Cost and Performance for Low-Rank Pulverized Coal Oxycombustion Energy Plants

DOE/NETL-401/093010

Final Report

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Disclaimer

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NETL Contact:

Michael Matuszewski

Systems Analyst

Office of Systems, Analyses and Planning

National Energy Technology Laboratory

www.netl.doe.gov

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PREPARED BY:

Research and Development Solutions, LLC (RDS)

UPDATED BY:

Energy Sector Planning and Analysis (ESPA)

John L. Haslbeck, Booz Allen Hamilton

Charlie Zhang, formerly Booz Allen Hamilton

Robert D. Brasington, formerly Parsons Corporation

Mark C. Woods, Booz Allen Hamilton

Eric G. Lewis, Booz Allen Hamilton

James Black, formerly Parsons Corporation

Allison Kyle, Booz Allen Hamilton

Marc Turner, Booz Allen Hamilton

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The Babcock & Wilcox Company (B&W)

Air Liquide

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The authors wish to acknowledge the excellent guidance, contributions, and cooperation of the NETL staff, particularly:

Michael Matuszewski, NETL Technical Monitor

James Black, Lead, Combustion-Based Processes Team, Office of Systems, Analyses and Planning (OSAP) Systems Division

John Wimer, Director of OSAP Systems Division

LIST OF ACRONYMS AND ABBREVIATION

AACE	Association for the Advancement of Cost Engineering
acfm	Actual cubic feet per minute
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASU	Air separation unit
BACT	Best available control technology
BFD	Block flow diagram
BFW	Boiler feed water
Btu	British thermal unit
CAA	Clean Air Act
CF	Capacity factor
CFB	Circulating fluidized bed
cfm	Cubic feet per minute
CMB	Circulating moving bed
CO_2	Carbon dioxide
COE	Cost of electricity
CPU	Compression and Purification Unit
CS	Carbon steel
CWT	Cold water temperature
DCC	Direct contact cooler
DCS	Distributed control system
DOE	Department of Energy
DRB	Dual register burner
EOR	Enhanced oil recovery
EPA	Environmental Protection Agency
EPC	Engineering, Procurement, and Construction
EPCM	Engineering, Procurement, Construction and Management
EPRI	Electric Power Research Institute
FDA	Flash dryer absorber
FD	Forced draft
FG	Flue gas
FGD	Flue gas desulfurization
FGR	Flue gas recirculation
FOAK	First of a kind
fpm	feet per minute
FRP	Fiberglass-reinforced plastic
GAN	Gaseous nitrogen
GHG	Greenhouse gas
GOX	Gaseous oxygen
gpm	Gallons per minute
GJ	Gigajoule
h, hr	Hour
H_2	Hydrogen
HCl	Hydrochloric acid
HHV	Higher heating value

HP	High pressure
HRSG	Heat recovery steam generator
HVAC	Heating, ventilating, and air conditioning
HWT	Hot water temperature
Hz	Hertz
IEA	International Energy Agency
ID	Induced draft
IEEE	Institute of Electrical and Electronics Engineers
IGCC	Integrated gasification combined cycle
IP	Intermediate pressure
ISO	International Standards Organization
ITM	Ion transport membrane
kV	Kilovolt
kW	Kilowatt
kWe	Kilowatts electric
kWh	Kilowatt-hour
LAER	Lowest achievable emission rate
lb	Pound
LCOE	Levelized cost of electricity
LHV	Lower heating value
LNB	Low NO_x burner
LP	Low pressure
lpm	Liter per minute
MCR	Maximum continuing rating
md	millidarcy (a measure of permeability)
MEA	Monoethanolamine
MHz	Megahertz
MMBtu	Million British thermal units (also shown as 10^6 Btu)
MMBtu/hr	Million British thermal units per hour (also shown as 10^6 Btu/hr)
MPa	Megapascals absolute
MVA	Mega volt amp
MW	Molecular weight
MWe	Megawatt electric
MWh	Megawatt-hour
NETL	National Energy Technology Laboratory
N/A, n/a	Not applicable
NAAQS	National Ambient Air Quality Standards
NFPA	National Fire Protection Association
Nm^3	Normal cubic meter
Nm^3/d	Normal cubic meter per day
NOx	Oxides of nitrogen
NPSH	Net positive suction head
NSPS	New Source Performance Standards
NSR	New source review
O&M	Operations and maintenance
OFA	Overfire air

OFO	Overfire oxygen
OP/VWO	Over pressure/valve wide open
OSHA	Occupational Safety and Health Administration
PA	Primary air
PC	Pulverized coal
PFD	Process flow diagram
PM	Particulate matter
POTW	Publicly owned treatment works
ppmvd	Parts per million by volume, dry
PRB	Powder River Basin
PSA	Pressure Swing Adsorption
PSD	Prevention of Significant Deterioration
psia	Pounds per square inch absolute
psig	Pounds per square inch gage
RDS	Research and Development Solutions, LLC
RO	Reverse osmosis
SC	Supercritical
scfm	Standard cubic feet per minute
SCR	Selective catalytic reduction
SNCR	Selective non-catalytic reduction
SO_2	Sulfur dioxide
ST	Steam turbine
STG	Steam turbine generator
TBtu	Trillion (Tera) Btu (10^{12} Btu)
TPC	Total plant cost
tpd	Tons per day
tph	Tons per hour
ton	2000 pounds
tonne	1000 kg
TSA	temperature swing adsorption
TS&M	Transport, storage, and monitoring
USC	Ultra-Supercritical
WG	Water gauge

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EXECUTIVE SUMMARY

BACKGROUND

As it becomes increasingly likely that future carbon dioxide (CO_2) emissions will be regulated in some fashion, new processes are being developed to capture CO_2 from the flue gas of fossil fuel-fired power plants. The commercially available method for capturing CO_2 from a conventional pulverized coal (PC)-fired boiler is the use of an amine-based system to absorb CO_2 from the flue gas stream, and its subsequent regeneration to produce a nearly pure product stream. An alternative method to capture CO_2 is to use oxygen rather than air as the oxidant in the combustion process, which yields a flue gas stream composed primarily of CO_2 and H_2O. By removing the water, a nearly pure CO_2 stream can be produced. This approach, known as oxyfuel or oxycombustion, is the subject of this systems analysis study.

The objective of this report is to present an independent assessment of the cost and performance of low-rank coal oxycombustion power systems, specifically PC and circulating fluidized bed (CFB) plants, using a consistent technical and economic approach that accurately reflects current market conditions for plants starting operation in 2015.

This report summarizes the results of a total of 17 power plant cases. In each case, heat and material balances were generated using Aspen Plus® software, major equipment specifications were developed, and capital and operating cost estimates were completed. In all cases, the feed rate for Powder River Basin (PRB) sub-bituminous coal and Beulah-Zap lignite coal was adjusted as necessary to maintain a nominal net plant output of 550 MW.

The work was a collaborative effort, with technical and cost information on the oxycombustion boiler provided by Babcock & Wilcox and information on the cryogenic distillation process and CO_2 purification and compression process provided by Air Liquide. The balance of plant designs, costs, and cost rollups were originally done by Research and Development Solutions, LLC (RDS). The report was subsequently updated by Booz Allen Hamilton Inc. Technical guidance was provided by the Department of Energy's National Energy Technology Laboratory (NETL). In each case, a 20-year levelized cost of electricity (LCOE) was calculated and is the figure of merit.

A total of 17 cases were examined, six of which are air-fired, supercritical (SC), non-capture cases taken from a separate study (Low Rank Coal Fossil Energy Combustion Process Power Plants [1]) and included here for reference. The other 11 cases in this report include eight new cases utilizing PRB sub-bituminous coal as a fuel and three additional cases involving Buelah-Zap lignite coal. Both supercritical (SC) 24.1MPa/593°C/593°C (3,500 psig/1,100°F/1,100°F) and ultra-supercritical (USC) 27.6MPa/649°C/649°C (4000 psig/1200°F/1200°F) steam cycles were analyzed.

The descriptions of these 17 cases are summarized in Exhibit ES-0-1. In all oxycombustion cases, cryogenic oxygen purity of 95 percent is assumed (see Exhibit ES-1).

[1] Cost and Performance Baseline for Low-Rank Coal Fossil Energy Combustion Process Power Plants with and without CO_2 Capture, DOE/NETL-401/011409, publication expected in 2010.

Exhibit ES-0-1 Case Descriptions

Case	Boiler Technology psig/°F/°F	Coal Type	Oxidant	Sulfur Removal/Recovery	CO_2 Purification	CO_2 Capture	Notes
S12A	Supercritical PC 3500/1100/1100	PRB	Air	Dry FGD	None		From LR Study
S12C			95% Oxygen	Co-sequestration	Drying Only	90%	New
S12D				Dry FGD	Drying Only		New
S12DS1				Dry FGD	Drying Only		New - Sensitivity Case - ISO conditions
S12DS2				Dry FGD	Drying Only		New - Sensitivity Case - ISO conditions and same ASU as Bituminous Oxycombustion Study
S12E				Dry FGD	Partial flash (~1% O_2)		New
S12F				Dry FGD	Cryogenic distillation		New
L12A	Supercritical PC 3500/1100/1100	Lignite	Air	Dry FGD	None		From LR Study
L12F			95% Oxygen		Cryogenic distillation	90%	New
S13A	Ultra-supercritical PC 4000/1200/1200	PRB	Air	Dry FGD	None		From LR Study
S13F			95% Oxygen		Cryogenic distillation	90%	New
L13A	Ultra-supercritical PC 4000/1200/1200	Lignite	Air	Dry FGD	None		From LR Study
L13F			95% Oxygen		Cryogenic distillation	90%	New
S22A	Supercritical CFBC 3500/1100/1100	PRB	Air	FDA (Alstom)	None		From LR Study
S22F			95% Oxygen		Cryogenic distillation	90%	New
L22A	Supercritical CFBC 3500/1100/1100	Lignite	Air	FDA (Alstom)	None		From LR Study
L22F			95% Oxygen		Cryogenic distillation	90%	New

Note: An "S" in case names stands for sub-bituminous coal; "L" stands for lignite coal.

PERFORMANCE

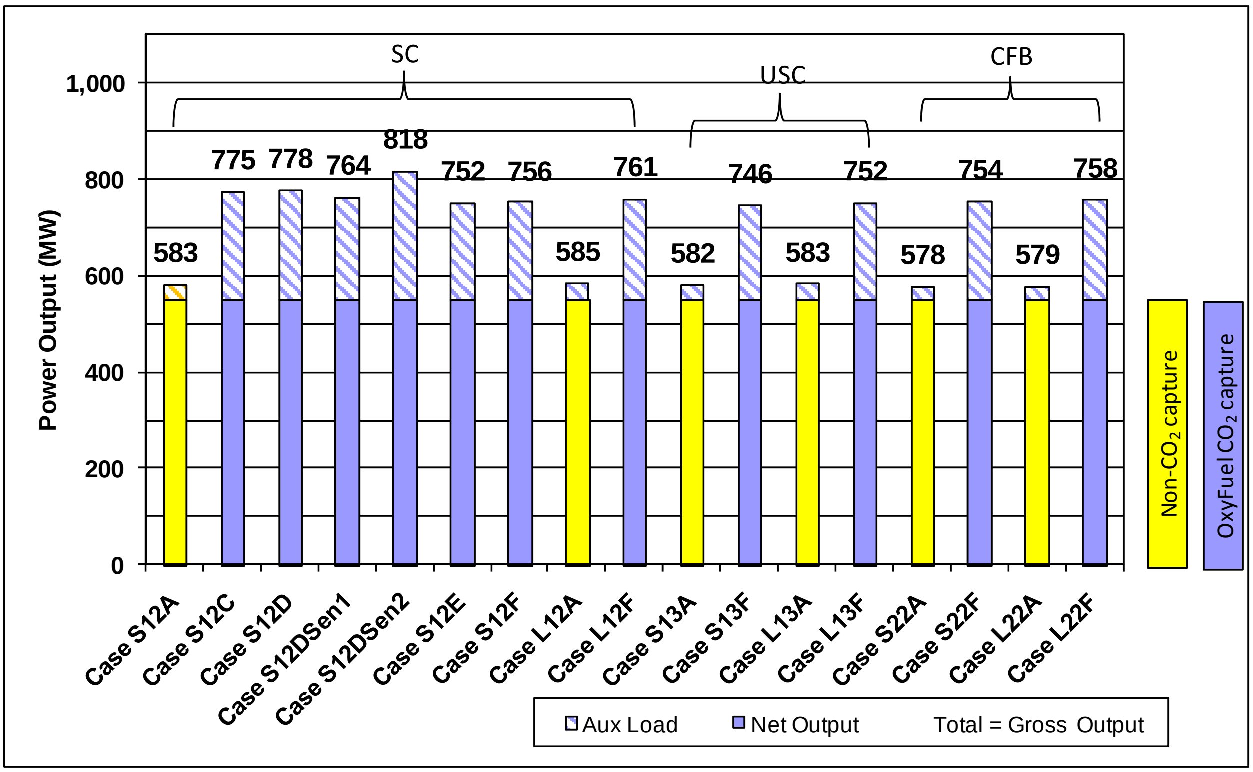
Gross Output

Gross power, auxiliary load and net power are shown graphically for all cases in Exhibit ES-0-2. The gross power output varies among cases, since the coal feed rate was adjusted to give a constant net power output of approximately 550 MW_e.

The gross output for all oxycombustion cases is significantly higher than that of the air-fired cases. Added auxiliary load is required in the oxycombustion cases to operate the Air Separation Unit (ASU) and the CO_2 Compression and Purification Unit (CPU). The auxiliary load in the air-fired cases averages 31 MW_e; the auxiliary load in the oxycombustion cases averages 214 MW_e. The 214 MW_e for the oxycombustion cases is equal to 28% of gross power output (average for all cases). This is the energy penalty paid to accomplish 90% CO_2 capture and sequestration.

Among the oxycombustion cases auxiliary load varies with coal type, combustor type and type of ASU. Auxiliary load is slightly higher (1-2%) for lignite coal since the heat content of lignite coal is lower than PRB and, therefore, cases using lignite require a higher coal feed rate to achieve the same net power output. The higher coal feed rate requires more auxiliary power for coal processing and handling. The auxiliary load for the USC steam cycle is 5% lower than the SC steam cycle (comparing Cases S12F and S13F). This difference is due to the more energy efficient operation of this advanced steam cycle. The auxiliary load for the CFBC is also 5% lower than SC. This is due to the reduced complexity of the flue gas processing equipment in the CFBC as compared to the SC. The auxiliary load varies with the type of ASU used. Recent technological advances by Air Liquide have reduced the auxiliary load required for the ASU. This difference is shown by comparing Case S12DSen2 (old design) with Case S12D (new design). The auxiliary load for Case S12DSen2 is 268 MW_e as compared to 228 MW_e for Case S12D, a 15% reduction. This reduction is accomplished with an increase in capital and operating costs (see Section 3.5).

Exhibit ES-0-2 Power Output Summary



Energy Efficiency

Net plant energy efficiencies for all cases are shown in Exhibit ES-0-3.

The energy penalty associated with capturing and compressing CO_2 can be seen by comparing Case S12A (air-fired, non-capture) with Case S12D (oxycombustion case with 90% CO_2 capture). The net plant efficiency for Case S12D is 27% higher than Case S12A (38.7% versus 30.5%). On average for all cases, adding CO_2 capture decreases energy efficiency by 7 to 9 absolute percentage points or ~21 percent on a relative basis. For comparison, the CO_2 capture efficiency penalty for an amine scrubbing system (post-combustion capture) is ~ 11 absolute percentage points or ~27 percent relative [1].

Two cases examine the effect of ambient conditions on energy efficiency. Case S12D uses ambient conditions typical in Montana; Case S12DS1 uses the International Standards Organization (ISO) ambient conditions. The cases are otherwise identical. The energy efficiency of Case S12DS1 is lower than S12D by 0.1% absolute percentage points due to the negative effect of higher temperature on boiler efficiency under ISO conditions.

