ.Water Piping	$0	$6,144	$5,955	$0	$0	$12,099	$1,133	$0	$1,985	$15,216	$28
9.5	Make-up Water System	$600	$0	$802	$0	$0	$1,401	$134	$0	$230	$1,766	$3
9.6	Component Cooling Water Sys	$614	$0	$488	$0	$0	$1,102	$105	$0	$181	$1,388	$3
9.9	Circ.Water System Foundations& Structures	$0	$3,636	$5,777	$0	$0	$9,413	$891	$0	$2,061	$12,364	$22
	SUBTOTAL 9.	**$20,295**	**$9,780**	**$18,083**	**$0**	**$0**	**$48,159**	**$4,533**	**$0**	**$7,098**	**$59,789**	**$109**
10	ASH/SPENT SORBENT HANDLING SYS											
10.1	Ash Coolers	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.2	Cyclone Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.3	HGCU Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.4	High Temperature Ash Piping	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.5	Other Ash Recovery Equipment	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.6	Ash Storage Silos	$1,402	$0	$4,320	$0	$0	$5,722	$562	$0	$628	$6,912	$13
10.7	Ash Transport & Feed Equipment	$9,076	$0	$9,297	$0	$0	$18,373	$1,757	$0	$2,013	$22,143	$40
10.8	Misc. Ash Handling Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.9	Ash/Spent Sorbent Foundation	$0	$333	$392	$0	$0	$726	$68	$0	$159	$952	$2
	SUBTOTAL 10.	**$10,478**	**$333**	**$14,009**	**$0**	**$0**	**$24,821**	**$2,386**	**$0**	**$2,800**	**$30,007**	**$55**

Exhibit 5-44 Case L22B Total Plant Cost Details (Continued)

Client: USDOE/NETL — Report Date: 2009-Oct-15
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case L22B - 1x550 MWnet SuperCritical CFB w/ CO2 Capture
Plant Size: 550.1 MW,net — Estimate Type: Conceptual — Cost Base (June) 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT											
11.1	Generator Equipment	$1,741	$0	$283	$0	$0	$2,024	$188	$0	$166	$2,377	$4
11.2	Station Service Equipment	$5,133	$0	$1,687	$0	$0	$6,820	$637	$0	$559	$8,016	$15
11.3	Switchgear & Motor Control	$5,901	$0	$1,003	$0	$0	$6,904	$640	$0	$754	$8,299	$15
11.4	Conduit & Cable Tray	$0	$3,700	$12,793	$0	$0	$16,493	$1,597	$0	$2,713	$20,803	$38
11.5	Wire & Cable	$0	$6,982	$13,477	$0	$0	$20,459	$1,724	$0	$3,327	$25,510	$46
11.6	Protective Equipment	$269	$0	$916	$0	$0	$1,185	$116	$0	$130	$1,431	$3
11.7	Standby Equipment	$1,369	$0	$31	$0	$0	$1,400	$128	$0	$153	$1,681	$3
11.8	Main Power Transformers	$11,474	$0	$189	$0	$0	$11,662	$884	$0	$1,255	$13,801	$25
11.9	Electrical Foundations	$0	$345	$845	$0	$0	$1,190	$114	$0	$261	$1,565	$3
	SUBTOTAL 11.	**$25,888**	**$11,026**	**$31,224**	**$0**	**$0**	**$68,138**	**$6,027**	**$0**	**$9,319**	**$83,484**	**$152**
12	INSTRUMENTATION & CONTROL											
12.1	PC Control Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.2	Combustion Turbine Control	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
12.3	Steam Turbine Control	w/8.1	$0	w/8.1	$0	$0	$0	$0	$0	$0	$0	$0
12.4	Other Major Component Control	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.5	Signal Processing Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.6	Control Boards,Panels & Racks	$512	$0	$306	$0	$0	$818	$77	$41	$140	$1,077	$2
12.7	Distributed Control System Equipment	$5,165	$0	$903	$0	$0	$6,067	$562	$303	$693	$7,627	$14
12.8	Instrument Wiring & Tubing	$2,800	$0	$5,554	$0	$0	$8,354	$712	$418	$1,423	$10,906	$20
12.9	Other I & C Equipment	$1,459	$0	$3,312	$0	$0	$4,771	$463	$239	$547	$6,020	$11
	SUBTOTAL 12.	**$9,936**	**$0**	**$10,075**	**$0**	**$0**	**$20,011**	**$1,814**	**$1,001**	**$2,804**	**$25,629**	**$47**
13	IMPROVEMENTS TO SITE											
13.1	Site Preparation	$0	$56	$1,123	$0	$0	$1,180	$117	$0	$259	$1,556	$3
13.2	Site Improvements	$0	$1,865	$2,316	$0	$0	$4,182	$412	$0	$919	$5,513	$10
13.3	Site Facilities	$3,342	$0	$3,296	$0	$0	$6,638	$654	$0	$1,459	$8,751	$16
	SUBTOTAL 13.	**$3,342**	**$1,921**	**$6,736**	**$0**	**$0**	**$12,000**	**$1,184**	**$0**	**$2,637**	**$15,820**	**$29**
14	BUILDINGS & STRUCTURES											
14.1	Boiler Building	$0	$10,870	$9,559	$0	$0	$20,429	$1,836	$0	$3,340	$25,605	$47
14.2	Turbine Building	$0	$12,909	$12,032	$0	$0	$24,941	$2,248	$0	$4,078	$31,267	$57
14.3	Administration Building	$0	$646	$683	$0	$0	$1,330	$121	$0	$218	$1,668	$3
14.4	Circulation Water Pumphouse	$0	$297	$236	$0	$0	$532	$48	$0	$87	$667	$1
14.5	Water Treatment Buildings	$0	$820	$748	$0	$0	$1,568	$141	$0	$256	$1,966	$4
14.6	Machine Shop	$0	$432	$290	$0	$0	$723	$64	$0	$118	$905	$2
14.7	Warehouse	$0	$293	$294	$0	$0	$587	$53	$0	$96	$736	$1
14.8	Other Buildings & Structures	$0	$239	$204	$0	$0	$443	$40	$0	$72	$555	$1
14.9	Waste Treating Building & Str.	$0	$458	$1,391	$0	$0	$1,849	$176	$0	$304	$2,328	$4
	SUBTOTAL 14.	**$0**	**$26,965**	**$25,436**	**$0**	**$0**	**$52,401**	**$4,726**	**$0**	**$8,569**	**$65,697**	**$119**
	TOTAL COST	**$946,136**	**$61,615**	**$422,601**	**$0**	**$0**	**$1,430,352**	**$135,919**	**$138,115**	**$239,185**	**$1,943,572**	**$3,533**

Exhibit 5-45 Case L22B Owner's Costs

Owner's Costs	$x1000	$/kW
Preproduction Costs		
6 Months Fixed O&M	$12,100	$22
1 Month Variable O&M	$4,398	$8
25% of 1 Months Fuel Cost at 100% CF	$1,092	$2
2% of TPC	$38,871	$71
Total	**$56,462**	**$103**
Inventory Capital		
60 day supply of fuel and consumables at 100% CF	$11,338	$21
0.5% of TPC (spare parts)	$9,718	$18
Total	**$21,055**	**$38**
Initial Cost for Catalyst and Chemicals	**$2,934**	**$5**
Land	**$900**	**$2**
Other Owner's Costs	**$291,536**	**$530**
Financing Costs	**$52,476**	**$95**
Total Owner's Costs	**$425,364**	**$773**
Total Overnight Cost (TOC)	**$2,368,935**	**$4,307**
TASC Multiplier	1.140	
Total As-Spent Cost (TASC)	**$2,700,586**	**$4,909**

Exhibit 5-46 Case L22B Initial and Annual O&M Costs

INITIAL & ANNUAL O&M EXPENSES					Cost Base (June)	2007
Case L22B - 1x550 MWnet SuperCritical CFB w/ CO2 Capture					Heat Rate-net(Btu/kWh):	13,182
					MWe-net:	550
					Capacity Factor: (%):	85
OPERATING & MAINTENANCE LABOR						
Operating Labor						
Operating Labor Rate(base):	34.65	$/hour				
Operating Labor Burden:	30.00	% of base				
Labor O-H Charge Rate:	25.00	% of labor				
			Total			
Skilled Operator	2.0		2.0			
Operator	11.3		11.3			
Foreman	1.0		1.0			
	2.0		2.0			
TOTAL-O.J.'s	16.3		16.3			
					Annual Cost	Annual Unit Cost
					$	$/kW-net
Annual Operating Labor Cost					$6,444,907	$11.716
Maintenance Labor Cost					$12,915,367	$23.479
Administrative & Support Labor					$4,840,069	$8.799
Property Taxes and Insurance					$38,871,432	$70.665
TOTAL FIXED OPERATING COSTS					**$63,071,775**	**$114.659**
VARIABLE OPERATING COSTS						
						$/kWh-net
Maintenance Material Cost					**$19,373,051**	**$0.00473**
Consumables	Consumption Initial	/Day	Unit Cost	Initial Cost		
Water(/1000 gallons)	0	6,525	1.08	**$0**	**$2,189,724**	**$0.00053**
Chemicals						
MU & WT Chem.(lb)	0	31,583	0.17	$0	$1,695,828	$0.00041
Limestone (ton)	0	761	21.63	$0	$5,107,691	$0.00125
Carbon (Mercury Removal) (lb)	0	0	1.05	$0	$0	$0.00000
MEA Solvent (ton)	1,204	1.71	2,249.89	$2,708,862	$1,193,626	$0.00029
NaOH (tons)	110	11.15	433.68	$47,705	$1,500,218	$0.00037
H2SO4 (tons)	81	8.11	138.78	$11,241	$349,188	$0.00009
Corrosion Inhibitor	0	0	0.00	$166,453	$7,926	$0.00000
Activated Carbon(lb)	0	2,037	1.05	$0	$663,686	$0.00016
Ammonia (19% NH3) ton	0	34	129.80	$0	$1,369,207	$0.00033
Subtotal Chemicals				**$2,934,261**	**$11,887,370**	**$0.00290**
Other						
Supplemental Fuel(MBtu)	0	0	0.00	$0	$0	$0.00000
SCR Catalyst(m3)	w/equip.	0.00	5,775.94	$0	$0	$0.00000
Emission Penalties	0	0	0.00	$0	$0	$0.00000
Subtotal Other				**$0**	**$0**	**$0.00000**
Waste Disposal						
Flyash (ton)	0	1,587	16.23	$0	$7,988,716	$0.00195
Bottom Ash(ton)	0	680	16.23	$0	$3,423,037	$0.00084
Subtotal-Waste Disposal				**$0**	**$11,411,754**	**$0.00279**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	$0.00000
Subtotal By-Products				**$0**	**$0**	**$0.00000**
TOTAL VARIABLE OPERATING COSTS				**$2,934,261**	**$44,861,899**	**$0.01095**
Fuel(ton)	0	13,039	10.92	**$0**	**$44,176,287**	**$0.01079**

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6. SENSITIVITY TO BITUMINOUS BASELINE CASE 12A MEA SYSTEM

Studies of PC plants with post combustion capture of CO_2 for the 2010 NETL Bituminous and Low Rank Baselines Studies are based on a performance and cost estimate for an Econamine CO_2 capture system provided by Fluor in 2005 [42]. A recent Fluor publication [43] indicates that Fluor has improved the Econamine system. The improved system is able to achieve a reboiler steam requirement of 1,270 Btu/lb_{CO2} as compared to the 1,530 Btu/lb_{CO2} used in the baseline studies. Fluor also indicated concurrent reductions in auxiliary electrical power requirements and capital costs.

The Fluor publication [43] indicates the improvements in performance and cost are enabled by an improved solvent formulation with an MEA concentration greater than 30 percent and improved corrosion inhibitors. Fluor states that the improved solvent results in increased reaction rates enabling less absorber packing and lower capital cost. Also, the higher solvent carrying capacity results in lower solvent circulation rates, lower steam requirements, and lower capital cost of solvent circulation equipment.

Cost and performance data on the improved system were unavailable directly from Fluor. Using a commercial acid gas removal software package, the CO_2 removal process was simulated using higher MEA concentrations, but the confidence in the generated results and any associated equipment sizing or costing changes were not adequate for use in this analysis. Therefore, a sensitivity analysis was performed using published data from Fluor and best engineering judgment to estimate the impact of an improved MEA CO_2 capture system on the performance and cost of a SC boiler firing bituminous coal. It is expected that the relative difference observed in the bituminous coal cases would be the same if applied to PRB or NDL coal cases.

6.1 BASIS FOR SENSITIVITY ANALYSIS

The sensitivity analysis was performed on Case 12 of the Bituminous Baseline Study. This case used a SC PC plant burning bituminous (Illinois #6) coal at International Standards Organization (ISO) conditions. The sensitivity case was labeled Case 12A.