Two cases examine the effect of an improved ASU design. Case S12DS2 uses an ASU design employed in a previous study of oxycombustion systems using bituminous coal [2]. Subsequently Air Liquide developed an improved ASU design that uses less energy per ton of oxygen produced. All cases except S12DS2 use the improved ASU design. Comparing Cases S12DS2 and S12D shows that the improved ASU design results in an 8% improvement in overall net plant energy efficiency. Net plant energy efficiency for Case S12DS2 is 28.1% as compared to 30.5% for Case S12D.

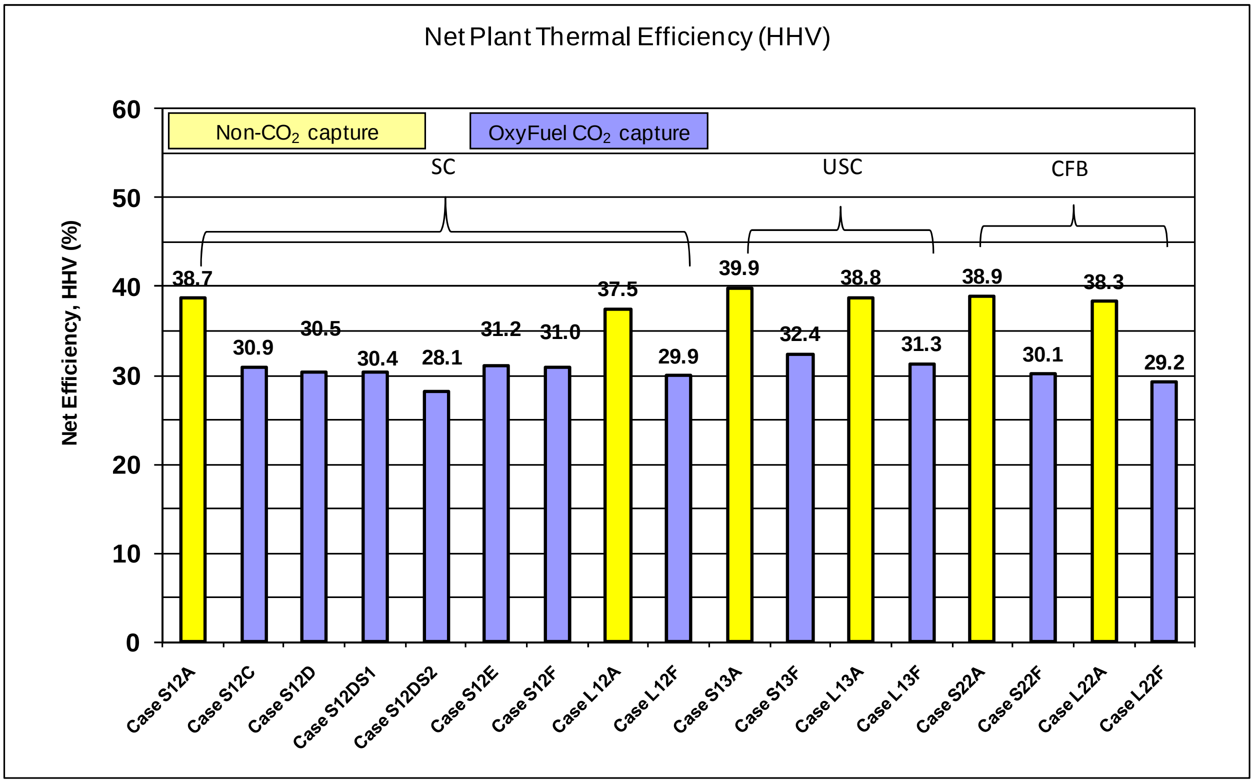
Three cases examine the effect of CPU design. In Case S12C, the captured CO_2 is dried during compression. In Case S12E, the captured CO_2 is subjected to partial condensation. Partial condensation produces a higher purity CO_2 stream, which allows CO_2 to be pumped (instead of compressed) pipeline transport. Partial condensation results in slightly less energy needed to compress the CO_2 stream resulting in an increase in overall net plant efficiency from 30.9% (dried only) to 31.2% (partial condensation). Case S12F uses a cryogenic distillation CPU design. Cases S12F and S12E are identical except for the CPU design. Cryogenic distillation produces a higher purity CO_2 stream than partial condensation but requires more energy to purify the CO_2 stream (see Section 3.6). This slightly reduces overall net plant energy efficiency to 31.0% (Case S12F).

Case S13F employs an ultrasupercritical (USC) steam cycle. Case S12F employs a supercritical (SC) steam cycle. Case S22F employs a SC circulating fluidized bed combustor (CFBC). Otherwise the cases are identical. The energy efficiency of Case S13F is 32.4%; the efficiency of Case S12F is 31.0%, a difference of approximately 5%. This improvement is due to the higher boiler efficiency achieved at the higher steam pressure and temperature conditions in the USC steam cycle. The energy efficiency of the SC CFBC (Case S22F) is 30.1%, similar to the SC.

Case S13F has the highest overall net plant energy efficiency of all the oxycombustion cases studied; however, the USC steam conditions are significantly more aggressive than those currently used in a conventional power plant. These USC steam cycle conditions are considered advanced or next generation, and were chosen to be consistent with the goals of an industry consortium for advanced material development. USC plant efficiencies are generally estimated to be 2 to 3 percentage points higher than comparable SC plant designs.

Energy efficiency varies with coal type. More lignite is needed to produce a given amount of power, since the higher heating value (HHV) of lignite is 27% less than the HHV of PRB. Higher coal throughput increases the amount of energy needed to transport and process the coal. This results in a decrease in net plant efficiency from 31.0% to 29.9% (comparing Cases S12F and L12F).

Exhibit ES-0-3 Plant Efficiency



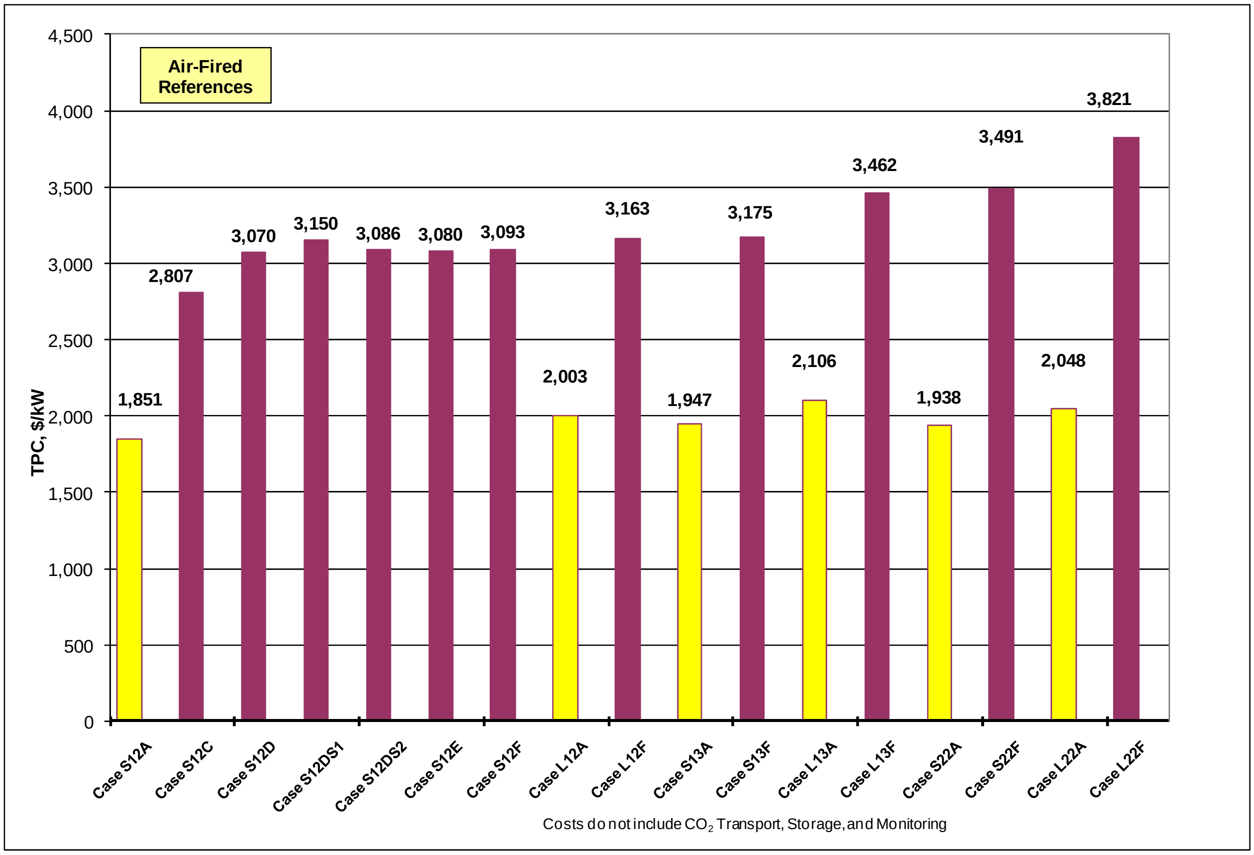
COST RESULTS

Total Plant Cost

The total plant costs (TPC's) for all cases are shown in Exhibit ES-0-4. The boundary limit is the pressurized CO_2 CPU discharge into the CO_2 pipeline. CO_2 transport, storage, and monitoring (TS&M) costs are not included in the TPC, but are included in the levelized cost of electricity (LCOE) below. The TPC's include the overnight cost of construction plus process contingencies for developing technologies. The TPC also includes project contingencies in the range of 15 to 20 percent, with the capture cases being higher than the non-capture cases. All costs are in June 2007 dollars and are for "greenfield" construction located at a generic site in either Montana (PRB cases) or North Dakota (lignite cases).

The TPC of the oxycombustion cases with contingencies is higher than the equivalent air-fired cases (comparing all "A" series cases with all "F" series cases). For USC and SC cases, the TPC is 58 to 67% higher in the oxycombustion cases. For the CFBC, the TPC is 80 to 87% higher. The higher cost differential in the CFBC cases is attributable to higher process contingencies which are applied to account for the fact that SC CFBC has never been demonstrated at any size near commercial scale. If all contingencies are removed, the cost differential is reduced to 18 to 25% for USC and SC cases and 43-47% for CFBC cases. This cost differential is primarily the added cost of capturing and compressing the CO_2 by adding an ASU, oxycombustor and CPU to the conventional air-fired unit.

Exhibit ES-0-4 Total Plant Cost (including contingencies)



Levelized Cost of Electricity

The 20-year LCOE was calculated for each case using the economic parameters shown in Exhibit ES-0-5. The cases were divided into two categories, representing high-risk and low-risk projects undertaken at investor-owned utilities. 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. The non-capture SC PC cases were considered to be low risk.

Exhibit ES-0-5 Economic Parameters Used to Calculate LCOE

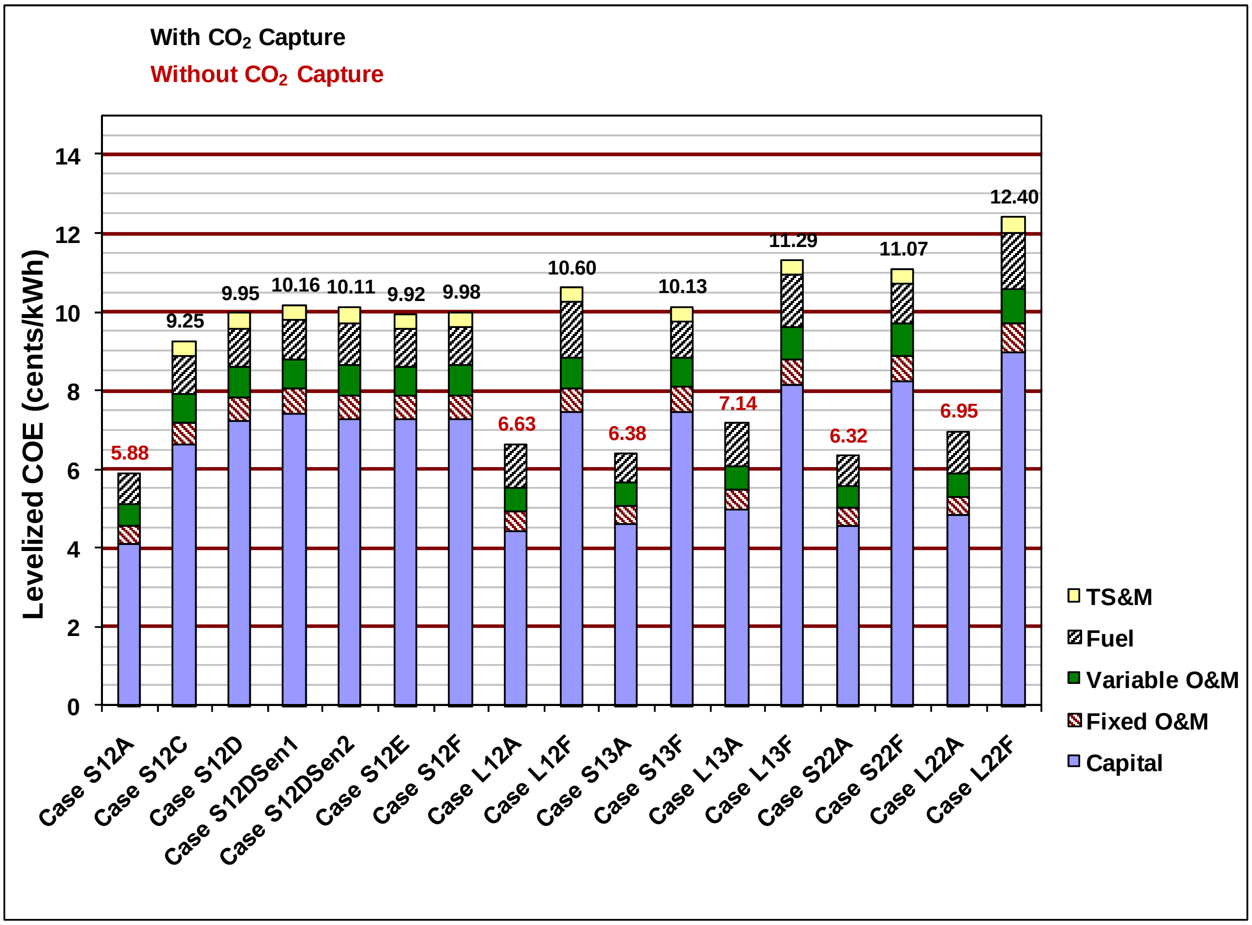
	High Risk	Low Risk	Nominal Escalation, %[a]
Capital Charge Factor	0.175	0.164	N/A
PRB Levelization Factor	1.1439	1.1485	1.73
Lignite Levelization Factor	1.3561	1.3685	3.81
General O&M Levelization Factor	1.1607	1.1660	1.91

[a] Nominal escalation is the real escalation plus the general annual average inflation rate of 1.91 percent.

The LCOE results are shown in Exhibit ES-0-6 with the capital cost, fixed operating cost, variable operating cost, and fuel cost shown separately. In the capture cases, the CO_2TS&M costs are also shown as a separate bar segment. The following conclusions can be drawn:

- CO_2 capture using oxycombustion technology significantly increases the LCOE. This increase is due to the addition of an ASU, an oxycombustor and equipment needed to capture and compress the CO_2 for pipeline transport. Comparing air-fired cases with similar oxycombustion cases (the "A" series with the "F" series of cases), the increase in LCOE ranges from 58 to 78%. The highest percentage increase occurs in the CFBC cases due to the relatively higher process contingencies applied to these cases.
- The LCOE is dominated by capital costs. The capital cost component is 69 to 75% of the LCOE for all cases.
- The fuel cost component is relatively minor in all cases, representing 10–11 percent of the LCOE costs in the PRB cases and 14–17 percent in the lignite cases.
- The TS&M component of LCOE in the CO_2 capture cases is about 4 percent for both PRB and lignite coal.

Exhibit ES-0-6 Levelized Cost of Electricity



Cost of CO_2 Removed/Avoided

The cost of CO_2 capture was calculated in two ways: the cost of CO_2 removed and the cost of CO_2 avoided, as illustrated in Equations ES-1 and ES-2, respectively.

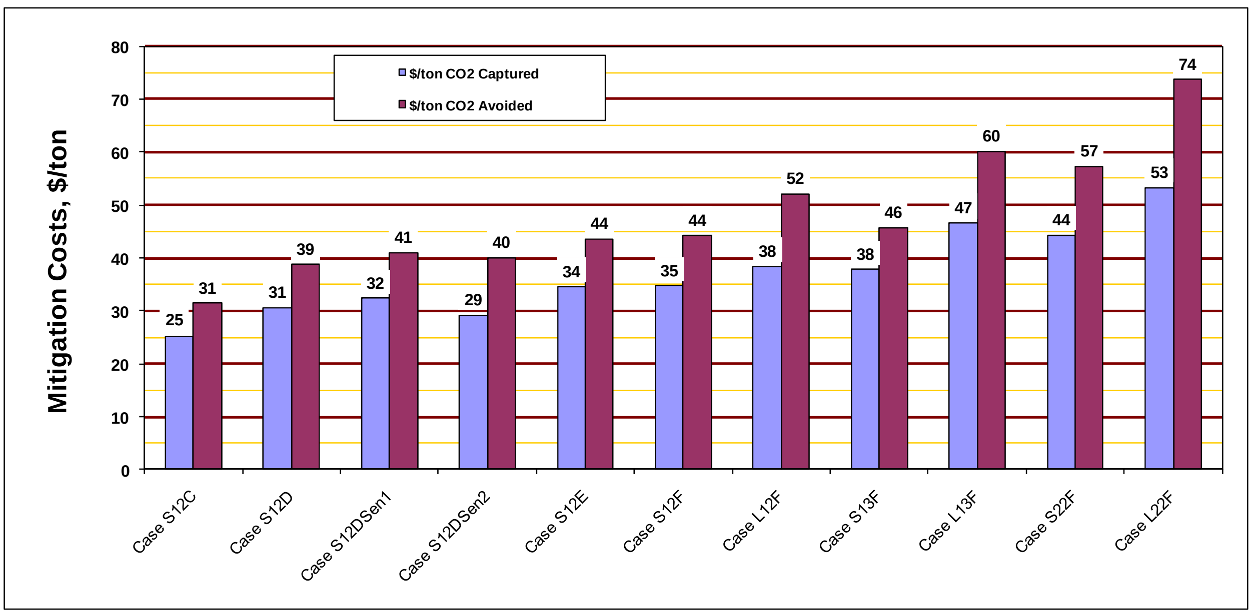
$$Removal\ Cost = \frac{\{LCOE_{with\ removal} - LCOE_{w/o\ removal}\}\ \$/MWh}{\{CO_2\ removed\}\ tons/MWh} \qquad \text{(ES-1)}$$

$$Avoided\ \ Cost = \frac{\{LCOE_{with\ removal} - LCOE_{w/o\ removal}\}\ \$/MWh}{\{CO_2 Emissions - CO_2 Emissions_{with\ removal}\}\ tons/MWh} \qquad \text{(ES-2)}$$

The results for the carbon capture cases are shown in Exhibit ES-0-7. The cost of CO_2 removed and CO_2 avoided are similar for SC and USC combustors for the same coal type. The cost rises for the CFBC combustor in an amount approximately equal to the rise in LCOE noted above.

The cost of CO_2 removed and CO_2 avoided is 20 to 30% higher for lignite coal. This is due to the lower heating value and higher cost of lignite ($/MMBtu). The lower heating value results in more coal required to produce a unit of net electrical energy. The higher coal throughput increases the cost of coal handling and processing.

Exhibit ES-0-7 CO_2 Captured and Avoided Costs



1. INTRODUCTION

The rising concentration of carbon dioxide (CO_2) in the environment has been widely documented. Levels of CO_2 in the atmosphere have shown a steady rise from approximately 300 parts per million (ppm) in 1940 to more than 370 ppm today [3]. At the same time, various studies have documented noticeable changes in climate in recent years and model predictions suggest that CO_2 levels play a role in these changes [4]. Given the potential implications surrounding global climate change and increasing concentrations of CO_2 in the atmosphere, technology and policy options are being investigated for mitigating CO_2 emissions.

Electric power generation represents one of the largest CO_2 contributors in the United States. Electricity consumption is expected to grow and fossil fuels will continue to be the dominant fuel source. Therefore, fossil fuel-based power generation can be expected to generate even more CO_2 emissions in the future. Coal fuels more than half of this electric power generation capacity and typically produces the cheapest electricity among all fuel sources. Compared to other fossil fuels, coal suffers inherent CO_2 disadvantages. Coal has higher carbon intensity than natural gas and many coal-fired power plants are older and less efficient than comparable natural gas plants. These disadvantages present a major challenge to coal-based power generation.

The U.S. Department of Energy (DOE) has adopted a goal of developing technology capable of capturing and sequestering 90 percent of the CO_2 produced in a pulverized coal (PC)-fired power plant, with an increase in the cost of electricity (COE) of no more than 35 percent over that for a non-capture-based plant. This target was based on a number of factors, most notably the history of costs associated with implementation of technologies for control of other pollutants, namely oxides of nitrogen (NO_x,) sulfur dioxide (SO_2), and particulate matter (PM). Technologies for control of these criteria pollutants are at a mature stage of development and have resulted in a 10 to 20 percent increase in COE. It is believed that mature carbon capture technology from PC power plants will show improvements to similar performance levels. Recent systems studies have shown that a 35 percent increase in COE is a good "stretch goal" that has a reasonable probability of being achieved through a combination of technology advances in oxygen production, advanced boiler materials and design, and co-sequestration.

Recent analyses carried out by Alstom Power [5], Air Liquide [6], International Energy Agency (IEA) GHG [7], and the National Energy Technology Laboratory's (NETL) Office of Systems Analysis and Planning have shown that oxycombustion with CO_2 capture is competitive with conventional air-based combustion and amine scrubbing for CO_2 control [2]. In addition, these studies identified potential areas for oxycombustion process improvements that have the potential to significantly decrease CO_2 mitigation costs and to approach the DOE Carbon Sequestration Program goal. The focus of the ALSTOM study was on new oxy-fired circulating fluidized bed (CFB) and circulating moving bed (CMB) units using both cryogenic and ion transport membrane (ITM) oxygen production approaches. Solids (limestone) were used to control combustion temperature (as well as provide sulfur removal), thereby limiting the amount of CO_2 recycle required. The Air Liquide study [6] focused on subcritical oxy-fired PC power plants via cryogenic oxygen production, and CO_2 recycle was employed for temperature control.

The main objectives of this study are to (1) provide a cost and performance baseline against which previous and future oxycombustion studies can be compared and (2) identify potential barriers to meeting the DOE goal of no more than a 35 percent increase in the cost of electricity for 90 percent CO_2 capture.

1.1 OXYCOMBUSTION CONCEPT

The objective of PC oxygen-fired combustion is to combust coal in an enriched oxygen environment by using pure oxygen diluted with recycled flue gas. In this manner, the flue gas is composed of primarily CO_2 and H_2O, so that a concentrated stream of CO_2 is produced by condensing the water in the exhaust stream. An advantage of oxycombustion is that it provides a high potential for a step-change reduction in CO_2 separation and capture costs because virtually all of the exhaust effluents can be captured and sequestered (co-sequestration). Assuming that trace species such as NO_x, carbon monoxide (CO), unburned hydrocarbons, and sulfur oxides (SO_x) do not interfere with the sequestration process and are below certain levels, they do not need to be controlled or scrubbed from the power plant exhaust. Enhanced oil recovery (EOR) has demonstrated successful hydrogen sulfide (H_2S)/CO_2 injection [8], and the question of how a combination of SO_x/NO_x/CO_2 affects compression, transport, and sequestration has been investigated to some extent in a recent study completed by the IEA GHG [9].

The four main benefits of oxycombustion technology with carbon capture and sequestration (CCS) are:

1. Pure oxygen is used for combustion and a highly concentrated CO_2 flue gas is produced, thereby reducing the CCS cost and lowering CCS energy consumption.
2. The technology uses conventional equipment already proven in the power generation industry.
3. NO_x reductions of 60–70 percent compared to air-fired combustion when using flue gas recirculation (FGR). This is mainly due to the FGR, with potential added benefit resulting from lower available nitrogen in the oxidant used for combustion. Some nitrogen is still present from the coal and from air infiltration.
4. Mercury ionization—potential for enhancement of mercury (Hg) removal in the baghouse and flue gas desulfurization (FGD) unit based on Babcock & Wilcox (B&W) data during Small Boiler Simulator (~5 million British thermal units per hour (MMBtu/hr) tests, which showed an increase in the oxidized Hg/elemental Hg ratio during oxycombustion with Powder River Basin (PRB) coal. Oxidized Hg is more efficiently captured in the baghouse and FGD unit.

Additional benefits include the following:

- The technology can readily be applied to new coal-fired power plants.
- Control during startup, shutdown, load following, and trips is very similar to a conventional PC plant.
- The key process principles have been proven in the past, including air separation and FGR.

The appeal of oxycombustion is tempered by several challenges, as described below:

1. Air infiltration into the boiler is an issue, as it dilutes the resulting flue gases. Various options are being investigated to minimize this, including improved boiler materials, sealants, control technologies, and membranes.
2. Combustion of fuels in pure oxygen would occur at temperatures too high for existing boiler or turbine materials. This issue is being addressed by diluting the oxygen using FGR, which results in an increase of the parasitic power load. Further developments aim

at reducing or suppressing the flue gas recycle, and are associated with developments of new boiler materials of construction.

3. The current high capital and operating costs of air separation units (ASUs).

All technologies for CO_2 capture from power plants increase the cost of electricity. In the PC-oxycombustion technology, a major part of this cost is due to the air separation plant (capital cost and power consumption). Therefore, all developments that target a decrease of the oxygen cost will improve the competitiveness of this technology. Such developments include steady improvements of the cryogenic distillation process (leading to a significant cost decrease, even in the past ten years), as well as investigations of alternative oxygen supply processes such as membranes.

At least four cases are modeled and analyzed for each technology. Two of these cases use PRB sub-bituminous coal, with and without CO_2 capture, and two other cases use North Dakota (ND) lignite coal, with and without CO_2 capture. The naming convention for the cases covered in this report is as follows:

- The first letter represents coal type: S = sub-bituminous (PRB) coal; L = lignite coal
- The two-digit number represents technology type: 12 = SC PC; 13 = USC PC; 22 = CFB
- The final letter—A, C, D, E, or F— is intended to symbolize differences in oxidant type and CO_2 purification. For instance, A is designated for air-fired/non-CO_2 capture case, C for oxycombustion/co-sequestration, D for CO_2 drying-only purification, E for CO_2 partial-flash purification, and F for cryogenic-distillation CO_2 purification.

This report covers all the combustion process cases described below:

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 S12C – This case includes a SC PC oxycombustion plant with co-sequestration of all flue gas constituents except water, which is removed by a dryer system. No FGD unit, SO_2 polishing scrubber, or CO_2 purification unit (CPU) is utilized. Rosebud PRB coal is the fuel and the plant is located in Montana.

Case S12D – This case is the same as Case S12C, except it includes a dry FGD and a SO_2 polishing scrubber before the CO_2-rich product stream enters the compression section.

Case S12DSen1 – This is the first sensitivity study based on Case S12D with International Standards Organization (ISO) condition.

Case S12DSen2 – This is the second sensitivity study based on Case S12D with ISO condition and using the same ASU as the bituminous oxycombustion study.

Case S12E – This case includes an SC PC oxycombustion plant with a dry FGD, SO_2 polishing scrubber, and a partial condensation CPU to reduce oxygen levels in the CO_2 product stream to approximately 0.4 molecule (mol)%. Rosebud PRB coal is the fuel and the plant is located in Montana, USA.

Case S12F – This case is the same as Case S12E, except it includes a cryogenic distillation CPU to reduce the oxygen concentration in the CO_2 product stream to 1 ppm.

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

Case L12F – This case is the same as Case S12F, except it uses ND lignite coal as the fuel and the plant is located in ND.

Case S13A – This case includes a USC PC plant without CO_2 capture. Rosebud PRB coal is the fuel and the plant is located at a generic site in Montana.

Case S13F – This case includes a USC PC oxycombustion plant with dry FGD, an SO_2 polishing scrubber, and a cryogenic distillation CPU to reduce oxygen levels in the CO_2 product stream to approximately 1 ppm. Rosebud PRB coal is the fuel and the plant is located at a generic site in Montana.

Case L13A – This case includes a USC PC plant without CO_2 capture. ND Lignite coal is the fuel and the plant is located at a minemouth site in ND.

Case L13F – This case includes a USC PC oxycombustion plant with dry FGD, an SO_2 polishing scrubber, and a cryogenic distillation CPU to reduce oxygen levels in the CO_2 product stream to approximately 1 ppm. ND Lignite coal is the fuel and the plant is located at a minemouth site in ND.

Case S22A – This case includes an SC circulating fluidized bed combustor (CFBC) with in-bed limestone injection for sulfur control. Rosebud PRB coal is the fuel and the plant is located in Montana. This case does not incorporate carbon capture. This case also will appear in Volume 3 of the Cost and Performance Baseline Series (Combustion Process Cases) and is presented here for comparison to the equivalent oxycombustion case (S22F).

Case S22F – This case includes an SC CFB oxycombustion plant as a means to concentrate and capture CO_2 emitted from the plant. There is no direct limestone injection into the combustor, but a back-end flash dryer absorber (FDA) that removes SO_2 from the flue gas stream. A cryogenic distillation CPU is utilized to reduce the oxygen concentration in the CO_2 product stream to 1 ppm. Rosebud PRB coal is the fuel and the plant is located in Montana.

Case L22A – This case includes an SC CFBC with in-bed limestone injection for sulfur control. ND lignite coal is the fuel and the plant is located at a minemouth site in ND. This case does not incorporate carbon capture. This case also will appear in Volume 3 of the Cost and Performance Baseline Series (Combustion Process Cases) and is presented here for comparison to the equivalent oxycombustion case (L22F).

Case L22F – This case is the same as Case S22F, except it uses ND lignite coal as the fuel and the plant is located at a minemouth site in ND.

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.

1.1.1 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 as that needed for the cases in this study, it is assumed that such a design will be possible in the near future. The coal feed rate was increased in the carbon 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 four SC and USC PC reference cases.

Chapter 5 provides the detailed results of the seven SC and USC PC cases.

Chapter 6 provides the detailed results of the six SC CFB cases.

Chapter 7 summarizes the results of the 17 combustion cases.

Chapter 8 contains the reference list.

2. GENERAL EVALUATION BASIS

For each of the plant configurations in this study, an AspenPlus® 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 Research and Development Solutions, LLC (RDS) based on simulation results and through a combination of vendor quotes and scaled estimates from previous design/build projects. Ultimately, a 20-year LCOE 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 ND. 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)[a]	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

[a] MPa = megapascals absolute, psia = pounds per square inch absolute

Exhibit 2-2 ND 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 in Montana (PRB coal) or ND (lignite)
Topography	Level
Size, acres	300
Transportation	Rail
Ash/Slag Disposal	Off Site
Water	Municipal (50 percent) / Groundwater (50 percent)
Access	Landlocked, 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 meters (4,055 feet)

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 sub-bituminous PRB coal from Montana and lignite coal from ND. The coal properties are from NETL's Coal Quality Guidelines and are shown in Exhibit 2-4 and Exhibit 2-5[10].