It was assumed, based on qualitative statements by Fluor, that the improved performance and reduced cost were achieved by increasing the MEA concentration from 30 wt% to 36 wt%. It was further assumed that Econamine reboiler steam requirements, power requirements and capital cost were inversely proportional to the increase in MEA concentration. The reboiler steam requirement and electrical auxiliary requirements were reduced by the ratio of 30/36 = 0.83. The Econamine plant capital cost was scaled using two factors – the first based on the amount of CO_2 captured to the 0.6 power and the second based on the ratio of the increased solvent concentration to the 0.7 power.

The Aspen model for Case 12 was modified for the reduced reboiler steam requirement and calculations were adjusted for the reduced auxiliary power requirement. Performance and cost estimates for Case 12A as compared to Case 12 are included in the following sections.

6.2 PERFORMANCE

The BFD, Stream Tables and Performance Summary for Case 12A are shown in Exhibit 6-1, Exhibit 6-2, and Exhibit 6-3. The Performance Summary from Case 12 is also included in

Exhibit 6-3 for comparison. The net plant efficiency for Case 12A is 29.8% compared to 28.4% for Case 12.

The auxiliary power for Case 12A is 104 MW compared to 113 MW for Case 12. Gross output was reduced for Case 12A by 9 MW to maintain a 550 MW net output for both cases. The reduction in auxiliary power results primarily from reductions in the Econamine and CO_2 compressor auxiliaries with minor reductions in most other auxiliary loads resulting from a slightly smaller gross plant size.

Exhibit 6-1 Bituminous Baseline Case 12A MEA Sensitivity Process Flow Diagram

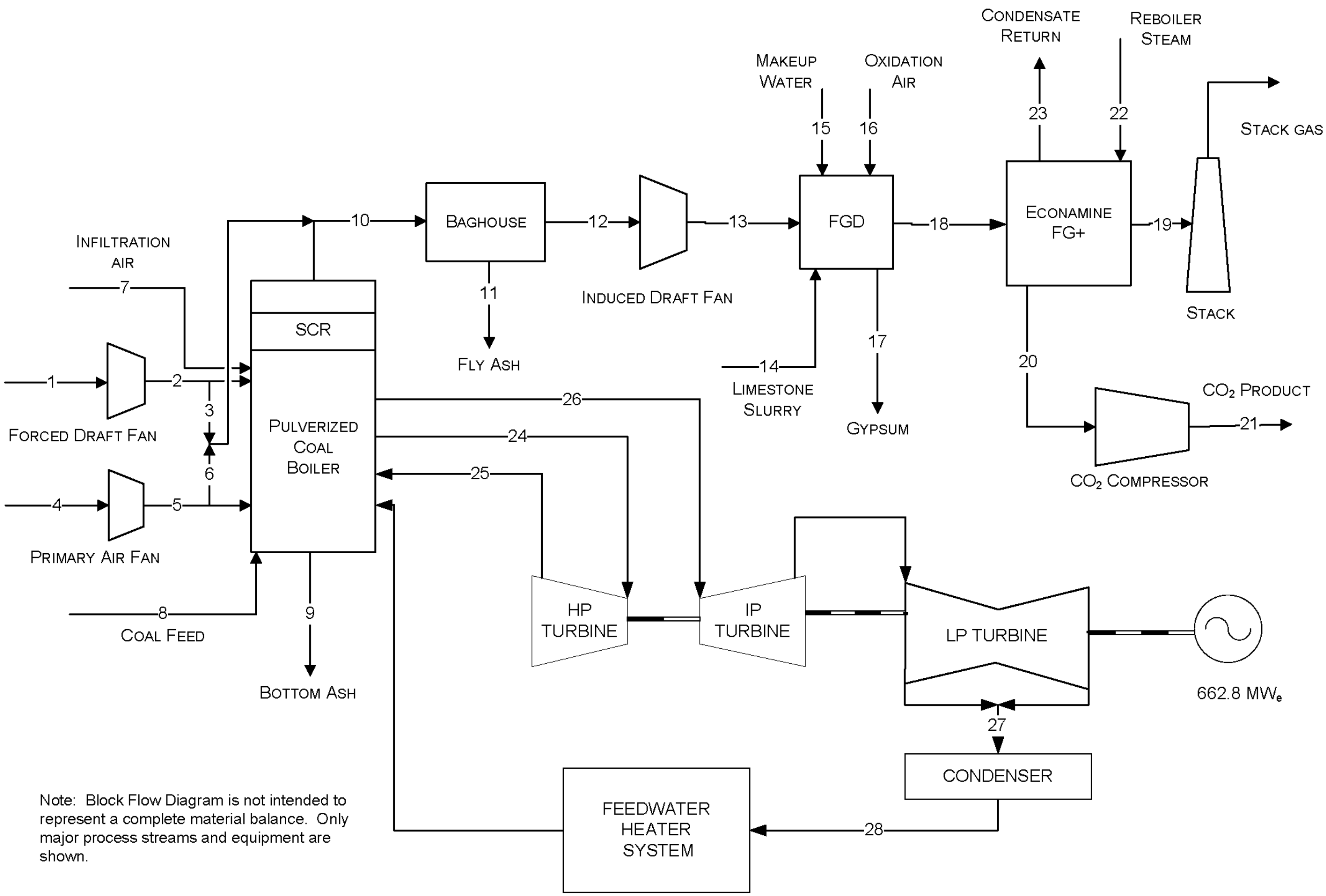


Exhibit 6-2 Bituminous Baseline Case 12A Stream Table, SC Unit with CO_2 Capture

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
V-L Mole Fraction														
Ar	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0000	0.0000	0.0087	0.0000	0.0087	0.0087	0.0000
CO_2	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0000	0.0000	0.1450	0.0000	0.1450	0.1450	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0099	0.0099	0.0099	0.0099	0.0099	0.0099	0.0099	0.0000	0.0000	0.0870	0.0000	0.0870	0.0870	1.0000
N_2	0.7732	0.7732	0.7732	0.7732	0.7732	0.7732	0.7732	0.0000	0.0000	0.7324	0.0000	0.7324	0.7324	0.0000
O_2	0.2074	0.2074	0.2074	0.2074	0.2074	0.2074	0.2074	0.0000	0.0000	0.0247	0.0000	0.0247	0.0247	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0021	0.0000	0.0021	0.0021	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	0.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	63,824	63,824	1,899	19,606	19,606	2,690	1,475	0	0	89,812	0	89,812	89,812	3,349
V-L Flowrate (kg/hr)	1,841,767	1,841,767	54,801	565,772	565,772	77,613	42,569	0	0	2,671,294	0	2,671,294	2,671,294	60,334
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	244,938	4,750	19,001	19,001	0	0	24,719
Temperature (°C)	15	19	19	15	25	25	15	15	15	169	15	169	182	15
Pressure (MPa, abs)	0.10	0.11	0.11	0.10	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.10
Enthalpy (kJ/kg)[A]	30.23	34.36	34.36	30.23	40.78	40.78	30.23	---	---	327.40	---	308.96	322.83	---
Density (kg/m^3)	1.2	1.2	1.2	1.2	1.3	1.3	1.2	---	---	0.8	---	0.8	0.8	---
V-L Molecular Weight	28.857	28.857	28.857	28.857	28.857	28.857	28.857	---	---	29.743	---	29.743	29.743	---
V-L Flowrate (lb_{mol}/hr)	140,708	140,708	4,187	43,224	43,224	5,930	3,252	0	0	198,001	0	198,001	198,001	7,383
V-L Flowrate (lb/hr)	4,060,401	4,060,401	120,816	1,247,313	1,247,313	171,108	93,850	0	0	5,889,196	0	5,889,196	5,889,196	133,014
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	539,995	10,472	41,890	41,890	0	0	54,497
Temperature (°F)	59	66	66	59	78	78	59	59	59	337	59	337	360	59
Pressure (psia)	14.7	15.3	15.3	14.7	16.1	16.1	14.7	14.7	14.7	14.4	14.7	14.2	15.4	15.0
Enthalpy (Btu/lb)[A]	13.0	14.8	14.8	13.0	17.5	17.5	13.0	---	---	140.8	---	132.8	138.8	---
Density (lb/ft^3)	0.076	0.078	0.078	0.076	0.081	0.081	0.076	---	---	0.050	---	0.049	0.052	---

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 6-2 Bituminous Baseline Case 12A Stream Table, SC Unit with CO2 Capture (Continued)

	15	16	17	18	19	20	21	22	23	24	25	26	27	28
V-L Mole Fraction														
Ar	0.0000	0.0128	0.0000	0.0081	0.0108	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.0000	0.0005	0.0004	0.1351	0.0179	0.9961	0.9985	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	1.0000	0.0062	0.9996	0.1537	0.0383	0.0039	0.0015	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.0000	0.7506	0.0000	0.6793	0.9013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0000	0.2300	0.0000	0.0238	0.0316	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	12,734	913	236	97,848	73,741	11,940	11,911	35,621	35,621	120,750	98,499	98,499	53,856	53,856
V-L Flowrate (kg/hr)	229,411	26,510	4,260	2,821,044	2,077,415	524,270	523,755	641,731	641,731	2,175,344	1,774,495	1,774,495	970,240	970,240
Solids Flowrate (kg/hr)	0	0	38,244	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	15	181	58	58	32	21	35	291	151	593	354	593	38	39
Pressure (MPa, abs)	0.10	0.31	0.10	0.10	0.10	0.16	15.27	0.51	0.92	24.23	4.90	4.52	0.01	1.69
Enthalpy (kJ/kg)[A]	-46.80	191.58	---	301.42	93.86	19.49	-211.71	3,045.10	636.31	3,476.62	3,081.96	3,652.22	2,111.17	166.38
Density (kg/m^3)	1,003.1	2.4	---	1.1	1.1	2.9	795.9	2.0	916.0	69.2	18.7	11.6	0.1	993.2
V-L Molecular Weight	18.015	29.029	---	28.831	28.172	43.908	43.971	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	28,074	2,013	521	215,717	162,571	26,323	26,260	78,532	78,532	266,208	217,154	217,154	118,733	118,733
V-L Flowrate (lb/hr)	505,766	58,445	9,392	6,219,337	4,579,917	1,155,818	1,154,682	1,414,774	1,414,774	4,795,812	3,912,091	3,912,091	2,139,012	2,139,012
Solids Flowrate (lb/hr)	0	0	84,314	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	59	357	136	136	89	69	95	556	304	1,100	669	1,100	101	103
Pressure (psia)	14.7	45.0	14.9	14.9	14.7	23.5	2,214.5	73.5	133.6	3,514.7	710.8	655.8	1.0	245.0
Enthalpy (Btu/lb)[A]	-20.1	82.4	---	129.6	40.4	8.4	-91.0	1,309.2	273.6	1,494.7	1,325.0	1,570.2	907.6	71.5
Density (lb/ft^3)	62.622	0.149	---	0.067	0.070	0.184	49.685	0.123	57.184	4.319	1.165	0.722	0.004	62.004

Exhibit 6-3 Bituminous Baseline Case 12A Plant Performance Summary

POWER SUMMARY (Gross Power at Generator Terminals, kWe)		
Bituminous Baseline Case	12	12A
Steam Turbine Power	662,800	654,200
TOTAL (STEAM TURBINE) POWER, kWe	**662,800**	**654,200**
AUXILIARY LOAD SUMMARY, kWe		
Coal Handling and Conveying	510	500
Pulverizers	3,850	3,670
Sorbent Handling & Reagent Preparation	1,250	1,190
Ash Handling	740	700
PA Fans	1,800	1,720
FD Fans	2,300	2,190
ID Fans	11,120	10,610
SCR	70	60
Baghouse	100	90
Wet FGD	4,110	3,920
Econamine Auxiliaries	20,600	16,400
CO_2 Compression	44,890	42,840
Miscellaneous Balance of Plant[2,3]	2,000	2,000
Steam Turbine Auxiliaries	400	400
Condensate Pumps	560	610
CWPs	10,100	9,390
Ground Water Pumps	920	850
Cooling Tower Fans	5,230	4,860
Transformer Losses	2,290	2,240
TOTAL AUXILIARIES, kWe	**112,840**	**104,240**
NET POWER, kWe	**549,960**	**549,960**
Net Plant Efficiency (HHV)	28.4%	29.8%
Net Plant Heat Rate, kJ/kWh (Btu/kWh)	12,663 (12,002)	12,085 (11,455)
CONDENSER COOLING DUTY, 10^6 kJ/h (10^6 Btu/h)	**1,737 (1,646)**	**1,893 (1,794)**
CONSUMABLES		
As-Received Coal Feed, kg/h (lb/h)	256,652 (565,820)	244,938 (539,995)
Limestone Sorbent Feed, kg/h (lb/h)	25,966 (57,245)	24,720 (54,497)
Thermal Input, kWt[1]	1,934,519	1,846,224
Raw Water Withdrawal, m^3/min (gpm)	38.1 (10,071)	35.4 (9,350)
Raw Water Consumption, m^3/min (gpm)	29.3 (7,733)	27.2 (7,177)

1. HHV of As Received Illinois No. 6 coal is 27,135 kJ/kg (11,666 Btu/lb)
2. Boiler feed pumps are turbine driven
3. Includes plant control systems, lighting, HVAC, and miscellaneous low voltage loads

6.3 COST ESTIMATING

The cost estimating methodology was described in Section 2.6 of this report. Exhibit 6-4 shows the TPC summary organized by cost account and Exhibit 6-5 shows a more detailed breakdown of the capital costs including the TOC and TASC. Exhibit 6-7 shows the initial and annual O&M costs.