The first-year cost of coal used in this study is $0.72/gigajoules (GJ) ($0.7567/MMBtu) for PRB coal and $0.86/GJ ($0.9045/MMBtu) for lignite coal (2015 cost of coal in 2007 dollars). All coal costs are based on higher heating value (HHV). These costs were determined using the following information from the EIA's 2007 Annual Energy Outlook (AEO):

- The 2015 minemouth cost of PRB coal in 2005 dollars, $10.85/tonne ($9.84/ton), was obtained from Supplemental Table 113 of the EIA's 2007 AEO for western Montana medium-sulfur sub-bituminous coal. The 2015 minemouth cost of ND lignite coal in 2005 dollars, $12.52/tonne ($11.36/ton), was obtained from the same source.
- The 2015 cost of PRB coal was escalated from 2005 dollars to 2007 dollars using the gross domestic product (GDP), chain-type, price index from AEO 2007, resulting in a price of $11.43/tonne ($10.37/ton) or $0.57/GJ ($0.61/MMBtu)[11]. Similarly, the 2015 cost of lignite coal in 2007 dollars is $13.19/tonne ($11.97/ton) or $0.86/GJ ($0.90/MMBtu)
- Transportation costs for PRB coal were estimated to be 25 percent of the minemouth cost based on the average transportation rate for medium sub-bituminous coal from the western Montana region delivered to the mountain region[12]. The final delivered cost of PRB coal used in the calculations is $14.28/tonne ($12.96/ton) or $0.72/GJ ($0.76/MMBtu). The ND lignite plant was assumed to be located at the minemouth, so transportation costs are zero.

Exhibit 2-4 Montana Rosebud PRB, Area D, Western Energy Co. Mine, Sub-bituminous 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[a]	15.01	11.14
Total	100.0	100.0
Heating Value	**Dry Basis, (Dulong Calc.)**	**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[b]	Hg	0.081

Notes:
[a]By difference
[b]Mercury value is the mean plus one standard deviation using the Environmental Protection Agency's (EPA) ICR data

Exhibit 2-5 ND 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[a]	16.44	10.51
Total	100.0	100.0
Heating Value	**Dry Basis, (Dulong Calc.)**	**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[b]	Hg	0.116

Notes:
[a]By difference
[b]Mercury value is the mean plus one standard deviation using EPA's ICR data

- The 2015 minemouth cost of PRB coal in 2005 dollars, \$10.85/tonne (\$9.84/ton), was obtained from Supplemental Table 113 of the EIA's 2007 AEO for western Montana medium-sulfur sub-bituminous coal. The 2015 minemouth cost of ND lignite coal in 2005 dollars, \$12.52/tonne (\$11.36/ton), was obtained from the same source.

- The 2015 cost of PRB coal was escalated from 2005 dollars to 2007 dollars using the GDP chain-type price index from AEO 2007, resulting in a price of \$11.43/tonne (\$10.37/ton) or \$0.57/GJ (\$0.61/MMBtu). Similarly, the 2015 cost of lignite coal in 2007 dollars is \$13.19/tonne (\$11.97/ton) or \$0.86/GJ (\$0.90/MMBtu).
- Transportation costs for PRB coal were estimated to be 25 percent of the minemouth cost, based on the average transportation rate for medium sub-bituminous coal from the western Montana region delivered to the mountain region. The final delivered cost of PRB coal used in the calculations is \$14.28/tonne (\$12.96/ton) or \$0.72/GJ (\$0.76/MMBtu). The ND lignite plant was assumed to be located at the minemouth, so transportation costs are zero.

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 ND lignite.[13] It was further assumed that all of the coal Hg enters the gas phase and none leaves with the bottom ash or slag.

2.3 ENVIRONMENTAL TARGETS

The environmental targets for the study were considered on a technology- and fuel-specific basis. In setting the environmental targets for this study 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). This section will discuss the various environmental regulations evaluated for potential use in this study.

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[14].

The new NSPS standards apply to units with the capacity to generate greater than 73 megawatts (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 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

	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

Exhibit 2-6 lists requirements for new plants, or NSPS. 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 United States are classified as "non-attainment," so the plant site for this study was assumed to be in an attainment area.[15]

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 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 Hg in combination with sub-bituminous 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 per year mean annual precipitation according to the Department of Agriculture's most recent, publicly available, 30-year data, and dry units were defined as plants located in a county receiving 25 inches of precipitation or less. The sub-bituminous 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 inches of rainfall, and therefore the "dry unit" designation is used for the NSPS limit.[16, 17] 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
Sub-bituminous (wet units)	66×10^{-6} lb/MWh
Sub-bituminous (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's Information Collection Request (ICR) database. The ICR database has 137 records of Montana Rosebud sub-bituminous coal with an average Hg concentration of 0.056 ppm (dry) and a standard deviation of 0.025 ppm. There are 266 records for ND lignite from the Beulah seam with an average Hg concentration of 0.081 ppm (dry) and a standard deviation of 0.035 ppm.

2.3.1 Design Targets

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

Exhibit 2-8
Environmental Target

Pollutants	Environmental Target	NSPS Limit [a]	Type of Technology
Filterable PM	0.013 lb/MMBtu	0.015 lb/MMBtu	Fabric Filter
Sulfur Dioxide	0.132 lb/MMBtu	1.4 lb/MWh (0.134 lb/MMBtu)	Low-Sulfur Fuel and Dry FGD or Low-Sulfur Fuel and In-bed Limestone Injection
Nitrogen Oxides	0.07 lb/MMBtu	1.0 lb/MWh (0.095 lb/MMBtu)	LNB's, OFA and SCR or CFB with SNCR
Mercury, Sub-bituminous (PC only)	0.60 lb/TBtu (~ 5.0 x 10^{-6} lb/MWh)	97 x 10^{-6} lb/MWh [b] (9.6 lb/TBtu)	Co-benefit capture, low coal Hg content, and carbon injection
Mercury, Lignite (PC only)	1.12 lb/TBtu (~ 9.6 x 10^{-6} lb/MWh)	175 x 10^{-6} lb/MWh [b] (16.7 lb/TBtu)	Low coal Hg content and carbon injection
Mercury, Sub-bituminous (CFB only)	3.0 lb/TBtu (~ 25 x 10^{-6} lb/MWh)	97 x 10^{-6} lb/MWh [b] (9.6 lb/TBtu)	Co-benefit capture and low coal Hg content [18,19,20].
Mercury, Lignite(CFB only)	4.8 lb/TBtu (~ 41 x 10^{-6} lb/MWh)	175 x 10^{-6} lb/MWh [b] (16.7 lb/TBtu)	Co-benefit capture and low coal Hg content.[18,19,20]

Notes:

[a] NSPS limits shown are for new units. The values in parenthesis are calculated using a conversion of 10,475 Btu/kWh (lignite with capture), except for the mercury sub-bituminous limit, which uses 10,061 Btu/kWh (PRB with capture).

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

2.3.2 Engineering Options for Meeting Environmental Targets

The following engineering options are available to achieve the environmental targets:

2.3.2.1 Air-Fired PC Control Options

A fabric filter used in conjunction with dry FGD is expected to remove 99.97 percent of the particulate. The dry lime FGD (spray dryer absorber) is expected to remove 93 percent of the SO_2 in the flue gas and a combination of low NO_x burners (LNBs), overfire air (OFA), and selective catalytic reduction (SCR) is expected to control NO_x emissions to 0.07 lb/MMBtu.

The dry FGD system for SO_2 control was chosen for the following reasons:

- Water is typically a limited resource in western locations and the spray dryer absorber uses less water than a wet limestone FGD system.
- A survey of recently announced PC plants using sub-bituminous coals showed that 9 out of 11 proposed to use dry FGD.

- There is potential to use the highly alkaline ash as part of the reagent, thereby lowering operating costs.
- Removal efficiencies of dry FGD systems have been steadily increasing and 93 percent removal is now within a commercially viable range.[21]

The LNB and OFA system is assumed to reduce NO_x emissions to 0.20 lb/MMBtu exiting the boiler. The relatively high coal-water content of PRB and lignite coal moderates the flame temperature so that boiler NO_x emissions are lower than for bituminous coal cases. According to the NETL Coal Database, there are 15 boilers burning lignite coal and using LNB/OFA only for NO_x control, with an average emissions rate of 0.187 lb/MMBtu. There are 35 sub-bituminous boilers using LNB/OFA only, with an average NO_x emission rate of 0.237 lb/MMBtu.[22] The value of 0.20 lb/MMBtu was used for both coal types and represents the approximate average of the two. The SCR efficiency is assumed to be 65 percent, which results in overall NO_x emissions of 0.07 lb/MMBtu. There are currently 28 sub-bituminous-fired boilers with SCR, and their average NO_x reduction is 64 percent.[22] The SCR catalyst volume is based on a space velocity of 4,800 hr^{-1} (at standard conditions).

There are no lignite-fired boilers currently using SCR for NO_x reduction in the United States. SCR was proposed for TXU's Oak Grove Steam Electric Station, which would have used Texas lignite coal. The air permit was initially denied by two administrative law judges for several reasons, including the lack of SCR operating experience on lignite coals. The findings of the Texas Commission on Environmental Quality included the following concerns [23]:

- The high levels of ash in lignite coal would clog and degrade the SCR reactor and high levels of silica would erode and degrade the catalyst material on the surface of the SCR reactor.
- Lignite ash deposition problems are exacerbated by "popcorn," or large particle ash.
- There has been no commercial-scale testing or long-term use of SCR with lignite anywhere in the United States.
- In slipstream tests performed by the University of North Dakota, pressure drop across the catalyst was more significant with lignite coal than sub-bituminous coal.

Subsequently, the Texas commission overruled the administrative law judges on the basis that the judges had set too strict a standard for unproven methods of controlling emissions. According to the commission, TXU only needed to show "a reasonable expectation that the technology will work"[24]. The Oak Grove plant is to meet a NO_x emission limit of 0.08 lb/MMBtu, which will be subject to review and potential revision (downward) after two years of operation.

Despite the lack of actual operating experience, and based on the approval of the Oak Grove Air Permit, SCR is assumed to be a viable control option for lignite coal in this study.

The spray dryer absorber (SDA) used for both sub-bituminous and lignite coal cases employs a recycle stream composed of ash, unreacted lime, and reaction byproducts collected in the baghouse. The recycle ratio (recycled ash material/fresh lime) is 26 [25]. Assuming the SDA removes 20 percent of the incoming solids, the baghouse efficiency must be 99.97 percent to achieve the environmental target of 0.015 lb/MMBtu. The high removal efficiency is possible because much of the unreacted lime and reaction byproducts are of sufficient size that removal efficiency is essentially 100 percent.

Minimal mercury removal is achieved through co-benefit capture in the SCR, dry FGD, and fabric filter with sub-bituminous and lignite coals. An EPA report [26] estimates co-benefit capture to be 25 percent for sub-bituminous coal and 0 percent for lignite. Recent NETL test site studies [27,28] indicate 15–20 percent co-benefit capture for PRB and 5–10 percent for ND lignite. For this study, 0 percent co-benefit capture will be assumed for ND lignite and 15 percent for PRB. An injection system utilizing brominated carbon is included to reduce Hg emission by 90 percent beyond the co-benefit capture levels.

2.3.2.2 Oxycombustion PC Control Options

A fabric filter will be implemented in all oxycombustion cases and remove 99.97 percent of the PM in the flue gas. While the oxycombustion cases do not have the typical stack emissions as air-fired cases because of the implementation of a recycle stream, a fabric filter is necessary to prevent the buildup of particulates in the process and to protect downstream equipment.

Due to the configuration of oxycombustion cases, nitrogen is significantly reduced from the oxidant stream and is present only in the boiler due to inherent nitrogen in the coal, small amounts of nitrogen in the oxidant, and infiltration air. Current studies have shown that the reduction in NO_x emissions range from 50 percent to 89 percent for oxycombustion when compared to air-fired combustion with no SCR [29]. A value of 70 percent reduction in NO_x emissions for the oxycombustion cases was chosen, which results in a NO_x emissions rate of 0.2 lb/MMBtu exiting the boiler. This will be subsequently co-sequestered in the cases purifying CO_2 by drying only. The emission of NO_x vented to the atmosphere (partial flash Case S12E and cryogenic distillation Cases S12F, L12F, L13F, S22F, and L22F) by the CPU will be provided by Air Liquide. Assuming all the NO_x is vented to the atmosphere in these CO_2 purification cases, the NSPS NO_x requirement is still met.

Based on recent literature searches, there is no consensus on the use of an FGD with low-rank coal for oxycombustion [30]. The primary reasons that are cited, which allow no implementation of an FGD, are the low sulfur content of the study coal, the lack of stack emissions, and the presumed ability to co-sequester SO_2 in the CO_2 product stream. However, these studies indicate that many of the operating temperatures occur below the acid dew point and special considerations to equipment materials are necessary. Other studies implement an FGD system to prevent such corrosion issues and allow the use of standard materials of construction similar to air-fired PC cases.

It is assumed for the oxycombustion cases, excluding Case S12C (co-sequestration without an FGD), that a dry FGD system will be used to remove 93 percent of the SO_2 in the flue gas to prevent excessive corrosion of the system equipment. For Case S12C, no FGD is used to determine the cost differential of the more corrosion-resistant materials and the different performance characteristics from those of Case S12D (co-sequestration with use of an FGD) that uses materials similar to air-fired cases. Preliminary estimates indicate that 0.85 lb SO_2/MMBtu and 0.021 lb SO_2/MMBtu (assuming 66 percent flue gas recycle) will be co-sequestered for Cases S12C and S12D, respectively. The emission of SO_2 vented to the atmosphere (partial flash Case S12E and cryogenic distillation Cases S12F, L12F, L13F, S22F, and L22F) by the CPU will be provided by Air Liquide. Assuming all the SO_2 is vented to the atmosphere in the CO_2 purification cases, the NSPS SO_2 requirement is still met.

A dry FGD has several advantages over a wet FGD, when used in conjunction with low-rank coals and oxycombustion. The dry FGD utilizes less water than a wet FGD, which is of concern in this study as the location is the Western United States. A dry FGD also enables the secondary air recycle stream to be extracted after the induced draft (ID) fan at a higher temperature than a wet FGD. A wet FGD cools the exiting flue gas to its saturation temperature, whereas a dry FGD remains approximately 30°F above this temperature. This creates an exit temperature of approximately 185°F for the dry FGD and 135°F for the wet FGD. The secondary recycle stream does not have to be reheated for the dry FGD before entering the air preheater. The superheated flue gas from a dry FGD offers a thermodynamic advantage over the saturated flue gas from a wet FGD.

The same design assumptions used for the air-fired PC cases will be used for the oxycombustion PC cases with regard to mercury. Zero percent co-benefit capture will be assumed for ND lignite and 15 percent for PRB. For oxycombustion cases, no brominated carbon injection is necessary because it is assumed that the uncaptured mercury will be co-sequestered with the CO_2. Mercury should not pose a problem because it is present at extremely low levels [31]. Based on estimates from a standard 550–MW, low-rank-coal-fired power plant without capture, the co-sequestration of Hg for the cryogenic distillation cases will be 4.6 x 10-6 lb/MMBtu and 1.12 x 10-5 lb/MMBtu (assuming a 66 percent flue gas recycle) for sub-bituminous and lignite coal, respectively. These estimates assume that a negligible amount of Hg is captured in the desiccant dryer in the CO_2 purification unit with drying only. For the partial flash and cryogenic distillation cases, the Hg is released in the vent stream. Assuming all of the Hg is released in this stream, the NSPS Hg requirement is still met.

2.3.2.3 Air-Fired CFB Control Options

SO_2 emissions are controlled using in-bed limestone injection. Removal efficiencies equal to SDAs (93 percent) can be achieved at Ca/S ratios of 2-2.5. Since the selected removal efficiency is at the high end of the effective range, a Ca/S ratio was chosen near the high end of its range (2.4) [25,32,33].

NO_x emissions from CFB boilers are inherently low because of the relatively low bed-operating temperature of 1,600°F. The uncontrolled NO_x emissions are 0.10–0.15 lb/MMBtu, and a value of 0.13 lb/MMBtu was chosen for this study [22, 25] (for both PRB and lignite coals). The system uses selective non-catalytic reduction (SNCR) to further reduce NO_x emissions to 0.07 lb/MMBtu. The required SNCR reduction efficiency of 46 percent is well within the technology capability [34]. The ammonia slip is less than 2 parts per million by volume, dry (ppm) [32].

Particulate emissions are controlled by cyclones, which return over 99 percent of the entrained particulate to the fluidized bed, and by a downstream baghouse with an efficiency of 99.8 percent. It is assumed that the particulate loading at the baghouse inlet will result in emissions of 0.013 lb/MMBtu.

Co-benefit capture from a CFB with SNCR, a fabric filter, and either dry or wet FGD is estimated in an EPA report to be 57 percent for either sub-bituminous or lignite coal [26]. Given the lack of Hg data on utility-scale CFBs, the EPA estimate is used for co-benefit capture levels in all CFB cases. Mercury emissions are reduced to approximately 25 percent of NSPS limits without the use of carbon injection.

2.3.2.4 Oxycombustion CFBC Control Options

The oxycombustion CFBC cases implement the same control technologies as the air-fired cases, with the exception of SNCR. Due to the nature of oxycombustion cases, nitrogen is significantly reduced from the oxidant stream and only is present in the boiler due to inherent nitrogen in the coal, small amounts of nitrogen in the oxidant, and infiltration air. Therefore, no SNCR system is necessary. Assuming the same reduction in NOx production in the boiler as the oxycombustion PC cases, the 70 percent reduction reduces the emission rate exiting the boiler to 0.04 lb/MMBtu, which is below NSPS requirements. The emission of NO_x vented to the atmosphere in the partial flash and cryogenic distillation units will be provided by Air Liquide.

The limestone injection will reduce SO_2 emissions by 94 percent. Preliminary estimates for Cases S22F and L22F indicate that 0.04 lb/MMBtu will be sent to the CO_2 processing unit. The emission of SO_2 vented to the atmosphere in the partial flash and cryogenic distillation units is provided by Air Liquide. Assuming all the SO_2 is vented to the atmosphere in the CO_2 purification cases, the NSPS SO_2 requirement is still met.

The same design assumptions used for the air-fired CFBC cases will be used for the oxycombustion CFBC cases with regard to Hg, resulting in 57 percent co-benefit capture for both sub-bituminous and lignite coal cases. Based on estimates from a standard 550–MW, low-rank-coal-fired power plant without capture, Hg will be co-sequestered at a rate of 2.35 x 10-6 lb/MMBtu and 3.76 x 10-6 lb/MMBtu (assuming 33 percent recycle) for sub-bituminous and lignite coal, respectively. These estimates assume that a negligible amount of Hg is captured in the desiccant dryer in the CPU and all the Hg remains in the CO_2 product stream during cryogenic distillation. Assuming all of the Hg is released in the vent stream in the CO_2 purification cases, the NSPS Hg requirement is still met.

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 SO_2 concentrations to less than 10 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 capture efficiency of 94 percent. The SDA used in the combustion cases has a capture efficiency of 93percent, 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.

2.3.3 Carbon Dioxide

CO_2 is not currently regulated. 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 lb/ (gross) MWh and lb/ (net) MWh bases 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 (not including the carbon contained in fly ash).

2.4 AIR SEPARATION UNIT

Air separation plants have ambient air quality requirements to prevent the build-up of certain components in the cold box. Similarly, the quality of the water used in the direct contact cooler must also meet certain requirements. The ASU design assumes ambient air quality as presented in Exhibit 2-9, and cooling water quality as presented in Exhibit 2-10,

Exhibit 2-9 Ambient Air Quality

Impurities	Chemical Formula	Basis of Design (volume - vapor phase)
Nitrogen	N_2	78.11%
Oxygen	O_2	20.96%
Argon	Ar	0.93%
Carbon Monoxide	CO	< 0.6 ppm
Carbon Dioxide	CO_2	< 480 ppm
Methane	CH_4	< 8 ppm
Ethane	C_2H_6	< 0.1 ppm
Acetylene	C_2H_2	< 0.4 ppm
Ethylene	C_2H_4	< 0.2 ppm
Propylene	C_3H_6	< 0.2 ppm
Propane	C_3H8	< 0.05 ppm
Other Hydrocarbons	C_4+	< 0.05 ppm each
Hydrogen	H_2	< 0.7 ppm
Hydrogen Sulfide	H_2S	< 0.001 ppm
Ammonia	NH_3	< 0.01 ppm
Nitrous Oxide	N_2O	< 0.35 ppm
Nitrogen Oxides	NO_x	< 0.1 ppm
Ozone	O_3	< 0.1 ppm
Sulfur Dioxide	SO_2	< 0.1 ppm
Chloride	Cl	< 0.1 ppm
Total Strong Acid	$HCl + HNO_3$	< 0.05 ppm
Dust		< 0.2 mg/Nm^3

Exhibit 2-10 Cooling Water Quality

Quality or Impurity	Parameter	Value
pH value		7.6 to 7.8
Carbonate hardness		8 to 10° DH (German degrees)
Carbonic acid	Free	8 to 15 mg/l
	Combined	8 to 15 mg/l
	Corroding	None
Ryznar index[a]		6.5
Oxygen	At least	4 to 5 mg/l
Chloride ions	Maximum	10 mg/l
Sulphate ions	Maximum	50 mg/l
Nitrates and Nitrites	Maximum	10 mg/l
Ammonia	Maximum	10 mg/l
Phosphates and silicates		not significant
Iron and manganese		0.1 to 0.2 mg/l
Suspended solids	Maximum	10 mg/l

Note: The cooling water must be free of living organisms, biological growth, and algae.

[a] Ryznar index is a modification of the Langelier index used to calculate the degree of calcium carbonate saturation and to predict the likelihood of scale formation from a water supply.

The quality of the low pressure steam used for regeneration of the front end separation of the ASU must meet the specifications shown in Exhibit 2-11.

Exhibit 2-11
Low Pressure Steam Quality

Property	Chemical Formula	Value
Pressure/Temperature		10 bars/(saturated)
pH value		7.0 to 9.5
Conductivity		<0.2 µS/cm
Silicates	SiO_2	<0.02 mg/kg
Iron	Fe	<0.02 mg/kg
Copper	Cu	<0.003 mg/kg
Sodium	Na	<0.01 mg/kg
Organics		<0.2 mg/kg
Calcium + Magnesium	Ca + Mg	<0.05 mg/kg
Oxygen	O_2	<0.25 mg/kg
Chloride ions	Cl^-	<0.1 mg/kg
Bromide ions	Br^-	<0.1 mg/kg
Iodide ions	I^-	<0.1 mg/kg
Fluoride ions	F^-	<0.02 mg/kg
Sulphate ions	SO_4^{2-}	<0.1 mg/kg
Solids		<1.0 mg/kg

2.5 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, capacity factor 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)[35].

NERC defines an equivalent availability factor (EAF) as a measure of the plant capacity factor, 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 capacity factor.

The average EAF for coal-fired plants in the 400–599 MW range was 84.9 percent in 2004 and averaged 83.9 percent from 2000 to 2004. Because 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 capacity factor.

The addition of CO_2 capture was assumed not to impact the capacity factor, 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 capacity factor would further increase the levelized cost of electricity (LCOE).

2.6 RAW WATER WITHDRAWAL

A water balance was performed on the major water consumers in the process for each case. The total water demand for each major subsystem was determined. The internal recycle water available from various sources like boiler feedwater blowdown was applied to offset the water demand. The difference between demand and recycle is raw water withdrawal.

Fifty percent of the raw water makeup 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, boiler feedwater makeup, and slurry preparation makeup.

The largest consumer of raw water in all cases is cooling tower makeup. Because plants located in the Western United States need to consider limited water supplies, a parallel wet/dry cooling tower was chosen for all plant configurations similar to the system being installed at the Comanche 3 plant, which is currently under construction. 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 design ambient wet bulb temperature of 3°C (37°F) at the Montana site and 2°C (36°F) at the North Dakota 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 [36]:

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, the temperature difference between saturated steam at steam turbine generator exhaust and inlet dry bulb cooling air temperature) of 40–55°F[37]. 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[38].

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 and, by difference, the amount of raw water required.

2.7 COST ESTIMATING METHODOLOGY

The total plant cost (TPC) and operation and maintenance (O&M) costs for each of the cases in the study were estimated by a comparison factoring analysis. The comparison factors were obtained from several earlier low-rank coal studies and the costs for these cases were originally produced by WorleyParsons Group Inc. The estimates produced by this analysis carry an accuracy of ±30 percent, consistent with the screening study level of information available for the various power technologies.

WorleyParsons used an in-house database and conceptual estimating models for the capital cost and O&M cost estimates. Costs were further calibrated using a combination of adjusted vendor-furnished and actual cost data from recent design and design/build projects.

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," and are expressed in June 2007 dollars 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 and into 2009. While some pricing is still currently declining, based on published information, pricing at the end of 2008 remains higher than June 2007 values.

Capital costs are presented at the TPC level. TPC includes

- 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 but not limited to the following, are excluded from this study:

- Prepaid royalties
- Preproduction (or startup) costs
- Inventory capital (for example, fuel storage and consumables)
- Initial cost for catalyst and chemicals
- Land
- Permits and licensing (other than construction permits)
- Land acquisition / Right-of-way costs
- Economic development
- Owner's contingencies
- Project development costs
- Legal fees
- Owner's engineering / Project and construction management staff
- Plant operators during startup

- Electricity consumed during startup
- Fuel and reagents consumed during startup
- Transmission interconnections and upgrades
- Taxes (other than EPCM payroll taxes)
- Operating spare parts
- Furnishings for new office, warehouse and laboratory
- Financing costs
- Preliminary feasibility studies
- Front end engineering design (FEED)
- Insurance
- Interest and escalation during construction

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.

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 each of these respective technologies.

Non-capture USC PC cases are based on available technologies that have not been proven and are consequently treated as first-of-a-kind (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 first-of-a-kind (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 to 800 tons per day (tpd)[39]. The plants in this study will capture on average 16,000 tpd. Consequently the CO_2 capture cases will be treated as FOAK.

Contracting Strategy

The estimates are based on an Engineering, Procurement, Construction and Management (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, and Construction (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. Site-specific considerations, such as unusual soil conditions and special seismic zone requirements, or unique local conditions, such as accessibility and regulatory requirements, are not considered in the estimates.

The estimate boundary limit is defined as the total plant facility within the "fence line," including the coal receiving and water supply system, but terminating at the high-voltage side of the main power transformers. The single exception to the fence line limit is in the CO_2 capture cases, where costs are included for TS&M of the CO_2.

Labor costs are based on Merit Shop (non-union), in a competitive bidding environment.

Capital Costs

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.

Key equipment costs for each of the cases were calibrated to reflect recent quotations and/or purchase orders for other ongoing, in-house power or process projects. These include, but are not limited to, the following equipment:

- Pulverized coal boilers
- Steam turbine generators
- Circulating water pumps and drivers
- Cooling towers
- Condensers
- Main transformers

Other key estimate considerations include the following:

- 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 (five 10-hour days). 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. Current indications are that regional craft shortages are likely over the next several years. The types and amounts of incentives will vary based on project location and timing relative to other work. The cost impact resulting from an inadequate local work force can be significant.
- 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 to be 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 of CO_2 in all capture cases.
- Engineering and construction management were estimated as a percent of bare erected cost. 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.

- All capital costs are presented as "overnight costs" in June 2007 dollars. Escalation to period-of-performance is specifically excluded.

Price Escalation

A significant change in power plant cost occurred in recent years due to the significant increases in the pricing of equipment and bulk materials. This estimate includes these increases. All vendor quotes used to develop these estimates were received within the last three years. The price escalation of vendor quotes incorporated a vendor survey of actual and projected pricing increases from 2004 through mid-2007 that WorleyParsons conducted for a recent project. The results of that survey were used to validate/recalibrate the corresponding escalation factors used in the conceptual estimating models.

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. As noted above, the capital costs were reviewed and compared across all cases to ensure that a consistent representation of the relative cost differences is reflected in the estimates.

When performing such a comparison, it is important to reference the technical parameters for each specific item, as these are the basis for establishing the costs. Scope or assumption differences can quickly explain any apparent anomalies.

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 extremely project-and site-specific, and are therefore excluded from the capital costs:

- Escalation to period-of-performance
- Owner's costs, including, but not limited to, land acquisition and right-of-way, permits and licensing, royalty allowances, economic development, project development costs, switchyard costs, allowance for funds-used-during construction, legal fees, owner's engineering, pre-production costs, furnishings, and owner's contingency
- All taxes, with the exception of payroll taxes
- Site specific considerations, including, but not limited to, seismic zone, accessibility, local regulatory requirements, water supply line, wastewater discharge line, transmission lines, excessive rock piles, and laydown space
- Labor incentives in excess of a 5-day/10-hour work week
- Additional premiums associated with an EPC contracting approach

Contingency

Both the project contingency and process contingency costs represent costs that are expected to be spent in the development and execution of the project that are not yet fully reflected in the design. It is industry practice to include project contingency in the TPC to cover project uncertainty and the cost of any additional equipment that would result during detailed design. Likewise, the estimates include process contingency to cover the cost of any additional equipment that would be required as a result of continued technology development.

Project Contingency

Project contingencies were added to each of the capital accounts to cover project uncertainty and the cost of any additional equipment that could result from detailed design. The project contingencies represent costs that are expected to occur. Each bare erected cost account was evaluated against the level of estimate detail, field experience, and the basis for the equipment pricing to define project contingency.

The capital cost estimates associated with the plant designs in this study were derived from various sources, which include prior conceptual designs and actual design and construction of both process and power plants.

The Association for the Advancement of Cost Engineering (AACE) International recognizes five classes of estimates. On the surface, the level of project definition of the cases evaluated in this study would appear to fall under an AACE International Class 5 Estimate, associated with less than 2 percent project definition, and based on preliminary design methodology. However, the study cases are actually more in line with the AACE International Class 4 Estimate, which is associated with equipment factoring, parametric modeling, historical relationship factors, and broad unit cost data.

Based on the AACE International contingency guidelines, as presented in NETL's "Quality Guidelines for Energy System Studies," it appears that the overall *project* contingencies for the subject cases should be in the range of 30 to 40 percent[40]. However, such contingencies are believed to be too high when the basis for the cost numbers is considered. The costs have been extrapolated from an extensive data base of project costs (estimated, quoted, and actual), based on both conceptual and detailed designs for the various technologies. This information has been used to calibrate the costs in the current studies, thus improving the quality of the overall estimates. As such, the overall project contingencies should be more in the range of 15 to 20 percent, with the capture cases being higher than the non-capture cases.

Process Contingency

Process contingency is intended to compensate for uncertainties arising as a result of the state of technology development. Process contingencies have been applied to the estimates as follows:

- CO_2 Removal System (Econamine FG Plus): 20 percent on all capture cases; unproven technology at commercial scale in PC service.
- USC PC Boiler: 10 percent of the total boiler; only the superheater and reheater components of the boiler have not been proven commercially at the elevated temperatures.

- Oxycombustion: 15 percent of the total boiler (in addition to the USC PC Boiler contingency as appropriate).
- Instrumentation and Controls: 5 percent on all accounts for carbon 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 first of a kind).

AACE International provides standards for process contingency relative to technology status; from commercial technology at 0 to 5 percent to new technology with little or no test data at 40 percent. The process contingencies as applied in this study are consistent with the AACE International standards[41].

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.

Operations and Maintenance

The production costs, or operating costs and related maintenance expenses, pertain to charges associated with operating and maintaining the power plants over their expected life. These costs include the following:

- Operating labor
- Maintenance: material and labor
- Administrative and support labor
- Consumables
- Fuel
- Waste disposal
- Co-product or by-product credit (i.e., 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/hr. The associated labor burden is estimated at 30 percent of the base labor rate.