The TPC was estimated using a factored cost method with Case 12 as the reference. Account 5B.1 was scaled based on CO_2 captured to the 0.6 power and additionally reduced by 12 percent as discussed previously to account for capital cost reductions resulting from the reduced solvent circulation rate.

The estimated TOC for Case 12A is $3,364/kW. This represents a reduction from Case 12 of 6 percent. Process contingency represents 2.6 percent of the TOC and project contingency represents 10.0 percent. The COE, including CO_2 TS&M costs of 5.3 mills/kWh, is 100.8 mills/kWh. This COE is 5.5% less than the Baseline Case 12 COE of 106.6 mills/kWh.

Exhibit 6-4 Bituminous Baseline Case 12A TPC Summary

Client: USDOE/NETL **Report Date:** 2010-Jan-14
Project: Bituminous Baseline Study

TOTAL PLANT COST SUMMARY

Case: Case 12A - 1x550 MWnet Super-Critical PC w/ CO2 Capture (MEA Sensitivity)
Plant Size: 550.0 MW,net **Estimate Type:** Conceptual **Cost Base (Jun)** 2007 ($x1000)

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Sales Tax	Bare Erected Cost $	Eng'g CM H.O.& Fee	Contingencies Process	Contingencies Project	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL & SORBENT HANDLING	$19,514	$5,244	$11,671	$0	$0	**$36,429**	$3,268	$0	$5,955	**$45,652**	$83
2	COAL & SORBENT PREP & FEED	$13,252	$772	$3,366	$0	$0	**$17,391**	$1,524	$0	$2,837	**$21,753**	$40
3	FEEDWATER & MISC. BOP SYSTEMS	$52,950	$0	$24,940	$0	$0	**$77,890**	$7,138	$0	$13,939	**$98,967**	$180
4	PC BOILER											
4.1	PC Boiler & Accessories	$189,629	$0	$106,401	$0	$0	**$296,030**	$28,810	$0	$32,484	**$357,324**	$650
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.3	Open	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
4.4-4.9	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 4	**$189,629**	**$0**	**$106,401**	**$0**	**$0**	**$296,030**	**$28,810**	**$0**	**$32,484**	**$357,324**	**$650**
5	FLUE GAS CLEANUP	$97,431	$0	$33,251	$0	$0	**$130,682**	$12,508	$0	$14,319	**$157,509**	$286
5B	CO_2 REMOVAL & COMPRESSION	$204,675	$0	$62,416	$0	$0	**$267,091**	$25,537	$46,378	$67,801	**$406,807**	$740
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
6.2-6.9	Combustion Turbine Other	$0	$0	$0	$0	$0	**$0**	$0	$0	$0	**$0**	$0
	SUBTOTAL 6	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	**$0**	$0	$0	$0	**$0**	$0
7.2-7.9	HRSG Accessories, Ductwork and Stack	$17,413	$958	$11,797	$0	$0	**$30,168**	$2,764	$0	$4,326	**$37,258**	$68
	SUBTOTAL 7	**$17,413**	**$958**	**$11,797**	**$0**	**$0**	**$30,168**	**$2,764**	**$0**	**$4,326**	**$37,258**	**$68**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$56,268	$0	$7,467	$0	$0	**$63,735**	$6,108	$0	$6,984	**$76,827**	$140
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$26,997	$1,189	$15,089	$0	$0	**$43,276**	$3,779	$0	$6,723	**$53,778**	$98
	SUBTOTAL 8	**$83,265**	**$1,189**	**$22,556**	**$0**	**$0**	**$107,010**	**$9,887**	**$0**	**$13,707**	**$130,605**	**$237**
9	COOLING WATER SYSTEM	$19,662	$9,537	$17,647	$0	$0	**$46,846**	$4,410	$0	$6,916	**$58,171**	$106
10	ASH/SPENT SORBENT HANDLING SYS	$5,135	$163	$6,865	$0	$0	**$12,163**	$1,169	$0	$1,372	**$14,705**	$27
11	ACCESSORY ELECTRIC PLANT	$24,767	$10,309	$29,247	$0	$0	**$64,322**	$5,686	$0	$8,780	**$78,788**	$143
12	INSTRUMENTATION & CONTROL	$9,915	$0	$10,054	$0	$0	**$19,969**	$1,811	$998	$2,798	**$25,575**	$47
13	IMPROVEMENTS TO SITE	$3,281	$1,886	$6,612	$0	$0	**$11,779**	$1,162	$0	$2,588	**$15,529**	$28
14	BUILDINGS & STRUCTURES	$0	$24,540	$23,290	$0	$0	**$47,830**	$4,315	$0	$7,822	**$59,967**	$109
	TOTAL COST	**$740,888**	**$54,598**	**$370,114**	**$0**	**$0**	**$1,165,600**	**$109,989**	**$47,376**	**$185,644**	**$1,508,610**	**$2,743**

Exhibit 6-5 Bituminous Baseline Case 12A Total Plant Cost Details

	Client:	USDOE/NETL							**Report Date:**	2010-Jan-14		
	Project:	Bituminous Baseline Study										
				TOTAL PLANT COST SUMMARY								
	Case:	Case 12A - 1x550 MWnet Super-Critical PC w/ CO2 Capture (MEA Sensitivity)										
	Plant Size:	550.0	MW,net	**Estimate Type:**		Conceptual		**Cost Base (Jun)**		2007	($x1000)	
Acct		**Equipment**	**Material**	**Labor**		**Sales**	**Bare Erected**	**Eng'g CM**	**Contingencies**		**TOTAL PLANT COST**	
No.	**Item/Description**	**Cost**	**Cost**	**Direct**	**Indirect**	**Tax**	**Cost $**	**H.O.& Fee**	**Process**	**Project**	**$**	**$/kW**
1	COAL & SORBENT HANDLING											
1.1	Coal Receive & Unload	$3,998	$0	$1,826	$0	$0	$5,823	$520	$0	$952	$7,295	$13
1.2	Coal Stackout & Reclaim	$5,166	$0	$1,171	$0	$0	$6,337	$554	$0	$1,034	$7,925	$14
1.3	Coal Conveyors	$4,803	$0	$1,158	$0	$0	$5,961	$522	$0	$973	$7,456	$14
1.4	Other Coal Handling	$1,257	$0	$268	$0	$0	$1,525	$133	$0	$249	$1,907	$3
1.5	Sorbent Receive & Unload	$163	$0	$49	$0	$0	$212	$19	$0	$35	$265	$0
1.6	Sorbent Stackout & Reclaim	$2,625	$0	$481	$0	$0	$3,106	$270	$0	$506	$3,883	$7
1.7	Sorbent Conveyors	$937	$203	$230	$0	$0	$1,369	$118	$0	$223	$1,710	$3
1.8	Other Sorbent Handling	$566	$133	$297	$0	$0	$995	$88	$0	$162	$1,245	$2
1.9	Coal & Sorbent Hnd.Foundations	$0	$4,909	$6,192	$0	$0	$11,101	$1,043	$0	$1,822	$13,966	$25
	SUBTOTAL 1.	**$19,514**	**$5,244**	**$11,671**	**$0**	**$0**	**$36,429**	**$3,268**	**$0**	**$5,955**	**$45,652**	**$83**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$2,315	$0	$451	$0	$0	$2,766	$241	$0	$451	$3,458	$6
2.2	Coal Conveyor to Storage	$5,927	$0	$1,294	$0	$0	$7,221	$631	$0	$1,178	$9,030	$16
2.3	Coal Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.4	Misc.Coal Prep & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.5	Sorbent Prep Equipment	$4,471	$193	$929	$0	$0	$5,593	$487	$0	$912	$6,991	$13
2.6	Sorbent Storage & Feed	$539	$0	$206	$0	$0	$745	$66	$0	$122	$933	$2
2.7	Sorbent Injection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.8	Booster Air Supply System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.9	Coal & Sorbent Feed Foundation	$0	$579	$486	$0	$0	$1,066	$99	$0	$175	$1,339	$2
	SUBTOTAL 2.	**$13,252**	**$772**	**$3,366**	**$0**	**$0**	**$17,391**	**$1,524**	**$0**	**$2,837**	**$21,753**	**$40**
3	FEEDWATER & MISC. BOP SYSTEMS											
3.1	FeedwaterSystem	$22,174	$0	$7,163	$0	$0	$29,337	$2,564	$0	$4,785	$36,686	$67
3.2	Water Makeup & Pretreating	$6,639	$0	$2,137	$0	$0	$8,776	$830	$0	$1,921	$11,526	$21
3.3	Other Feedwater Subsystems	$6,789	$0	$2,869	$0	$0	$9,658	$865	$0	$1,578	$12,101	$22
3.4	Service Water Systems	$1,301	$0	$708	$0	$0	$2,009	$189	$0	$440	$2,638	$5
3.5	Other Boiler Plant Systems	$8,379	$0	$8,272	$0	$0	$16,651	$1,582	$0	$2,735	$20,968	$38
3.6	FO Supply Sys & Nat Gas	$273	$0	$341	$0	$0	$613	$58	$0	$101	$772	$1
3.7	Waste Treatment Equipment	$4,501	$0	$2,566	$0	$0	$7,066	$688	$0	$1,551	$9,305	$17
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	$2,894	$0	$884	$0	$0	$3,779	$363	$0	$828	$4,970	$9
	SUBTOTAL 3.	**$52,950**	**$0**	**$24,940**	**$0**	**$0**	**$77,890**	**$7,138**	**$0**	**$13,939**	**$98,967**	**$180**
4	PC BOILER											
4.1	PC Boiler & Accessories	$189,629	$0	$106,401	$0	$0	$296,030	$28,810	$0	$32,484	$357,324	$650
4.2	SCR (w/4.1)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.3	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.4	Boiler BoP (w/ ID Fans)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4.5	Primary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.6	Secondary Air System	w/4.1	$0	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.8	Major Component Rigging	$0	w/4.1	w/4.1	$0	$0	$0	$0	$0	$0	$0	$0
4.9	Boiler Foundations	$0	w/14.1	w/14.1	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 4.	**$189,629**	**$0**	**$106,401**	**$0**	**$0**	**$296,030**	**$28,810**	**$0**	**$32,484**	**$357,324**	**$650**

Exhibit 6-5 Bituminous Baseline Case 12A Total Plant Cost Details (Continued)

	Client:	USDOE/NETL								**Report Date:**	2010-Jan-14	
	Project:	Bituminous Baseline Study										
				TOTAL PLANT COST SUMMARY								
	Case:	Case 12A - 1x550 MWnet Super-Critical PC w/ CO2 Capture (MEA Sensitivity)										
	Plant Size:	550.0	MW,net	**Estimate Type:**		Conceptual			**Cost Base (Jun)**		2007	($x1000)
Acct		**Equipment**	**Material**	**Labor**		**Sales**	**Bare Erected**	**Eng'g CM**	**Contingencies**		**TOTAL PLANT COST**	
No.	**Item/Description**	**Cost**	**Cost**	**Direct**	**Indirect**	**Tax**	**Cost $**	**H.O.& Fee**	**Process**	**Project**	**$**	**$/kW**
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$67,660	$0	$14,566	$0	$0	$82,226	$7,839	$0	$9,006	$99,071	$180
5.2	Other FGD	$3,531	$0	$4,001	$0	$0	$7,532	$731	$0	$826	$9,089	$17
5.3	Bag House & Accessories	$19,454	$0	$12,346	$0	$0	$31,801	$3,065	$0	$3,487	$38,352	$70
5.4	Other Particulate Removal Materials	$1,317	$0	$1,409	$0	$0	$2,725	$264	$0	$299	$3,289	$6
5.5	Gypsum Dewatering System	$5,469	$0	$929	$0	$0	$6,398	$609	$0	$701	$7,708	$14
5.6	Mercury Removal System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5.9	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 5.	**$97,431**	**$0**	**$33,251**	**$0**	**$0**	**$130,682**	**$12,508**	**$0**	**$14,319**	**$157,509**	**$286**
5B	CO_2 REMOVAL & COMPRESSION											
5B.1	CO_2 Removal System	$177,879	$0	$54,009	$0	$0	$231,888	$22,171	$46,378	$60,087	$360,524	$656
5B.2	CO_2 Compression & Drying	$26,796	$0	$8,406	$0	$0	$35,202	$3,367	$0	$7,714	$46,283	$84
	SUBTOTAL 5B.	**$204,675**	**$0**	**$62,416**	**$0**	**$0**	**$267,091**	**$25,537**	**$46,378**	**$67,801**	**$406,807**	**$740**
6	COMBUSTION TURBINE/ACCESSORIES											
6.1	Combustion Turbine Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
6.2	Open	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.3	Compressed Air Piping	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6.9	Combustion Turbine Foundations	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK											
7.1	Heat Recovery Steam Generator	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
7.2	HRSG Accessories	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7.3	Ductwork	$9,063	$0	$5,823	$0	$0	$14,886	$1,298	$0	$2,428	$18,611	$34
7.4	Stack	$8,350	$0	$4,886	$0	$0	$13,236	$1,274	$0	$1,451	$15,962	$29
7.9	Duct & Stack Foundations	$0	$958	$1,088	$0	$0	$2,046	$192	$0	$448	$2,685	$5
	SUBTOTAL 7.	**$17,413**	**$958**	**$11,797**	**$0**	**$0**	**$30,168**	**$2,764**	**$0**	**$4,326**	**$37,258**	**$68**
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$56,268	$0	$7,467	$0	$0	$63,735	$6,108	$0	$6,984	$76,827	$140
8.2	Turbine Plant Auxiliaries	$379	$0	$812	$0	$0	$1,191	$116	$0	$131	$1,438	$3
8.3	Condenser & Auxiliaries	$5,837	$0	$2,151	$0	$0	$7,988	$765	$0	$875	$9,629	$18
8.4	Steam Piping	$20,781	$0	$10,247	$0	$0	$31,028	$2,607	$0	$5,045	$38,680	$70
8.9	TG Foundations	$0	$1,189	$1,879	$0	$0	$3,069	$290	$0	$672	$4,031	$7
	SUBTOTAL 8.	**$83,265**	**$1,189**	**$22,556**	**$0**	**$0**	**$107,010**	**$9,887**	**$0**	**$13,707**	**$130,605**	**$237**

Exhibit 6-5 Bituminous Baseline Case 12A Total Plant Cost Details (Continued)

	Client:	USDOE/NETL								**Report Date:**	2010-Jan-14	
	Project:	Bituminous Baseline Study										
				TOTAL PLANT COST SUMMARY								
	Case:	Case 12A - 1x550 MWnet Super-Critical PC w/ CO2 Capture (MEA Sensitivity)										
	Plant Size:	550.0	MW,net	**Estimate Type:**		Conceptual		**Cost Base (Jun)**		2007	($x1000)	
Acct		**Equipment**	**Material**	**Labor**		**Sales**	**Bare Erected**	**Eng'g CM**	**Contingencies**		**TOTAL PLANT COST**	
No.	**Item/Description**	**Cost**	**Cost**	**Direct**	**Indirect**	**Tax**	**Cost $**	**H.O.& Fee**	**Process**	**Project**	**$**	**$/kW**
9	COOLING WATER SYSTEM											
9.1	Cooling Towers	$14,675	$0	$4,570	$0	$0	$19,245	$1,840	$0	$2,109	$23,194	$42
9.2	Circulating Water Pumps	$3,023	$0	$233	$0	$0	$3,255	$275	$0	$353	$3,884	$7
9.3	Circ.Water System Auxiliaries	$754	$0	$100	$0	$0	$854	$81	$0	$94	$1,029	$2
9.4	Circ.Water Piping	$0	$5,974	$5,789	$0	$0	$11,763	$1,101	$0	$1,930	$14,794	$27
9.5	Make-up Water System	$613	$0	$819	$0	$0	$1,433	$137	$0	$235	$1,805	$3
9.6	Component Cooling Water Sys	$597	$0	$475	$0	$0	$1,072	$102	$0	$176	$1,350	$2
9.9	Circ.Water System Foundations& Structures	$0	$3,563	$5,661	$0	$0	$9,224	$873	$0	$2,019	$12,116	$22
	SUBTOTAL 9.	**$19,662**	**$9,537**	**$17,647**	**$0**	**$0**	**$46,846**	**$4,410**	**$0**	**$6,916**	**$58,171**	**$106**
10	ASH/SPENT SORBENT HANDLING SYS											
10.1	Ash Coolers	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.2	Cyclone Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.3	HGCU Ash Letdown	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.4	High Temperature Ash Piping	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.5	Other Ash Recovery Equipment	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
10.6	Ash Storage Silos	$687	$0	$2,117	$0	$0	$2,804	$275	$0	$308	$3,387	$6
10.7	Ash Transport & Feed Equipment	$4,448	$0	$4,556	$0	$0	$9,004	$861	$0	$986	$10,851	$20
10.8	Misc. Ash Handling Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.9	Ash/Spent Sorbent Foundation	$0	$163	$192	$0	$0	$356	$33	$0	$78	$467	$1
	SUBTOTAL 10.	**$5,135**	**$163**	**$6,865**	**$0**	**$0**	**$12,163**	**$1,169**	**$0**	**$1,372**	**$14,705**	**$27**
11	ACCESSORY ELECTRIC PLANT											
11.1	Generator Equipment	$1,714	$0	$278	$0	$0	$1,993	$185	$0	$163	$2,341	$4
11.2	Station Service Equipment	$4,791	$0	$1,574	$0	$0	$6,366	$595	$0	$522	$7,483	$14
11.3	Switchgear & Motor Control	$5,508	$0	$936	$0	$0	$6,445	$597	$0	$704	$7,746	$14
11.4	Conduit & Cable Tray	$0	$3,454	$11,941	$0	$0	$15,395	$1,490	$0	$2,533	$19,418	$35
11.5	Wire & Cable	$0	$6,517	$12,580	$0	$0	$19,097	$1,609	$0	$3,106	$23,811	$43
11.6	Protective Equipment	$261	$0	$888	$0	$0	$1,149	$112	$0	$126	$1,388	$3
11.7	Standby Equipment	$1,352	$0	$31	$0	$0	$1,383	$127	$0	$151	$1,660	$3
11.8	Main Power Transformers	$11,140	$0	$187	$0	$0	$11,327	$859	$0	$1,219	$13,405	$24
11.9	Electrical Foundations	$0	$339	$830	$0	$0	$1,168	$112	$0	$256	$1,536	$3
	SUBTOTAL 11.	**$24,767**	**$10,309**	**$29,247**	**$0**	**$0**	**$64,322**	**$5,686**	**$0**	**$8,780**	**$78,788**	**$143**
12	INSTRUMENTATION & CONTROL											
12.1	PC Control Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.2	Combustion Turbine Control	N/A	$0	N/A	$0	$0	$0	$0	$0	$0	$0	$0
12.3	Steam Turbine Control	w/8.1	$0	w/8.1	$0	$0	$0	$0	$0	$0	$0	$0
12.4	Other Major Component Control	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.5	Signal Processing Equipment	w/12.7	$0	w/12.7	$0	$0	$0	$0	$0	$0	$0	$0
12.6	Control Boards,Panels & Racks	$511	$0	$306	$0	$0	$816	$77	$41	$140	$1,074	$2
12.7	Distributed Control System Equipment	$5,154	$0	$901	$0	$0	$6,055	$561	$303	$692	$7,611	$14
12.8	Instrument Wiring & Tubing	$2,794	$0	$5,542	$0	$0	$8,336	$710	$417	$1,420	$10,883	$20
12.9	Other I & C Equipment	$1,456	$0	$3,305	$0	$0	$4,761	$462	$238	$546	$6,007	$11
	SUBTOTAL 12.	**$9,915**	**$0**	**$10,054**	**$0**	**$0**	**$19,969**	**$1,811**	**$998**	**$2,798**	**$25,575**	**$47**

Exhibit 6-5 Bituminous Baseline Case 12A Total Plant Cost Details (Continued)

	Client:	USDOE/NETL								**Report Date:**	2010-Jan-14	
	Project:	Bituminous Baseline Study										
					TOTAL PLANT COST SUMMARY							
	Case:	Case 12A - 1x550 MWnet Super-Critical PC w/ CO2 Capture (MEA Sensitivity)										
	Plant Size:	550.0	MW,net	**Estimate Type:**		Conceptual				**Cost Base (Jun)**	2007	($x1000)
Acct		**Equipment**	**Material**	**Labor**		**Sales**	**Bare Erected**	**Eng'g CM**	**Contingencies**		**TOTAL PLANT COST**	
No.	**Item/Description**	**Cost**	**Cost**	**Direct**	**Indirect**	**Tax**	**Cost $**	**H.O.& Fee**	**Process**	**Project**	**$**	**$/kW**
13	IMPROVEMENTS TO SITE											
13.1	Site Preparation	$0	$55	$1,103	$0	$0	$1,158	$115	$0	$255	$1,528	$3
13.2	Site Improvements	$0	$1,831	$2,274	$0	$0	$4,105	$405	$0	$902	$5,411	$10
13.3	Site Facilities	$3,281	$0	$3,235	$0	$0	$6,516	$642	$0	$1,432	$8,590	$16
	SUBTOTAL 13.	**$3,281**	**$1,886**	**$6,612**	**$0**	**$0**	**$11,779**	**$1,162**	**$0**	**$2,588**	**$15,529**	**$28**
14	BUILDINGS & STRUCTURES											
14.1	Boiler Building	$0	$8,791	$7,731	$0	$0	$16,522	$1,485	$0	$2,701	$20,708	$38
14.2	Turbine Building	$0	$12,699	$11,836	$0	$0	$24,535	$2,211	$0	$4,012	$30,758	$56
14.3	Administration Building	$0	$637	$673	$0	$0	$1,310	$119	$0	$214	$1,644	$3
14.4	Circulation Water Pumphouse	$0	$168	$134	$0	$0	$302	$27	$0	$49	$378	$1
14.5	Water Treatment Buildings	$0	$842	$768	$0	$0	$1,610	$145	$0	$263	$2,018	$4
14.6	Machine Shop	$0	$426	$286	$0	$0	$712	$63	$0	$116	$892	$2
14.7	Warehouse	$0	$289	$290	$0	$0	$578	$52	$0	$95	$725	$1
14.8	Other Buildings & Structures	$0	$236	$201	$0	$0	$437	$39	$0	$71	$547	$1
14.9	Waste Treating Building & Str.	$0	$452	$1,372	$0	$0	$1,825	$173	$0	$300	$2,298	$4
	SUBTOTAL 14.	**$0**	**$24,540**	**$23,290**	**$0**	**$0**	**$47,830**	**$4,315**	**$0**	**$7,822**	**$59,967**	**$109**
	TOTAL COST	**$740,888**	**$54,598**	**$370,114**	**$0**	**$0**	**$1,165,600**	**$109,989**	**$47,376**	**$185,644**	**$1,508,610**	**$2,743**

Exhibit 6-6 Case S12A Owner's Costs

Owner's Costs		
Preproduction Costs		
6 Months All Labor	$10,153	$18
1 Month Maintenance Materials	$1,457	$3
1 Month Non-fuel Consumables	$1,478	$3
1 Month Waste Disposal	$309	$1
25% of 1 Months Fuel Cost at 100% CF	$1,882	$3
2% of TPC	$30,172	$55
Total	**$45,451**	**$83**
Inventory Capital		
60 day supply of fuel and consumables at 100% CF	$18,151	$33
0.5% of TPC (spare parts)	$7,543	$14
Total	**$25,694**	**$47**
Initial Cost for Catalyst and Chemicals	$2,383	$4
Land	$900	$2
Other Owner's Costs	$226,291	$411
Financing Costs	$40,732	$74
Total Overnight Costs (TOC)	**$1,850,062**	**$3,364**
TASC Multiplier	1.140	
Total As-Spent Cost (TASC)	**$2,109,071**	**$3,835**

Exhibit 6-7 Bituminous Baseline Case 12A Initial and Annual O&M Costs

INITIAL & ANNUAL O&M EXPENSES						Cost Base (Jun):	2007
Case 12A - 1x550 MWnet Super-Critical PC w/ CO2 Capture (MEA Sensitivity)						Heat Rate-net (Btu/kWh):	11,455
						MWe-net:	550
						Capacity Factor (%):	85
OPERATING & MAINTENANCE LABOR							
Operating Labor							
Operating Labor Rate(base):	34.65	$/hour					
Operating Labor Burden:	30.00	% of base					
Labor O-H Charge Rate:	25.00	% of labor					
Operating Labor Requirements(O.J.)per Shift:	1 unit/mod.		Total Plant				
Skilled Operator	2.0		2.0				
Operator	11.3		11.3				
Foreman	1.0		1.0				
Lab Tech's, etc.	2.0		2.0				
TOTAL-O.J.'s	16.3		16.3				
						Annual Cost $	Annual Unit Cost $/kW-net
Annual Operating Labor Cost						$6,444,907	$11.719
Maintenance Labor Cost						$9,800,561	$17.820
Administrative & Support Labor						$4,061,367	$7.385
Property Taxes and Insurance						$30,172,197	$54.863
TOTAL FIXED OPERATING COSTS						**$50,479,031**	**$91.787**