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 operation and maintenance 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 capacity factor.

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.

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 additional determining factors for some companies in the selection of technology and sites. A high local value of a co-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, since in these cases the fly ash contains Hg from carbon injection and FGD byproducts, it was assumed to be a waste material rather than a saleable byproduct. Similarly the bottom ash was considered a waste, with both materials having a concomitant disposal cost of $17.89/tonne ($16.23/ton).

CO_2 Transport, Storage, and Monitoring

For cases that feature CO_2 capture, the capital and operating costs for CO_2 TS&M were independently estimated by NETL. Those costs were converted to a LCOE and combined with the plant capital and operating costs to produce an overall LCOE. The TS&M costs were levelized over a 20-year period using the methodology described in the next subsection of this report.

CO_2 TS&M costs were estimated 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 2-12.

Exhibit 2-12 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

- The CO_2 is transported 80 kilometers (50 miles) via pipeline to a geologic sequestration field for injection into a saline formation.
- The CO_2 is transported and injected as a supercritical fluid in order to avoid two-phase flow and achieve maximum efficiency[42]. The pipeline is assumed to have an outlet pressure (above the supercritical pressure) of 10.4 MPa (1,515 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 4.8 MPa (700 psi) over an 80 kilometer (50 mile) pipeline length[43]. (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.
- The saline formation is at a depth of 1,239 meters (4,055 ft) and has a permeability of 22 millidarcy (22 μm^2) and formation pressure of 8.4 MPa (1,220 psig)[44]. 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[44]. The assumed aquifer characteristics are tabulated in Exhibit 2-13.

For CO_2 transport and storage, capital and O&M costs were assessed using metrics from a 2001 study[42]. These costs were scaled from the 1999-year dollars described in the study to 2007-year dollars using U.S. Bureau of Labor Statistics (BLS) Producer Price Indices for the oil and gas industry and the *Chemical Engineering* Plant Cost Index. Project and process contingencies of 30 and 20 percent, respectively, were applied to the costs to cover additional costs that are expected to arise from developing a more detailed project definition, and using technologies that have not been well-demonstrated to date in a similar commercial application.

Exhibit 2-13 Deep Saline Aquifer Specification

Parameter	Units	Base Case
Pressure	MPa (psi)	8.4 (1,220)

Parameter	Units	Base Case
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)

For CO_2 monitoring, costs were assessed using metrics for a saline formation "enhanced monitoring package" as reported in a 2004 IEA report[45]. The IEA report presented costs for two types of saline formations: those with low and high residual gas saturations. The reported monitoring costs were higher for saline formations with low residual gas saturation, and those costs were used as the basis for this report. The IEA report calculated the present value of life-cycle monitoring costs using a 10 percent discount rate. The present value cost included the initial capital cost for monitoring as well as O&M costs for monitoring over a period of 80 years (a 30-year injection period followed by 50 years of post-injection monitoring).

For this study, the present value reported in the IEA report was adjusted from Nov-2004-year dollars to June-2007-year dollars using U.S. BLS Producer Price Indices for the oil and gas industry. Project and process contingencies of 30 and 35 percent, respectively, were applied to the IEA value to cover additional costs that are expected to arise as described above. The resulting metric used for this report is a present value of $0.176 per metric ton of CO_2 stored over a 30-year injection period.

In accordance with the IEA's present-value, life-cycle methodology, this report levelized monitoring costs over a 20-year period by simply applying a capital charge factor to the present value of life-cycle monitoring costs (10 percent discount rate). This approach is representative of a scenario in which the power plant owner establishes a "CO_2 Monitoring Fund" prior to plant startup that is equal to the present value of life-cycle monitoring costs. Establishing such a fund at the outset could allay concerns about the availability of funds to pay for monitoring during the post-injection period, when the plant is no longer operating. While it is recognized that other, more nuanced, approaches could be taken to levelizing 80 years of monitoring costs over a 20-year period, the approach applied in this report was chosen because it is simple to describe and should result in a conservative (i.e., higher) estimate of the funds required.

Levelized Cost of Electricity

The revenue requirement method of performing an economic analysis of a prospective power plant has been widely used in the electric utility industry. This method permits the incorporation of the various dissimilar components for a potential new plant into a single value that can be compared to various alternatives. The revenue requirement figure-of-merit in this report is COE levelized over a 20 year period and expressed in mills/kWh (numerically equivalent to $/MWh).

The 20-year LCOE was calculated using a simplified model derived from the NETL Power Systems Financial Model[46].

The equation used to calculate LCOE is as follows:

$$LCOE_P = \frac{(CCF_P)(TPC) + [(LF_{F1})(OC_{F1}) + (LF_{F2})(OC_{F2}) + \ldots] + (CF)[(LF_{V1})(OC_{V1}) + (LF_{V2})(OC_{V2}) + \ldots]}{(CF)(MWh)}$$

Where

$LCOE_P$ =	levelized cost of electricity over P years, \$/MWh
P =	levelization period (e.g., 10, 20, or 30 years)
CCF =	capital charge factor for a levelization period of P years
TPC =	total plant cost, \$
LF_{Fn} =	levelization factor for category n fixed operating cost
OC_{Fn} =	category *n* fixed operating cost for the initial year of operation (but expressed in "first-year-of-construction" year dollars)
CF =	plant capacity factor
LF_{Vn} =	levelization factor for category *n* variable operating cost
OC_{Vn} =	category *n* variable operating cost at 100 percent capacity factor for the initial year of operation (but expressed in "first-year-of-construction" year dollars)
MWh =	annual net megawatt-hours of power generated at 100 percent capacity factor

All costs are expressed in June 2007 dollars, and the resulting LCOE is also expressed in June 2007 year dollars.

In CO_2 capture cases, the LCOE for TS&M costs was added to the LCOE calculated using the above equation to generate a total cost including CO_2 capture, sequestration, and subsequent monitoring.

Although their useful life is usually well in excess of 30 years, a 20-year levelization period is typically used for large energy conversion plants and is the levelization period used in this study.

The technologies modeled in this study were categorized as investor owned utilities (IOUs). The supercritical non-capture PC plants are categorized as low risk, while all the capture cases, ultra-supercritical plants, and CFB plants are categorized as high risk. The resulting capital charge and levelization factors are shown in Exhibit 2-14.

Exhibit 2-14 Economic Parameters for LCOE Calculation

	High Risk	Low Risk	Nominal Escalation, %[a]
Capital Charge Factor	0.175	0.164	N/A
PRB Levelization Factor	1.1439	1.1485	1.73
Lignite Levelization Factor	1.3561	1.3685	3.81
General O&M Levelization Factor	1.1607	1.1660	1.91

[a] Nominal escalation is the real escalation plus the general annual average inflation rate of 1.91 percent.

The economic assumptions used to derive the capital charge factors are shown in Exhibit 2-15. The difference between the high-risk and low-risk categories is manifested in the debt-to-equity ratio and the weighted cost of capital. The values used to generate the capital charge factors and levelization factors in this study are shown in Exhibit 2-16.

Exhibit 2-15 Parameter Assumptions for Capital Charge Factors

Parameter	Value
Income Tax Rate	38% (Effective 34% Federal, 6% State)
Repayment Term of Debt	15 years
Grace Period on Debt Repayment	0 years
Debt Reserve Fund	None
Depreciation	20 years, 150% declining balance
Working Capital	Zero for all parameters
Plant Economic Life	30 years
Investment Tax Credit	0%
Tax Holiday	0 years
Start-Up Costs (% of EPC)[a]	2%
All other additional capital costs ($)	0
EPC escalation	0%
Duration of Construction	3 years

[a] EPC costs equal total plant costs less contingencies

Exhibit 2-16 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	9%	4.5%	2.79%
Equity	50	12%	6%	6%
Total			11%	8.79%
High Risk				
Debt	45	11%	4.95%	3.07%
Equity	55	12%	6.6%	6.6%
Total			11.55%	9.67%

The cost of CO_2 capture was calculated by the cost of CO_2 removed and the cost of CO_2 avoided, as illustrated in Equations 1 and 2, respectively. The cost of electricity in the CO_2 capture cases includes TS&M as well as capture and compression.

$$(1) \qquad Removal\ Cost = \frac{\{LCOE_{with\ removal} - LCOE_{w/o\ removal}\}\ \$/MWh}{\{CO_2\ \ removed\}\ tons/MWh}$$

$$(2) \qquad Avoided\ Cost = \frac{\{LCOE_{with\ removal} - LCOE_{w/o\ removal}\}\ \$/MWh}{\{Emissions_{w/o\ removal} - Emissions_{with\ removal}\}\ tons/MWh}$$

3. PROCESS DESCRIPTIONS

The system descriptions are provided in the subsections below. When the description is common to both air-based and oxycombustion cases, a single description is provided. Otherwise, the description distinguishes between the technologies and provides information on each. Differences between supercritical and ultra-supercritical designs are handled in the same manner.

3.1 COAL HANDLING

The function of the coal handling system is the same for all cases. It 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 delivery point up to the pulverizer fuel inlet. The system is designed to support short-term operation at the 5 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 3" x 0 low-rank coal is delivered to the site by unit trains of 100-ton rail cars. Each unit train consists of 100 100-ton rail cars. The unloading is done by a trestle bottom dumper, which unloads the coal to two receiving hoppers. Coal from each hopper is fed directly into a vibratory feeder. The 3" x 0 coal from the feeder is discharged onto a belt conveyor. The coal is then transferred to a conveyor that transfers the coal 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 1¼" x 0 by the coal crusher. 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 parallel boiler silos.

3.2 STEAM GENERATOR AND ANCILLARIES

The steam generators for the air-based and oxycombustion cases are very similar and are based on the B&W supercritical or ultra-supercritical once-through, spiral-wound, Benson-boiler. The air-based system is described first, followed by modifications related to the oxycombustion cases.

The steam generator for the air-based reference designs is a once-through, PC wall-fired, balanced draft type unit with a water-cooled dry bottom furnace. 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.

3.2.1 Scope and General Arrangement

The steam generator comprises the following:

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

The steam generator operates as follows:

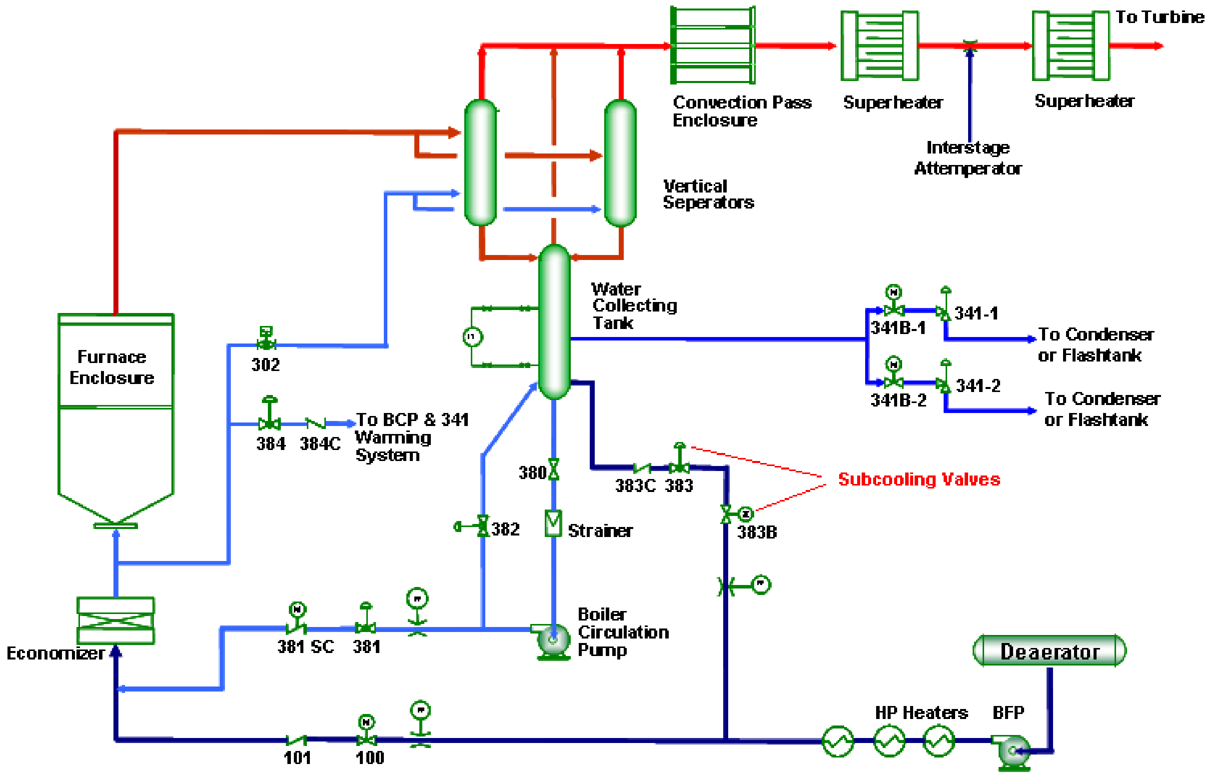
3.2.2 Feedwater and Steam

Feedwater enters the bottom header of the economizer (Exhibit 3-1). Water passes upward through the economizer tube bank 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, then to the primary superheater, through the first stage of water attemperation, and on 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 surface, then through crossover piping containing inter-stage attemperation. The crossover piping feeds the steam to the final reheater banks and then out to the turbine. Inter-stage attemperation is used to provide outlet temperature control during load changes.

Exhibit 3-1
Once-Through Variable Pressure Boiler Flow Diagram



Source: B&W Figure

3.2.3 Air and Combusting Product Circulation

The steam generator is furnished with vertical-shaft, Ljungstrom-type air preheaters. These units are driven by electric motors through gear reducers. Two tri-sector regenerative air heaters are located after the economizer. These air heaters are designed first to deliver heat to the primary stream used to dry and convey the PC through the pulverizers and second to cool the flue gases leaving the boiler envelope by preheating the stream going to the burners.

Combustion air from the FD fans is heated in air heaters, 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 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 the various elevations of the furnace. The hot combustion products rise to the top of the boiler and pass through the superheater and reheater sections. The gases then pass through the economizer and air preheater. The gases exit the steam generator at this point and flow to the SCR, dust collector, ID fan, FGD system, and stack.

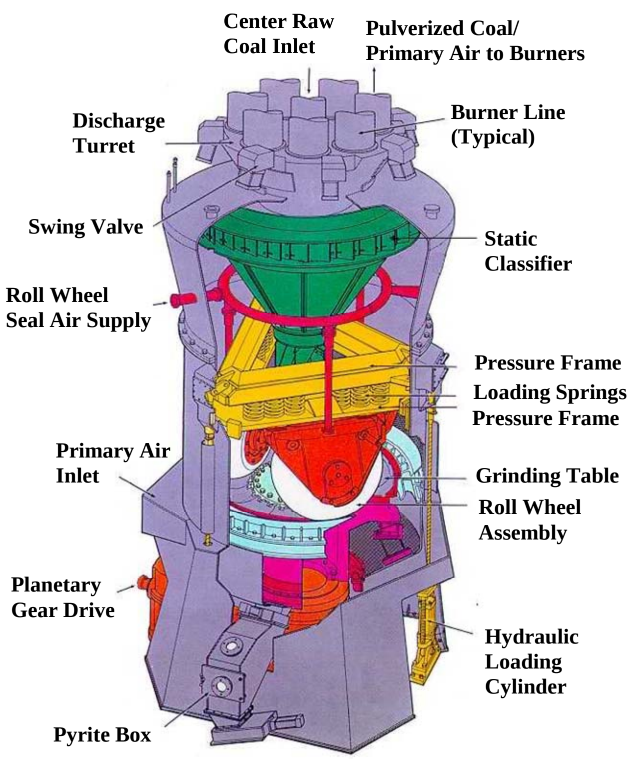
3.2.4 Fuel Feed

B&W 89G pulverizers feed the burners on the front and rear walls (Exhibit 3-2). When firing with air, coal is dried in the pulverizers and conveyed through the burner lines with air. When firing with oxygen, hot recycled gas from the primary airheater is mixed with enough O_2 to have about a 21% oxygen content (by volume dry) flowing to the pulverizers. There were three considerations for determining how much recycle gas to divert to the mills:

- Maintain an equivalent amount of heat in the gas mixture as was used during air firing. This would ensure an equal amount of drying and mill outlet temperature.
- Maintain a minimum 27 ft^3 of gas per lb of coal in the mills for fineness and classifier operation.
- Maintain a minimum of 3,000 feet per minute (fpm) burner line velocity for coal conveying.