VARIABLE OPERATING COSTS						
						$/kWh-net
Maintenance Material Cost					**$14,863,811**	**$0.00363**
Consumables	Consumption Initial	Consumption /Day	Unit Cost	Initial Cost		
Water(/1000 gallons)	0	6,801	1.08	**$0**	**$2,282,387**	**$0.00056**
Chemicals						
MU & WT Chem.(lb)	0	32,922	0.17	$0	$1,767,714	$0.00043
Limestone (ton)	0	654	21.63	$0	$4,389,274	$0.00107
Carbon (Mercury Removal) (lb)	0	0	1.05	$0	$0	$0.00000
MEA Solvent (ton)	981	1.39	2,249.89	$2,208,132	$971,338	$0.00024
NaOH (tons)	69	6.93	433.68	$30,065	$932,782	$0.00023
H2SO4 (tons)	66	6.62	138.78	$9,181	$284,854	$0.00007
Corrosion Inhibitor	0	0	0.00	$135,751	$0	$0.00000
Activated Carbon(lb)	0	1,662	1.05	$0	$541,593	$0.00013
Ammonia (28% NH3) ton	0	97	129.80	$0	$3,904,140	$0.00095
Subtotal Chemicals				**$2,383,130**	**$12,791,695**	**$0.00312**
Other						
Supplemental Fuel (MBtu)	0	0	0.00	$0	$0	$0.00000
SCR Catalyst (m3)	w/equip.	0.41	5,775.94	$0	$730,089	$0.00018
Emission Penalties	0	0	0.00	$0	$0	$0.00000
Subtotal Other				**$0**	**$730,089**	**$0.00018**
Waste Disposal						
Fly Ash (ton)	0	502	16.23	$0	$2,524,978	$0.00062
Bottom Ash (ton)	0	125	16.23	$0	$628,224	$0.00015
Subtotal-Waste Disposal				**$0**	**$3,153,202**	**$0.00077**
By-products & Emissions						
Gypsum (tons)	0	1,013	0.00	$0	$0	$0.00000
Subtotal By-Products				**$0**	**$0**	**$0.00000**
TOTAL VARIABLE OPERATING COSTS				**$2,383,130**	**$33,821,185**	**$0.00826**
Fuel(ton)	0	6,480	38.18	$0	**$76,766,172**	**$0.01875**

7. SUMMARY

7.1 PERFORMANCE

The nominal net plant output for this study is set at 550 MW. The boilers and steam turbines are readily available in a wide range of capacities. Higher auxiliary load and extraction steam requirements are accommodated in CO_2 capture cases using larger boilers and steam turbines.

The performance summaries for all cases are shown in Exhibit 7-1. The efficiencies (based on HHV) are shown in Exhibit 7-2. The primary conclusions regarding plant efficiencies that can be drawn are:

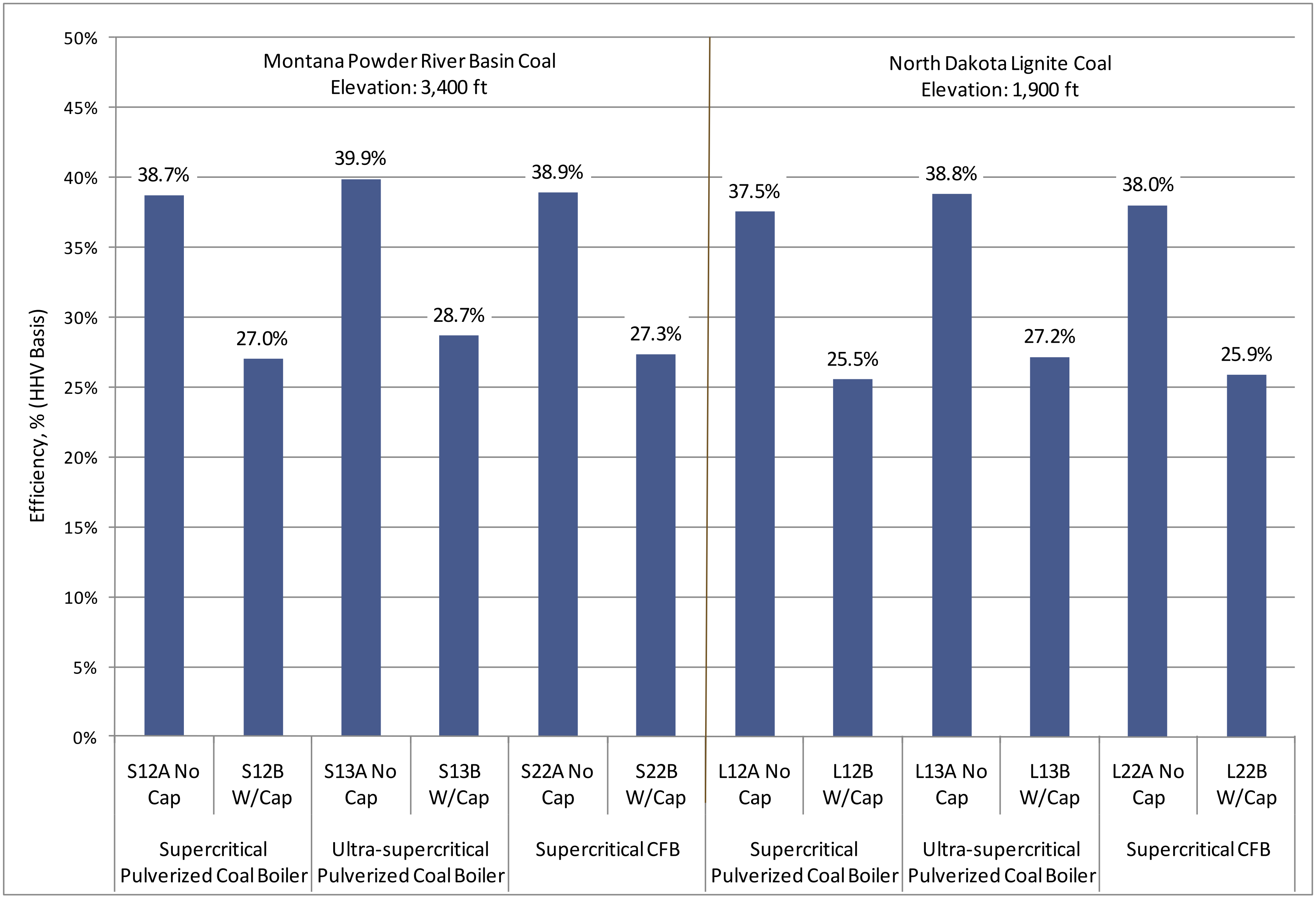
- The USC PC plant with no CO_2 capture and PRB coal has the highest net efficiency of the technologies modeled in this study with an efficiency of 39.9 percent. The combination of aggressive steam conditions and higher quality coal (relative to NDL) results in the highest net efficiency.
- The USC PC case with CO_2 capture and PRB coal results in the highest efficiency (28.7 percent) among all of the capture technologies. Similar to the non-capture case, the aggressive steam conditions and higher quality coal are the primary reasons for the highest net efficiency.
- The CO_2 capture results in an efficiency penalty of 11 to 12 absolute percent, relative to the non-capture case for all the technologies.

Exhibit 7-1 Estimated Performance, Emissions, and Cost Results

	Supercritical Pulverized Coal Boiler				Ultra-supercritical Pulverized Coal Boiler				Supercritical CFB			
PERFORMANCE	**S12A**	**L12A**	**S12B**	**L12B**	**S13A**	**L13A**	**S13B**	**L13B**	**S22A**	**L22A**	**S22B**	**L22B**
CO_2 Capture	0%	0%	90%	90%	0%	0%	90%	90%	0%	0%	90%	90%
Gross Power Output (kW_e)	582,700	584,700	673,000	683,900	581,500	583,200	665,400	675,200	578,400	578,700	664,000	672,900
Auxiliary Power Requirement (kW_e)	32,660	34,640	122,940	133,850	31,430	33,170	115,320	125,170	28,330	28,670	113,990	122,820
Net Power Output (kW_e)	550,040	550,060	550,060	550,050	550,070	550,030	550,080	550,030	550,070	550,030	550,010	550,080
Coal Flowrate (lb/hr)	566,042	755,859	811,486	1,110,668	549,326	731,085	764,212	1,043,879	563,307	745,997	801,270	1,095,812
HHV Thermal Input (kW_{th})	1,420,686	1,465,801	2,036,717	2,153,863	1,378,732	1,417,757	1,918,067	2,024,343	1,413,821	1,446,676	2,011,075	2,125,054
Net Plant HHV Efficiency (%)	38.7%	37.5%	27.0%	25.5%	39.9%	38.8%	28.7%	27.2%	38.9%	38.0%	27.3%	25.9%
Net Plant HHV Heat Rate (Btu/kWh)	8,813	9,093	12,634	13,361	8,552	8,795	11,898	12,558	8,770	8,975	12,476	13,182
Raw Water Withdrawal (gpm/MW_{net})	4.8	4.9	13.9	14.2	4.7	4.7	12.9	13.2	4.4	4.3	14.1	14.5
Process Water Discharge (gpm/MW_{net})	1.0	1.0	3.8	4.3	1.0	1.0	3.6	4.0	1.0	1.0	3.7	4.2
Raw Water Consumption (gpm/MW_{net})	3.8	3.9	10.0	9.9	3.7	3.7	9.3	9.2	3.3	3.3	10.4	10.4
CO_2 Emissions (lb/MMBtu)	215	219	21	22	215	219	21	22	213	219	21	22
CO_2 Emissions (lb/MWh_{gross})	1,786	1,877	222	236	1,737	1,820	211	225	1,775	1,865	220	236
CO_2 Emissions (lb/MWh_{net})	1,892	1,996	271	293	1,836	1,930	255	276	1,866	1,963	265	288
SO_2 Emissions (lb/MMBtu)	0.119	0.132	0.002	0.002	0.119	0.132	0.002	0.002	0.102	0.113	0.002	0.002
SO_2 Emissions (lb/MWh_{gross})	0.990	1.130	0.020	0.020	0.960	1.100	0.020	0.020	0.850	0.970	0.020	0.020
NOx Emissions (lb/MMBtu)	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070
NOx Emissions (lb/MWh_{gross})	0.582	0.599	0.723	0.752	0.566	0.581	0.689	0.716	0.584	0.597	0.723	0.754
PM Emissions (lb/MMBtu)	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
PM Emissions (lb/MWh_{gross})	0.108	0.111	0.134	0.140	0.105	0.108	0.128	0.133	0.108	0.111	0.134	0.140
Hg Emissions (lb/TBtu)	0.597	1.121	0.597	1.121	0.597	1.121	0.597	1.121	0.302	0.482	0.302	0.482
Hg Emissions (lb/MWh_{gross})	4.96E-06	9.59E-06	6.16E-06	1.20E-05	4.83E-06	9.29E-06	5.87E-06	1.15E-05	2.52E-06	4.11E-06	3.12E-06	5.19E-06
COST												
Total Plant Cost (2007$/kW)	1,879	2,041	3,268	3,560	1,972	2,156	3,322	3,588	1,932	2,042	3,295	3,533
Total Overnight Cost (2007$/kW)	2,293	2,489	3,987	4,341	2,405	2,628	4,049	4,372	2,357	2,490	4,018	4,307
Bare Erected Cost	1,530	1,663	2,517	2,750	1,577	1,725	2,530	2,738	1,480	1,563	2,424	2,600
Home Office Expenses	145	157	238	261	149	163	239	259	141	149	230	247
Project Contingency	204	220	406	438	213	231	408	437	210	221	407	435
Process Contingency	0	0	107	112	33	37	144	154	102	110	233	251
Owner's Costs	414	448	718	781	433	472	727	783	425	448	722	773
Total Overnight Cost (2007$ x 1,000)	1,261,175	1,369,100	2,192,877	2,387,887	1,322,909	1,445,367	2,227,086	2,404,506	1,296,474	1,369,642	2,209,764	2,368,935
Total As Spent Capital (2007$/kW)	2,600	2,823	4,545	4,949	2,742	2,996	4,615	4,984	2,687	2,839	4,580	4,909
COE (mills/kWh, 2007$)[1]	57.8	62.2	107.5	116.4	62.2	67.3	107.7	115.4	61.5	64.6	108.0	115.2
CO_2 TS&M Costs	0.0	0.0	6.0	6.2	0.0	0.0	5.8	6.0	0.0	0.0	5.9	6.1
Fuel Costs	7.8	7.5	11.2	11.0	7.6	7.3	10.6	10.4	7.8	7.4	11.1	10.9
Variable Costs	5.1	6.1	9.3	11.0	5.1	6.1	9.0	10.3	5.3	6.1	9.5	11.0
Fixed Costs	9.0	9.7	14.5	15.7	9.3	10.1	14.7	15.8	9.1	9.5	14.5	15.4
Capital Costs	35.9	39.0	66.5	72.4	40.1	43.9	67.6	73.0	39.3	41.6	67.0	71.9
LCOE (mills/kWh, 2007$)[1]	73.3	78.8	136.3	147.5	78.8	85.3	136.5	146.3	78.0	81.9	136.9	146.0

[1] COE and Levelized COE are defined in Section 2.6

Exhibit 7-2 Net Plant Efficiency (HHV Basis)



7.2 COST RESULTS

The TOCs are shown in Exhibit 7-3. Observations related to the TOCs include:

- For the SC PC cases the TOC is higher for the NDL coal cases as compared to the PRB coal cases: approximately 8.7 percent for both the non-capture and CO_2 capture case.
- For the SC PC cases the TOC increase to add CO_2 capture is approximately 74 percent for both the PRB and NDL cases.
- For the USC PC cases the TOC is also higher for the NDL coal cases as compared to the PRB coal cases: approximately 9 percent for the non-capture case and 8 percent for the CO_2 capture case.
- For the USC PC cases the TOC increase to add CO_2 capture is approximately 68 percent for the PRB case and 66 percent for the NDL case.
- Following the same trend as the SC PC and USC PC cases, for the SC CFB cases the TOC is higher for the NDL coal cases as compared to the PRB coal cases: approximately 5.6 percent for the non-capture case and 7.2 percent for the CO_2 capture case. The NDL cases have consistently higher TOC because of higher coal feed associated with lower boiler efficiency.
- For the SC CFB cases the TOC increase to add CO_2 capture is approximately 70 percent for the PRB case and 73 percent for the NDL case.

The COEs are shown in Exhibit 7-4. The following observations can be made:

- The COE is dominated by capital charges in all cases. The capital cost component of COE comprises 62-63 percent in all four SC PC cases, 63-65 percent in all four USC PC cases, and 62-64 percent in all four CFB cases.
- The fuel cost component is relatively minor in all cases, representing 10-14 percent of the COE costs in the PRB cases and 9-12 percent in the NDL cases.
- For each coal type and CO_2 capture scenario, the COE is lowest for the more conventional technology (SC PC) compared to the more advanced technologies (USC PC and SC CFB). The only exception is for NDL coal with CO_2 capture where USC PC and SC CFB have a very slight cost benefit because of the higher USC efficiency.
- The TS&M component of COE in the CO_2 capture cases is 5-6 percent for both PRB and NDL coal.
- The COE is 5-8 percent lower in both the CO_2 capture and non-capture PRB cases compared to the NDL coal cases because of higher efficiencies resulting in lower plant costs.

The COE with CO_2 removal includes the costs of capture and compression, as well as TS&M costs. The resulting avoided costs are shown in Exhibit 7-5 for each of the CO_2 capture technologies modeled. The avoided costs for each capture case are calculated using the analogous non-capture plant as the reference and again with SC PC without CO_2 capture as the reference. The cost of CO_2 avoided for analogous plant designs averages $68.8/tonne ($62.4/ton) with a range of $67-$70/tonne ($61-$64/ton) for the SC PC cases, $63.7/tonne ($57.8/ton) with a range of $63-$64/tonne ($57-$58/ton) for the USC PC cases, and $65.6/tonne ($59.5/ton) with a range of $64-$67/tonne ($58-$61/ton) for the CFB cases. The CO_2 avoided costs are lower for PRB coal than NDL, mainly because of the significant capital cost increase in the NDL fuel cases resulting from lower plant efficiency. CO_2 avoided costs are also shown compared to the baseline SC PC plant (12 series cases) firing the same coal.

Exhibit 7-3 Total Overnight Cost

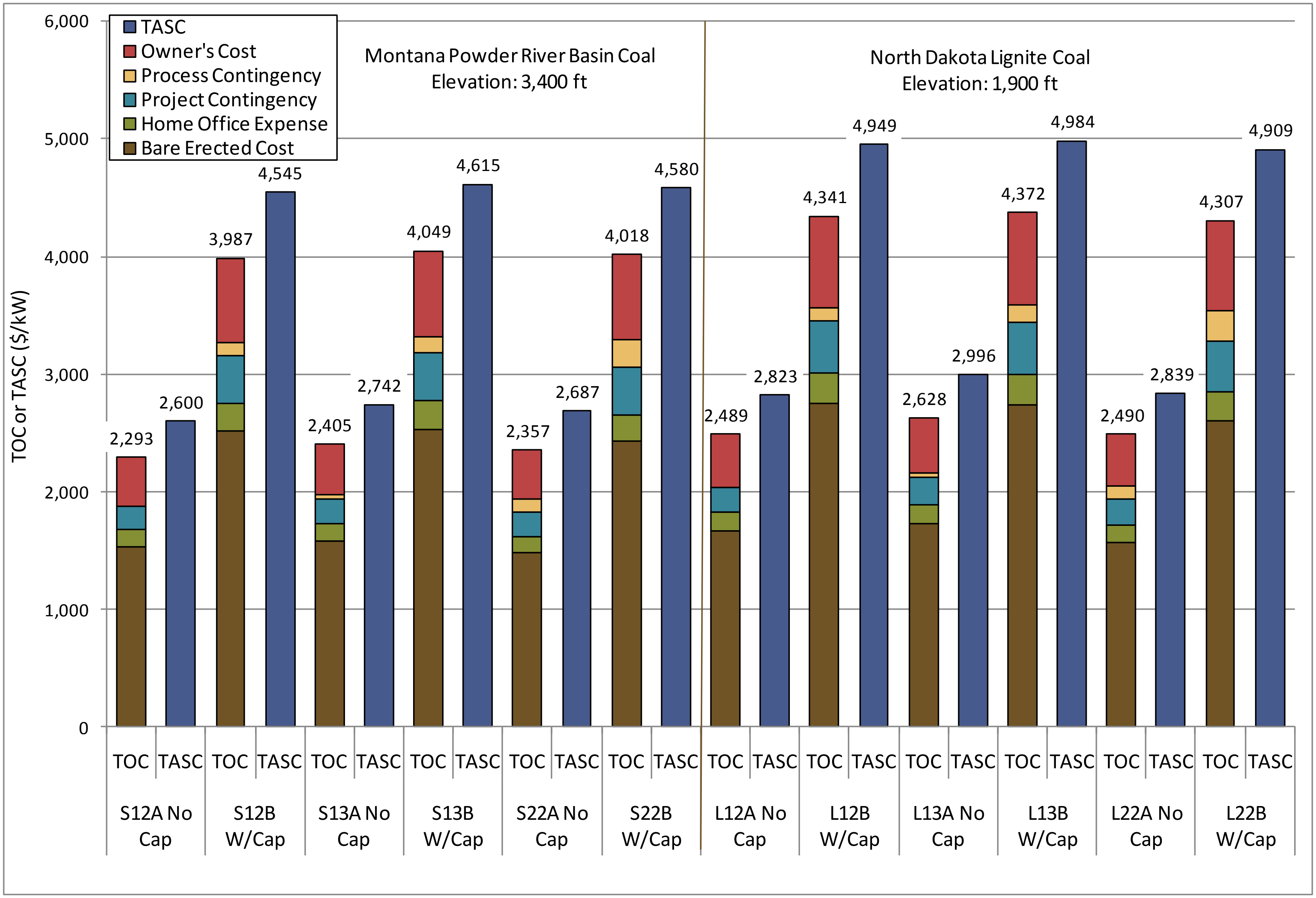


Exhibit 7-4 Cost of Electricity

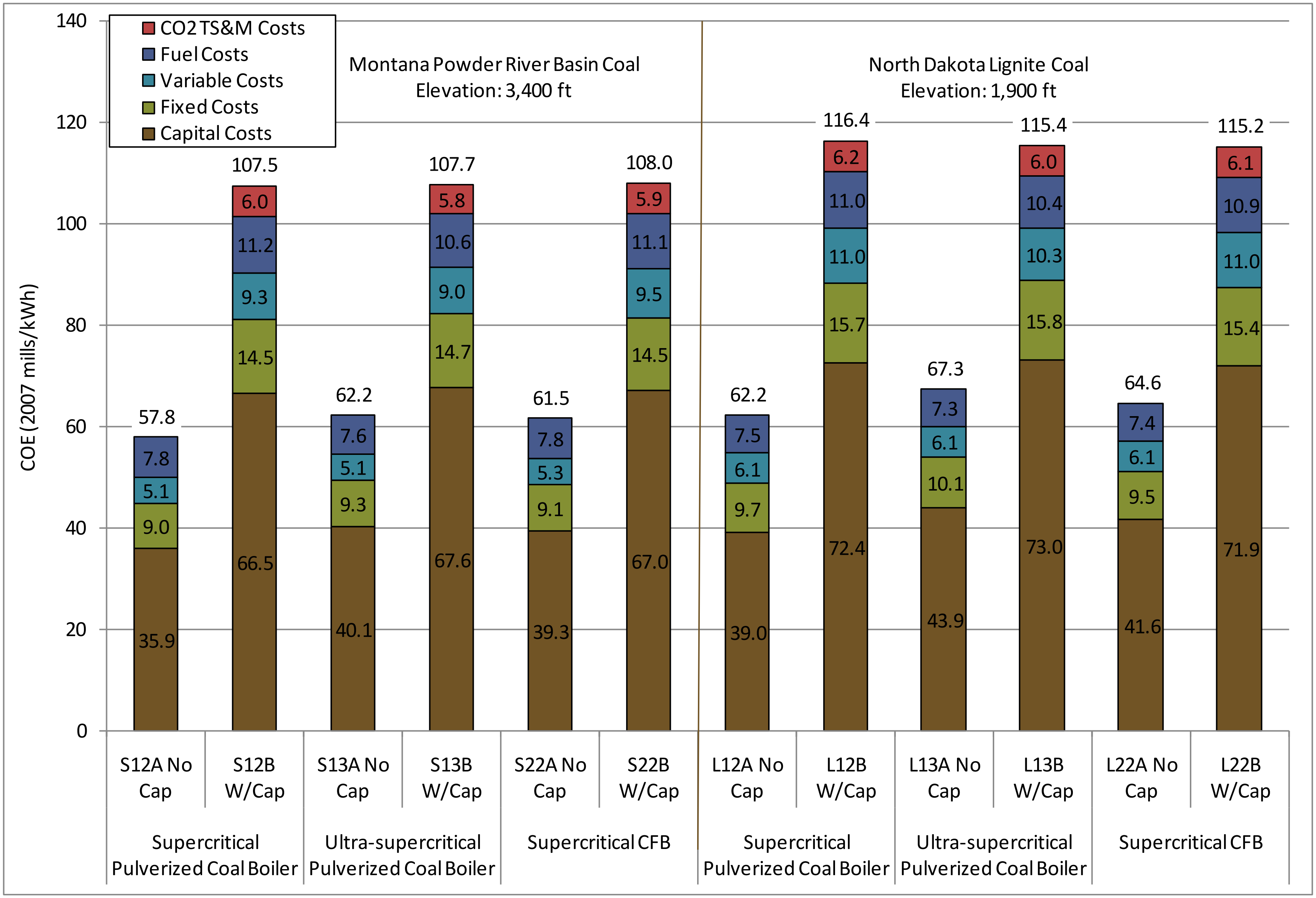
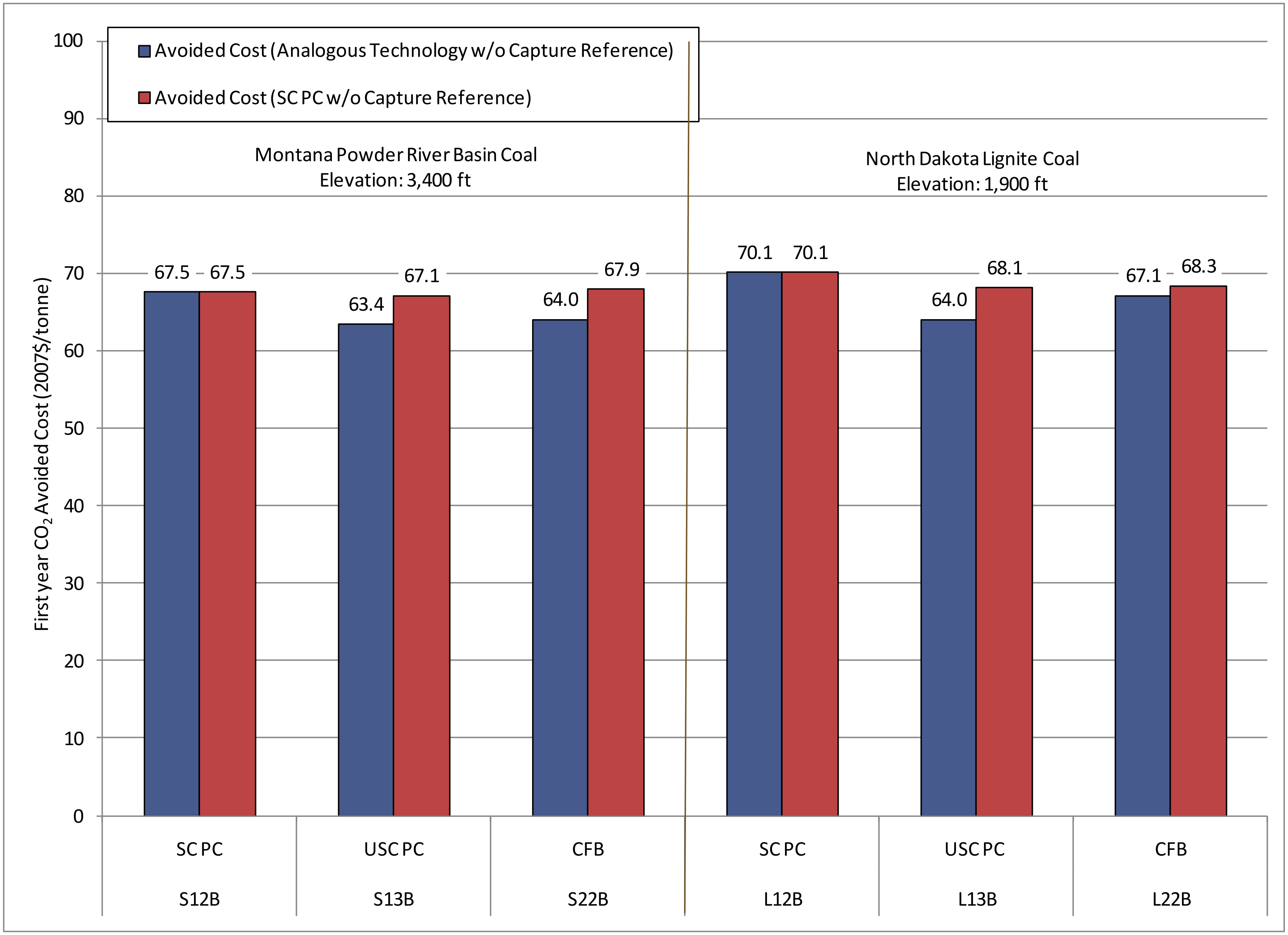