The second and third considerations are the governing criteria, since as little recycle gas as possible is needed going through the primary airheater.

Exhibit 3-2
B&W Pulverizer



Source: B&W Figure

3.2.5 Ash Removal

The furnace bottom comprises several hoppers, with a clinker grinder under each hopper. The hoppers are of welded steel construction, lined with 9-inch-thick 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 description of the balance of the bottom ash handling system is presented in

Section 3.8. The steam generator incorporates fly ash hoppers under the economizer outlet and air heater outlet.

3.2.6 Burners

A boiler of this capacity (~ 500,000 lb/h coal flow rate) will employ approximately 24 to 36 coal burners arranged in multiple elevations. Each burner is designed as a low-NO_x configuration, with staging of the coal combustion to minimize NO_x formation. In addition, overfire air nozzles are provided to further stage combustion and thereby minimize NO_x formation. See Section 3.2.9 for more detail on NO_x control.

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

3.2.7 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 high-pressure 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.

3.2.8 Oxycombustion Modifications

The operation of an oxygen-fired boiler with gas recirculation is essentially the same as an air-fired boiler, with the exception that recycled flue gas takes the place of the primary and secondary air streams. The oxygen is injected into primary and secondary streams downstream of the airheater. All equipment remains the same except for the gas cooler for condensing water from the gas to be recycled and a gas reheater downstream of the cooler. This gas reheater heats the recycle gas by 10-15°F to vaporize any water droplets before entering the fans.

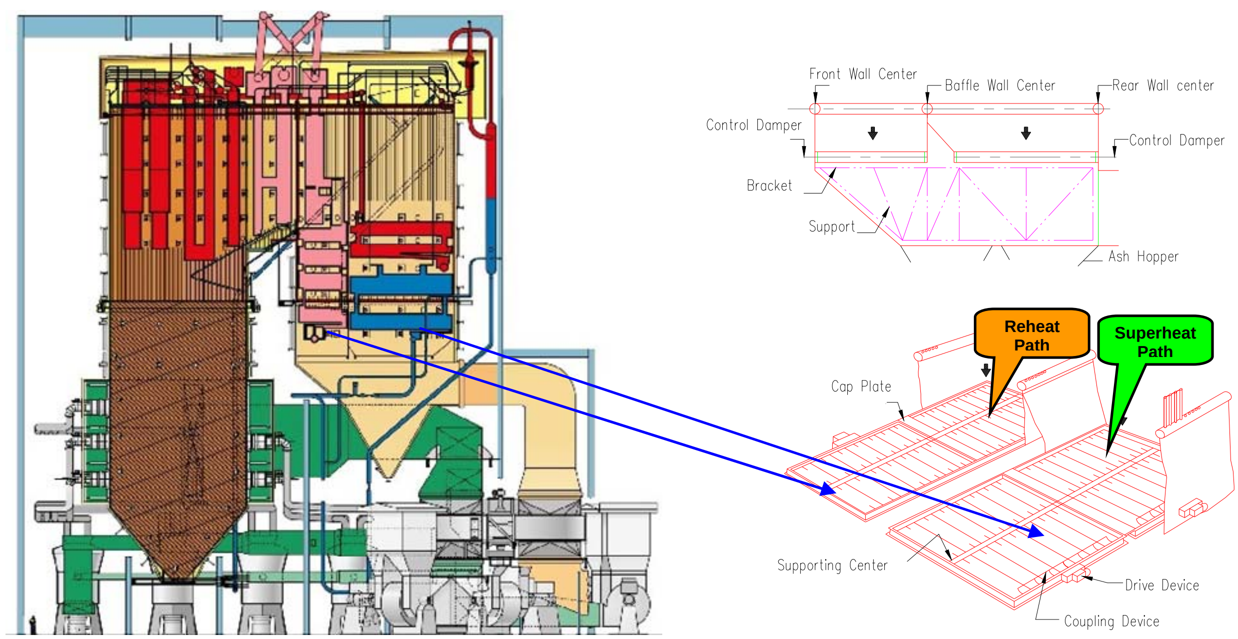
Since the flue gas is recycled and only “pure” oxygen is introduced, the flue gas throughout the system contains a much higher level of CO_2 and very little nitrogen. This, in itself, does not pose any significant problems or differences from air firing, though it does increase emissivity, which is essentially offset, with regard to heat transfer, by the change in density and resulting gas velocity. One other effect is that the concentration of all constituents in the boiler and recycle gas path increase relative to an air-fired unit, if not controlled. This is because there is a large amount of nitrogen diluent in an air-fired unit that is not present in an oxyfired unit. When all influences are considered (e.g., change in boiler efficiency, air infiltration), the concentration of the constituents in the flue gas increases by a factor of 3.4 to 3.5.

The steam generating unit described herein is a B&W supercritical or ultra- supercritical, once-through, spiral wound, Benson boiler. The boiler was designed to utilize coal as the main fuel. The boiler is a Carolina (two pass) design, with the primary superheater and economizer in one pass and a horizontal reheater in the other (Exhibit 3-3).

Recycled flue gas is fed to the forced draft fans, heated in the tri-sector air heaters, and distributed to the burner windboxes as the secondary air stream. The windboxes are arranged to contain the three elevations of burners and one elevation of over fire oxygen (OFO) ports comprising the advanced OFO system. A portion of the recycled gas is taken by the primary air fans, which provide the required static pressure to pass this air through the air heater and pulverizers, to the burners. A portion of the air (or oxygen in the oxycombustion cases) from the primary air fans is passed, unheated, around the air heater as tempering primary air. The preheated and tempering primary gas streams are mixed upstream of each pulverizer to obtain the desired fuel-air mixture temperature at the pulverizer outlet.

Within the boiler, hot flue gas from the furnace passes successively across the furnace platens, the secondary superheater and the pendant reheater located in the convection pass as it leaves the high radiant heat transfer zone of the furnace. The flue gas turns downward, entering the parallel backend consisting of one flue gas pass with pendant and horizontal reheater and one flue gas pass with primary superheater and economizer surface. After the economizer, the flue gas enters the airheater and is then routed out to the flue gas clean-up equipment. The reheat steam temperature is controlled by flue gas biasing dampers at the outlet of each flue gas pass of the parallel backend. The furnace can be spiral or vertical tube geometry.

Exhibit 3-3
Side View of B&W Once-Through Variable Pressure Boiler



Source: B&W Figure

3.2.9 NO_x Control System

The plants were designed to achieve 0.07 lb/MMBtu NO_x emissions for both coal types. This was accomplished differently in the air-based cases and the oxycombustion cases.

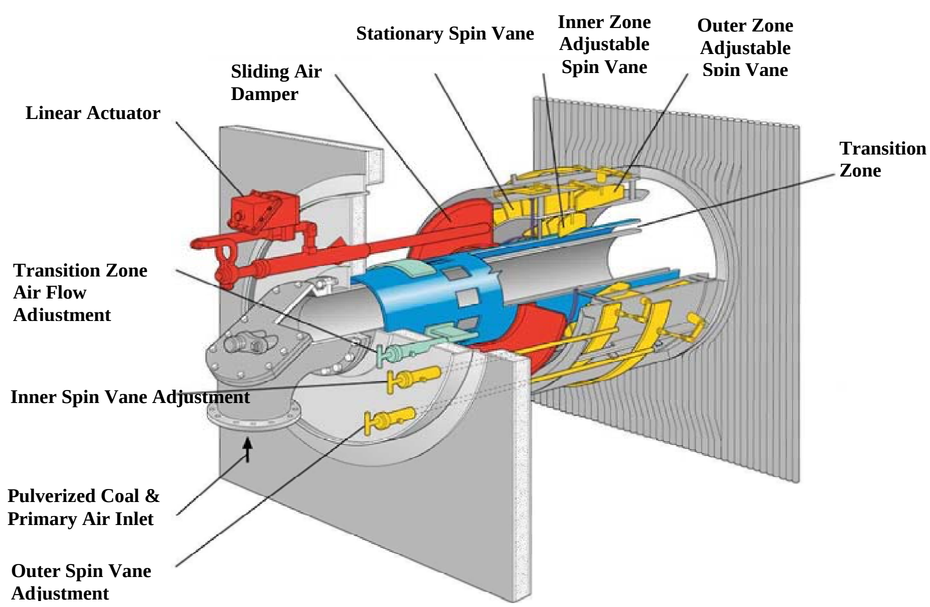
In the air-based cases, three measures are taken to reduce the NO_x. The first two are a combination of low-NO_x burners and the introduction of staged overfire air in the boiler. The low-NO_x burners and overfire air reduce the emissions to about 0.5 lb/MMBtu. The third control method is SCR designed to achieve a NO_x reduction efficiency of 65 percent.

Likewise, in the case of oxycombustion, the burners are low NO_x burners with OFO ports on the front and rear walls of the furnace. These state-of-the-art burners in combination with the OFO recycle gas provide the lowest possible NO_x leaving the combustion zone. The burners are modified for oxygen service by incorporation of oxygen jets in the upstream ducting and the burner itself in order to deliver the required amount of oxygen to the flame. However, SCR is not required to meet the NO_x emission limit of 0.07 lb/MMBtu in the oxycombustion cases.

Due to the configuration of oxycombustion cases, nitrogen is significantly reduced from the oxidant stream and only is present in the boiler due to inherent nitrogen in the coal, small amounts of nitrogen in the oxidant, and infiltration air. Therefore, no SNCR system is necessary. Assuming the same reduction in NO_x production in the boiler as the oxycombustion PC cases, the 70% reduction reduces the emission rate exiting the boiler to 0.04 lb/MMBtu, which is below BACT requirements. The emission of NO_x vented to the atmosphere in the partial flash.

The oxycombustion CFBC cases implement the same NO_x control technologies as the air-fired cases, with the exception of SNCR. For oxycombustion CFBC cases, a greater percentage of the solids that are separated by the cyclone system are cooled and subsequently recycled to the boiler than in the air-fired CFBC cases. This helps to maintain proper temperature control in an oxygen-rich environment. It also provides the additional benefit of reducing the amount of flue gas recycle necessary to achieve the boiler temperature control.

Exhibit 3-4
B&W DRB 4Z™ Burner



Source: B&W Figure

3.3 PARTICULATE CONTROL

A bag house composed of multiple filter bags is located after the air heater. The bag house is designed to achieve 99.8 percent removal efficiency for both air-based and oxycombustion cases, and consists of two separate single-stage, in-line, and 10-compartment units. Each unit is a high air-to-cloth ratio design with a pulse-jet on-line cleaning system. The ash is collected on the outside of the 8-m-long bags, which are supported by steel cages. The dust cake is removed by a pulse of compressed air. The bag material is polyphenylensulfide (PPS) with an intrinsic Teflon (PTFE) coating [47]. Each compartment contains a number of gas passages with filter bags and heated ash hoppers supported by a rigid steel casing. The fabric filter is provided with necessary control devices, inlet gas distribution devices, insulators, inlet and outlet nozzles, expansion joints, and other items as required.

In the air-based cases, the fabric filter reduces particulate loading in the stack gas to below the required levels. It serves the same purpose in the oxycombustion cases, but in addition, the fabric filter reduces the particulate loading in the recycle stream to protect the fans. Also, since the flue gas density is higher during oxycombustion, the flue gas velocities are less than those encountered during air-based combustion, leading to greater residence time during oxycombustion, which should contribute to improving the particulate capture efficiency relative to air firing. Despite this potential improvement, the same removal efficiency was assumed for both oxycombustion and air-based cases. In the oxycombustion case, the dust cake from the bags is removed by pulse-jet–compressed, CO_2-rich recycle gas (taken off after the wet scrubber).

3.4 FLUE GAS DESULFURIZATION

3.4.1 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 CO_2 CPU. 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 3.6.1, the CPU 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 CPU facility.

Lime-spray drying is a dry scrubbing process that is generally used for low-sulfur coal [48]. 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 300°F or higher to 160°F to 180°F. The final temperature is maintained at approximately 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
- Baghouse and Stack (described in Section 3.8.7)

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 concurrent 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 carbon steel 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 30°F adiabatic approach to saturation temperature.

3.4.2 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 ND lignite. The basis for the coal Hg concentration was discussed in Section 2.3. The combination of SCR, dry FGD, and fabric filter pollution control technologies used in the PC plants result in a range of estimated co-benefit capture, depending on the study source[18, 49]. Average values of 15 percent co-benefit Hg reduction for the PRB coal and 0 percent co-benefit reduction for the ND lignite 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/MMscf flue gas for PRB and ND lignite 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.

3.5 AIR SEPARATION UNIT

The ASU is unique to the oxycombustion cases. For the quantities required by an oxycombustion process at a commercial power generation scale (several thousand metric tons of oxygen), the only available technology today is cryogenic distillation. In this study, conventional cryogenic distillation producing 95 mol% will be used for all oxycombustion cases.

The cryogenic distillation systems proposed in this study are designed and quoted using today's commercially available technology. Future improvements leading to lower O_2 cost are expected in the 2015-2020 timeframe, but have not been included in this study. The ASU system description is based on the referenced Air Liquide Process & Construction, Inc.

specification [50]. The equipment identification numbers are referenced to the general ASU layout presented in Exhibit 3-6.

3.5.1.1 Air Compression

Atmospheric air is drawn through inlet air filters (F01-1/2) to remove particulate matter. The filtered atmospheric air is then compressed by two main air compressors (C01-1/2), which are driven by electric motors. The heat of compression from the main air compressors is removed in water-cooled intercoolers.

3.5.1.2 Air Pre-Cooling

Warm air from the discharge of the main air compressor is cooled in a water-wash tower (E07). Cooling water is pumped by the water wash tower pumps (P60.1/2) into the water-wash tower. Another stream of water is sent to the top of the water chiller tower (E60). In this tower (E60), cooling water is cooled against dry waste nitrogen. The resulting chilled water coming off the bottom of E60 is pumped by the water chiller pumps (P61.1/2) to the water wash tower (E07). Inside E07, warm air from the discharge of the main air compressor is cooled through direct contact with the two water streams. In addition to cooling the water, the water wash tower helps reduce or eliminate some gaseous impurities that may be present in the ambient air.

3.5.1.3 Air Purification

A front-end temperature swing adsorption (TSA)-type purification system is provided for the removal of water and CO_2 from the air feed. The system is made up of two radial flow bed vessels (R01/R02) containing activated alumina and molecular sieve adsorbents. By means of a set of automatically controlled switching valves, the compressed air passes alternately through one of the adsorbers or the other. This adsorption process removes moisture, CO_2, and other trace impurities. The activated alumina removes the moisture and the molecular sieve removes the CO_2contained in the air, as well as some of the trace impurities. At the end of every adsorption cycle, the air stream is redirected to the other bed and the vessel containing the adsorbed impurities is regenerated by a stream of dry, heated waste nitrogen (WN_2). The waste nitrogen is heated by low-pressure, pressure-saturated steam in a reactivation heater (E08). After it passes through the bed in regeneration, the gas is vented to the atmosphere. Once the adsorber has been heated for the desired amount of time, the vessel is cooled down and pressurized for the next adsorption phase.