Exhibit 7-5 Cost of CO_2 Avoided



7.3 ENVIRONMENTAL PERFORMANCE

7.3.1 Emissions

The environmental targets were described in Section 2.3. The emissions of SO_2, NOx, and PM are shown in Exhibit 7-6 and mercury emissions are shown in Exhibit 7-7. CO_2 emissions are shown on a lb/MWh basis (both gross and net) in Exhibit 7-8. The following observations can be made:

- For the PC cases, emissions of SO_2 are controlled using a lime spray-dryer system that achieves a removal efficiency of 93 percent and satisfies the emissions target of 0.132 lb/MMBtu for the NDL cases. The SO_2 emissions are lower for the PRB coal cases because the sulfur loading to the FGD system is less while the removal efficiency remains the same. For the CO_2 capture cases, SO_2 exiting the spray dryer is further reduced to 10 ppmv in the CDR facility polishing scrubber resulting in extremely low emissions.
- For the CFB cases, emissions of SO_2 are controlled using in-bed limestone injection that achieves a removal efficiency of 94 percent and exceeds the emissions target of 0.132 lb/MMBtu. For the CO_2 capture cases, SO_2 exiting the baghouse is further reduced to 10 ppmv in the CDR facility polishing scrubber resulting in extremely low emissions.
- Particulate emissions are controlled using a pulse jet fabric filter, which removes over 99.9 percent of the particulates present in the flue gas.
- NOx emissions are the same for each PC case and controlled to about 0.2 lb/MMBtu using LNBs and OFA. An SCR unit further reduces the NOx concentration by 65 percent to 0.07 lb/MMBtu. For the CFB cases, combustion temperature controls and OFA are used to limit NOx emissions to 0.13 lb/MMBtu, and an SNCR unit further reduces the NOx concentration by 46 percent to 0.07 lb/MMBtu.
- For the PC cases, mercury emissions are constant for each coal type and significantly below the environmental targets. Emissions for PRB coal are less than NDL because of lower mercury in the coal and higher co-benefit capture. All PC cases used carbon injection designed to remove 90 percent of the mercury in the flue gas. The emissions shown in Exhibit 7-7 range from 0.6-1.2 lb/TBtu for the eight PC cases.
- For the CFB cases, co-benefit capture of mercury and carbon injection designed for 90 percent removal of mercury in the flue gas results in mercury emissions ranging from 0.3-0.48 lb/TBtu.
- CO_2 emissions, normalized to both net and gross power output, are shown in Exhibit 7-8. The emissions follow a similar trend to the overall plant efficiency. The more efficient plants have lower emissions, and with identical CO_2 removal efficiencies, other than differences in normalized auxiliary power, the trends should mirror those seen in overall plant efficiency.

Exhibit 7-6 Emissions Profile

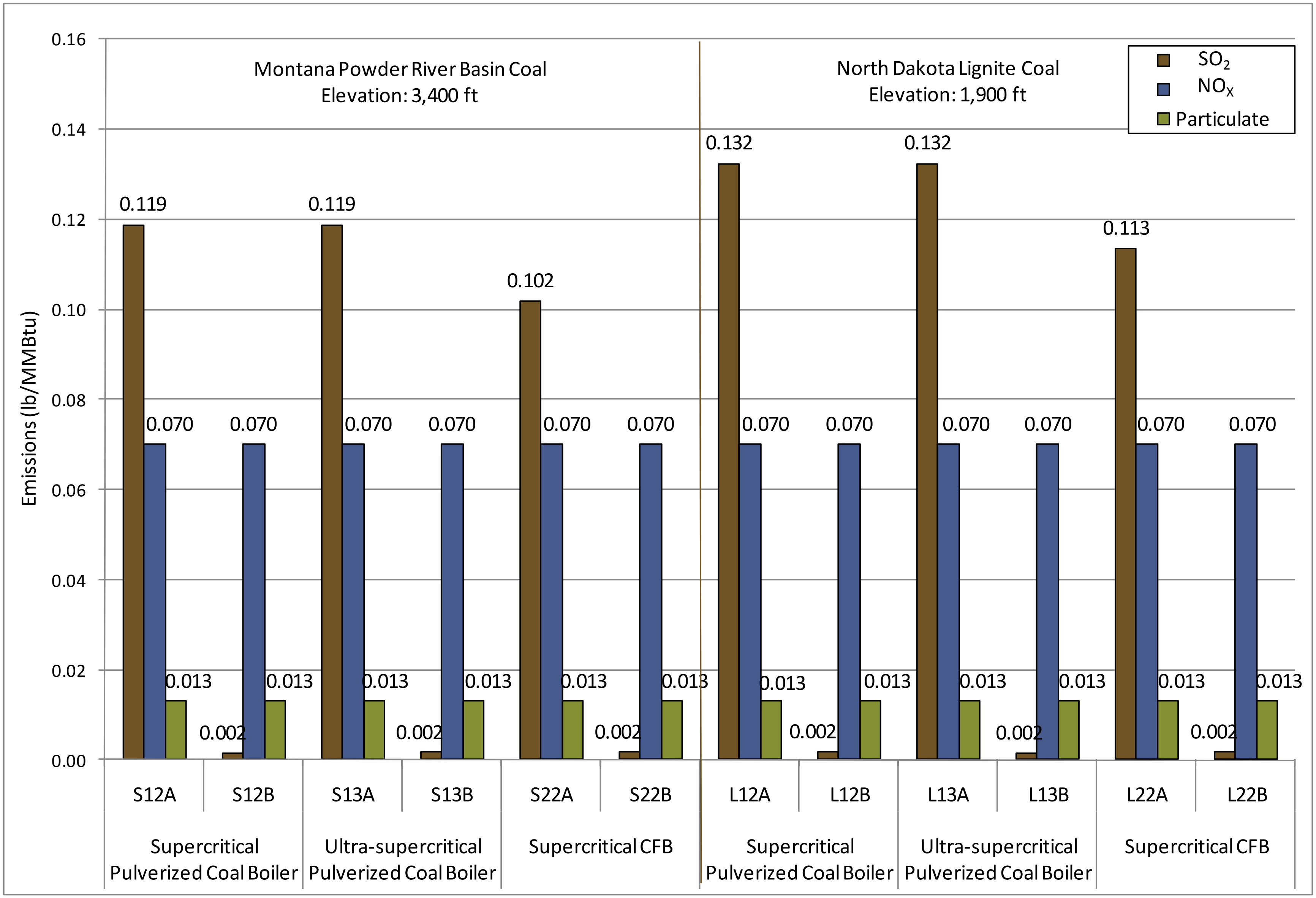


Exhibit 7-7 Mercury Emissions

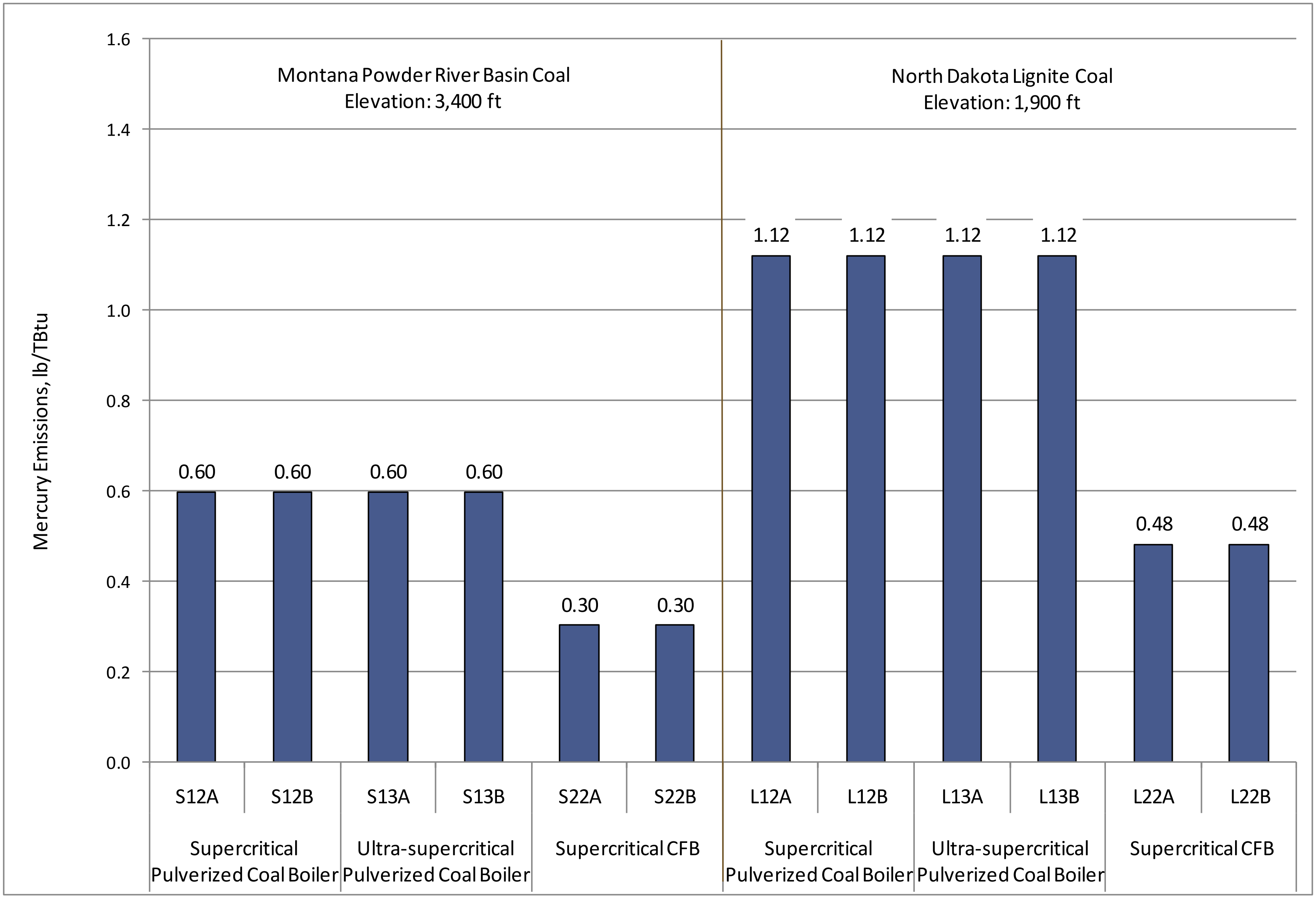
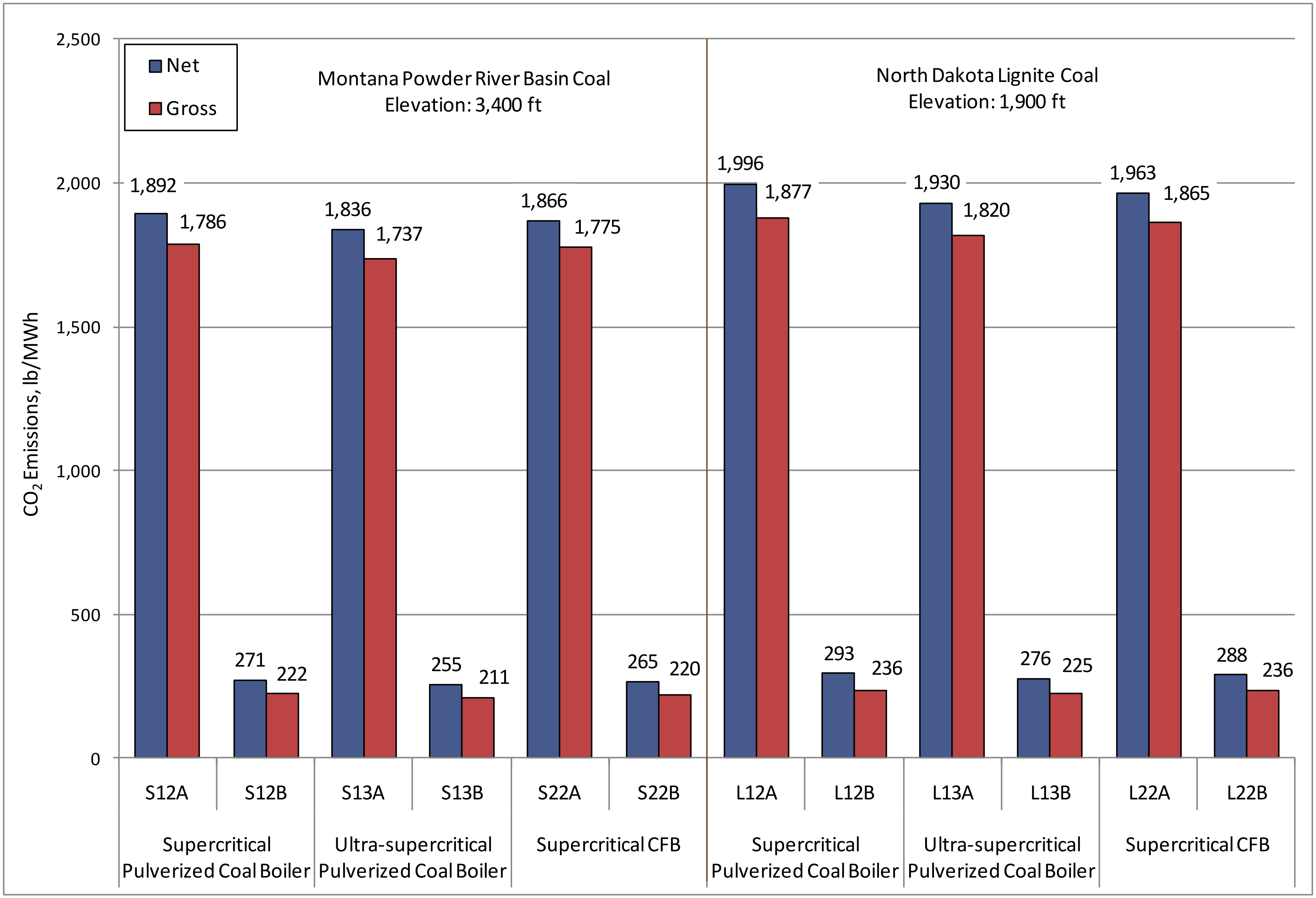


Exhibit 7-8 CO_2 Emission – lb/MWh



7.3.2 **Water Usage**

Exhibit 7-9 shows water usage values from a process perspective. Water demand, internal recycle, and water withdrawal, all normalized by net output, are shown. Water demand is the gross water required by the process. Internal recycle is water obtained from the process that is recycled to partially supply the demand. Water withdrawal is the net water required to supply the demand for the process. Half of the withdrawal is obtained from a municipal water system and half from wells. The following observations can be made:

- For the non-capture cases, the raw water withdrawal is similar for both fuels. There is minimal internal recycle so both the water demand and the water withdrawal are nearly equal in the PRB and NDL coal cases.
- The use of the parallel wet/dry cooling system reduces water demand relative to an all wet cooling system. For the non-capture PC cases, the reductions are approximately 6.8 m^3/min (1,760 gpm) and 6.4 m^3/min (1,700 gpm) for the SC and USC cases respectively, resulting in a 46 percent reduction. For the non-capture CFB cases, the reductions are approximately 6.6 m^3/min (1,730 gpm) resulting in a 49 percent reduction. For the PC CO_2 capture cases, the reductions are 4.8 m^3/min (1,270 gpm) and 4.3 m^3/min (1,130 gpm) resulting in only a 19 percent reduction. For the CFB CO_2 capture cases, the reductions are approximately 4.8 m^3/min (1,250 gpm) resulting in an 18 percent reduction. The water savings are less in the CO_2 capture cases because a significant amount of extraction steam is used in the Econamine system and therefore not condensed in the surface condenser.
- The water demand is significantly greater for the CO_2 capture cases because of the significant cooling load required for the Econamine system. The Econamine cooling load is provided by the wet cooling tower system and does not benefit from the dry cooling system.

Exhibit 7-10 shows water usage values from an environmental perspective. Water withdrawal, discharge, and consumption are shown, all normalized by net output. Water discharge is water from the system that would be discharged to permitted outfalls or with the proper treatment could be used to reduce the water withdrawal. Water consumption is the net amount of water extracted from the environment.

- For all cases, the discharge represents approximately 25 percent of the water withdrawal. This is because the cooling tower blowdown produces nearly all, if not all, of the water discharge. The blowdown is calculated based on a cooling tower cycles of concentration of 4. Since the cooling tower is the largest consumer of water, the discharge as a percentage of water withdrawal is approximately equal to the inverse of cycles of concentration.

Exhibit 7-9 Normalized Water Usage – Process Perspective

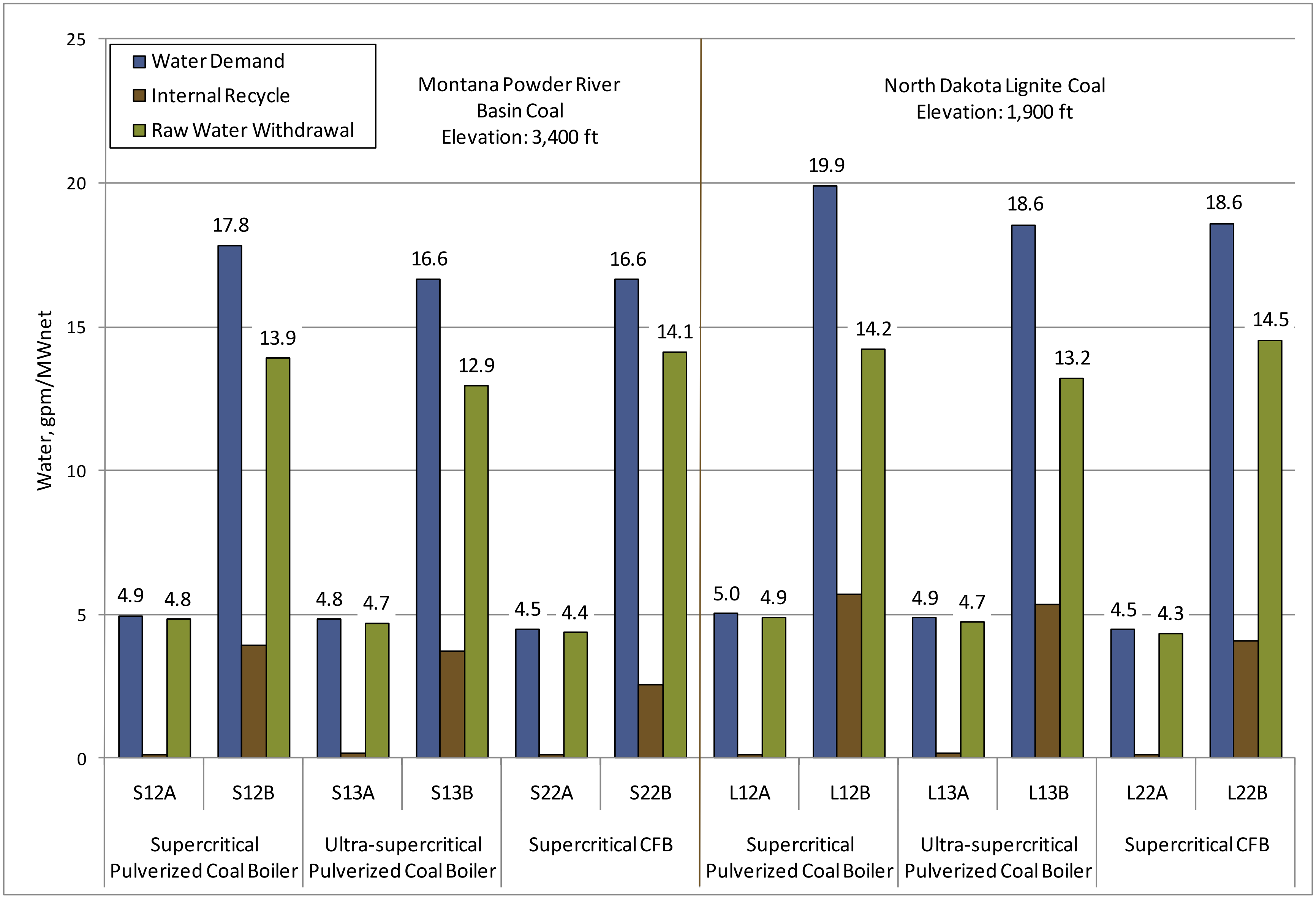
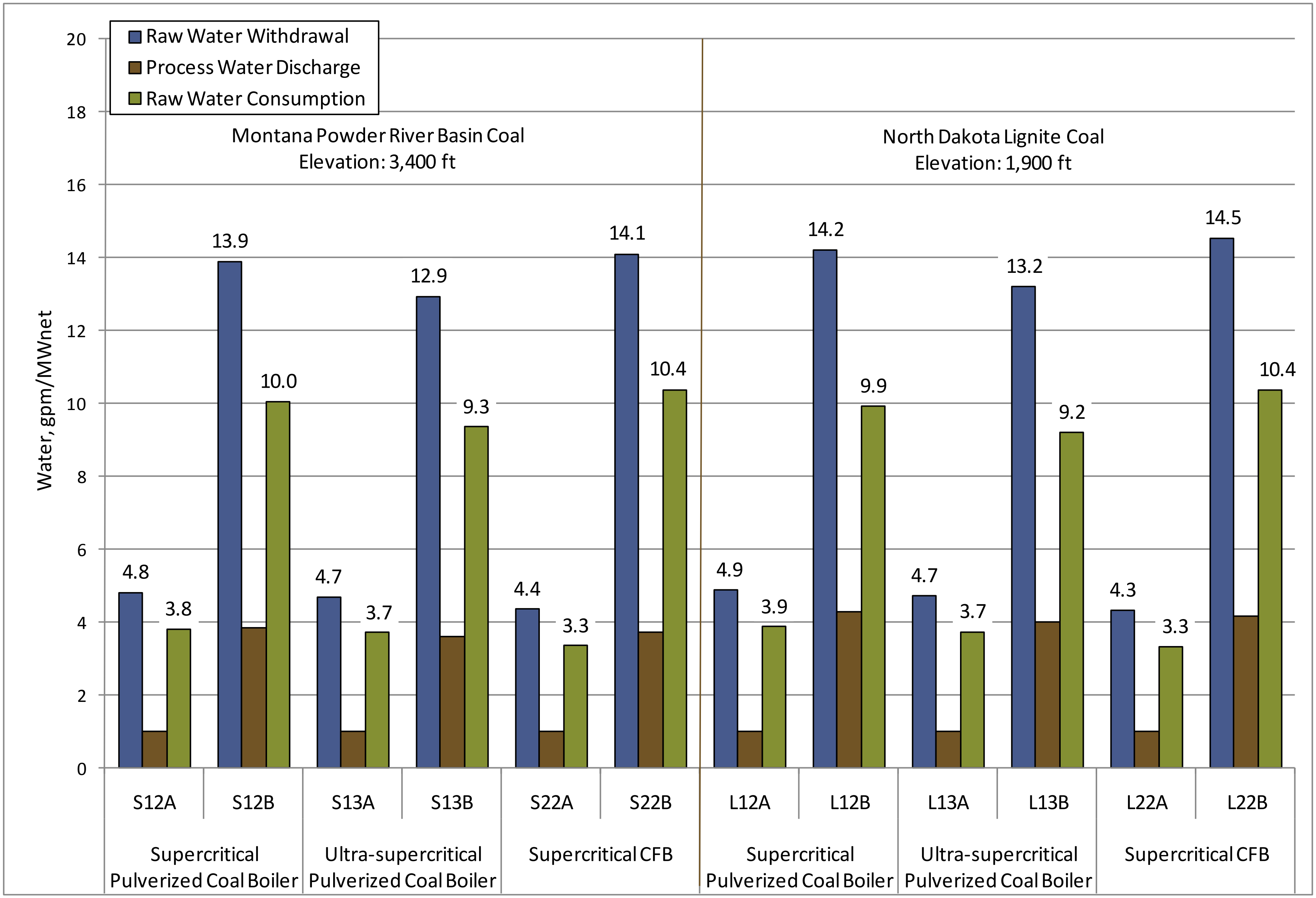


Exhibit 7-10 Normalized Water Usage – Environmental Perspective



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