3.5.1.4 Air Refrigeration

Dry compressed air exits the adsorber vessels and is split into two streams. Both enter the main heat exchanger (E01) and are cooled against the waste nitrogen and product streams to near the liquefaction temperature. After exiting the exchanger, one stream is sent directly to the bottom of the high-pressure (HP) column (K01) as feed. The second air stream liquefies against vaporizing gaseous oxygen (GOX) product. The liquid air stream is flashed through a valve and the resulting two-phase stream is separated into liquid and vapor streams. The vapor stream enters the low pressure (LP) column (K02). The liquid stream is split into two parts. One part of the stream is sent to the LP column, and the other part is sent to the HP column (K01). The refrigeration necessary for the air liquefaction is obtained by the expansion of a nitrogen stream inside the coldbox. A medium pressure gaseous nitrogen (MP GAN) stream that is extracted from the top of the HP column is sent to the main heat exchanger (E01), extracted from an intermediate location, and subsequently expanded in a nitrogen expander (ET01). This cold nitrogen stream is reintroduced to E01 to provide refrigeration to the air streams. Mechanical power obtained from the turbine is recovered in an electric generator.

3.5.1.5 Cold Production and Distillation

Air sent to the HP column is separated into an oxygen-rich liquid at the bottom and almost pure nitrogen at the top. The separation of the air is carried out in this column, as in any other rectification column, by the interaction of vapor rising with a descending stream of reflux liquid over sections of structured packing materials. The descending liquid gradually becomes rich in oxygen and, at the same time, the vapors passing through the packing lose a corresponding small amount of oxygen at each pack until, when they reach the top pack, almost pure nitrogen is obtained. The gaseous nitrogen at the top of the HP column enters the side of the main vaporizer (E02), where it is condensed by liquid oxygen (LOX) boiling on the other side of the heat transfer surface. The resulting liquid nitrogen falls by gravity from the top of the HP column, where it acts as pure reflux. A liquid nitrogen stream is withdrawn from the top of the HP column and sent to the top of the LP column as reflux. Additionally, rich liquid is withdrawn from the bottom of the HP column and expanded to the LP column as feed. The rectification in the LP column is the same as that in the HP column. Impure liquid nitrogen and oxygen-rich liquids are fed into the appropriate levels of the LP column. Liquid arriving at the bottom is almost entirely oxygen (95 or 99 percent purity). The reboil duty for the LP column is provided by the main vaporizer, which, by vaporizing LOX, condenses the pure nitrogen at the top of the HP column. The main vaporizer is a bath-type vaporizer submerged in LOX drained from the bottom of the LP column. LOX is extracted from the bottom of the LP column, vaporized, then warmed in the main heat exchanger (E01) and exits the coldbox as GOX product. Low-pressure WN_2 is extracted at the top of the LP then sent through the main heat exchanger (E01), where it cools down the incoming air. Part of the stream is then used to chill water in the nitrogen chiller tower (E60) while the remaining portion is sent to the steam reactivation heater (E08) and subsequently used to regenerate the adsorbers.

3.5.1.6 Capital Expenses (CAPEX) and Operating Expenses (OPEX) Trade-Off

In the early stage of development, ASUs were optimized to produce relatively high-pressure oxygen (from 5 bara to 80 bara) and in some cases to co-produce nitrogen. In 2007, one of ASU's major technology providers launched a new ASU development program targeting an improved version that optimized for oxycombustion applications. The idea was not to fully redesign an ASU, but rather to adapt the process cycle to the specific requirements of oxycombustion (i.e. low oxygen pressure, no nitrogen production requirement). By doing so, the energy consumption of the ASU could be reduced significantly, from ~ 200 kWh per ton of product oxygen to ~160 kWh per ton of product oxygen. Because ASU power consumption is a major contributor to power plant efficiency reductions, the improved version significantly enhanced oxycombustion plant performance. Currently, there are two kinds of ASUs on the market: the original type, commercialized in the early 1990s, requires higher levels of operating expenses with lower initial capital expenditure requirements. The second version requires lower operating expenses but the initial capital cost is higher.

Exhibit 3-5
Tradeoff of CAPEX and OPEX in ASU Design

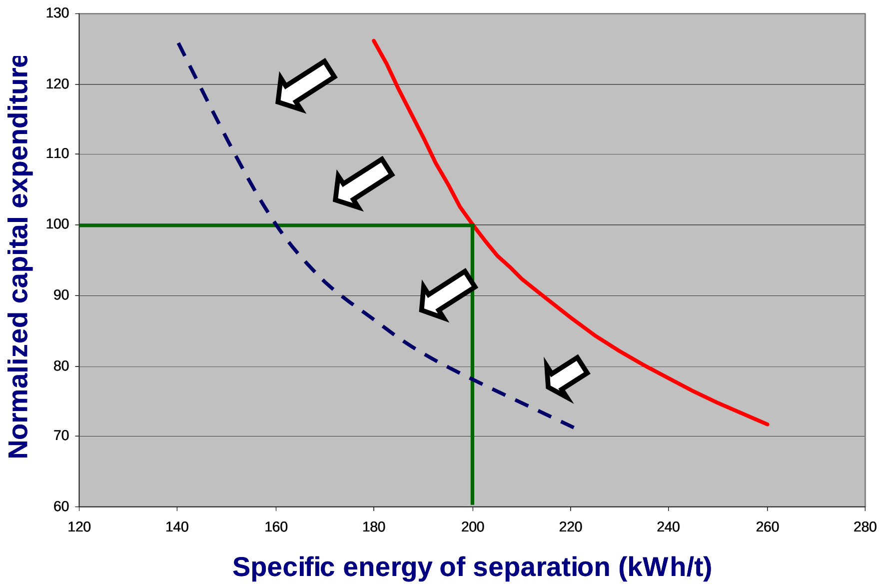
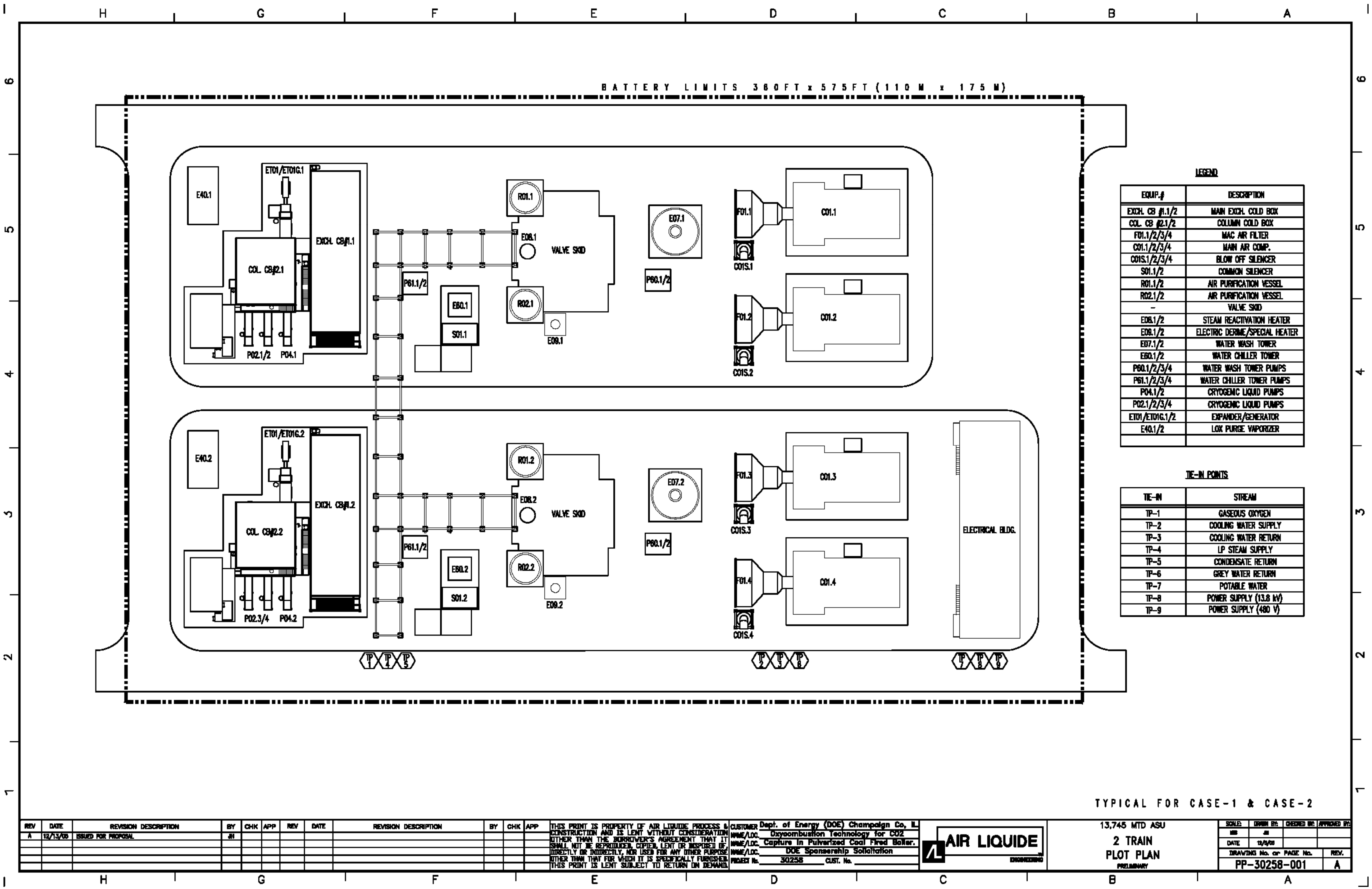


Exhibit 3-5 illustrates the trade-off relationship between CAPEX and OPEX; the older technology is represented by the red solid line while the newly optimized ASU is represented by the blue dotted line. The dotted line shows that by increasing capital expenditure by 25 percent, it's possible to further decrease power consumption of the ASU by 10 percent (e.g., from a specific energy of separation of 160 kWh/metric ton to reach close to 140 kWh/t). Conversely, if capital expenditure is decreased by 15 percent, power consumption increases by 10 percent.

In this study, we included two sensitivity cases (S12DSen1 and S12DSen2) to explore this trade-off. Both case designs were based on ISO ambient conditions, but case S12DSen2 adopted the low-capital-cost ASU used in the earlier bituminous oxycombustion study (with energy consumption of 225 kWh/ton), while S12DSen1 and all other new oxycombustion cases adopted the newer type of ASU with a better energy efficiency (energy consumption: 167 kWh/ton).

Exhibit 3-6 Air Liquide ASU Typical Plot Plan



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3.6 CO_2 RECOVERY FACILITY

Several different types of CO_2 recovery configurations have been adopted for these low-rank oxycombustion cases; and the configurations usually consist of condensation, purification (in some cases), drying, and compression.

3.6.1 CO_2 Compression and Purification System

The CO_2 CPU system process design, description, and cost information for the oxycombustion cases is based on an American Air Liquide specification [51]. CO_2compression and purification unit specifications for the study design cases are presented in Exhibit 3-7.

Exhibit 3-7 CO_2 Compression/Purification Unit Specification

Option	Description	%CO_2 Recovery	%CO_2 Purity	Oxycombustion Cases
1a	Compression only	100	>83	S12C, S12D, S12DSen1, S12DSen2
1b	Compression only with BFW heating	100	>83	
2a	Partial condensation	90	>97	S12E
2b	Partial condensation with BFW heating	90	>97	
3a	Partial condensation with distillation	90	>99.9	
3b	Partial condensation with distillation with BFW heating	90	>99.9	All other carbon capture cases

To satisfy various CO_2 recovery and purity requirements, three process schemes are considered:

1. Compression Only: In this process, flue gas (FG) is compressed and dried to the water specifications required. The product gas is further compressed and cooled to the desired temperature. This is the simplest process with 100 percent recovery and no purification except drying. The disadvantage of this approach is its low CO_2 purity (>83 percent).
2. Partial Condensation: In this process, the FG is compressed, dried, and then purified using a partial condensation process, which can reduce the oxygen concentration of the CO_2 product stream to below 0.4 mol%, achieving a much higher CO_2 purity (>97 percent).
3. Cryogenic Distillation: The FG is compressed, dried, and then purified using a partial condensation and distillation process. The main advantage of adding a distillation column is the fact that it can produce nearly 100 percent CO_2 purity (1 ppmv oxygen content). This significantly improved product purity, which meets EOR specifications.

For each of the above process schemes, two different options are considered for the heat integration purpose. In cases tagged with an “a,” cooling is performed using cooling water only, whereas heat integration is added for cases 1b, 2b, and 3b. Boiler feed water (BFW) is heated against CO_2 product for final cooling of the product.

Process schematics for the three types of systems (heat integration is not shown) are presented in Exhibit 3-8 through Exhibit 3-10.

Exhibit 3-8 Oxycombustion CO_2 Recovery without Purification – Case 1a – Compression Only

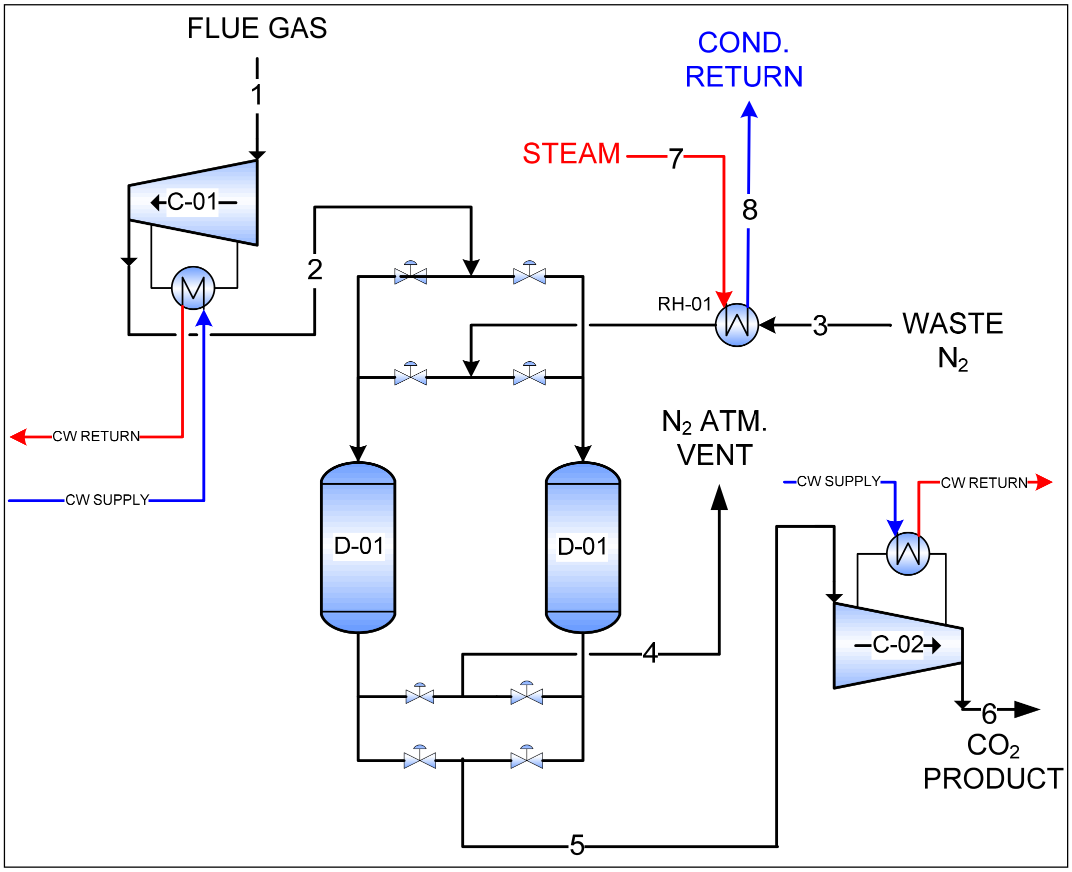


Exhibit 3-9 Oxycombustion CO_2 Recovery with a Partial Condensation Purification System – Case 2a

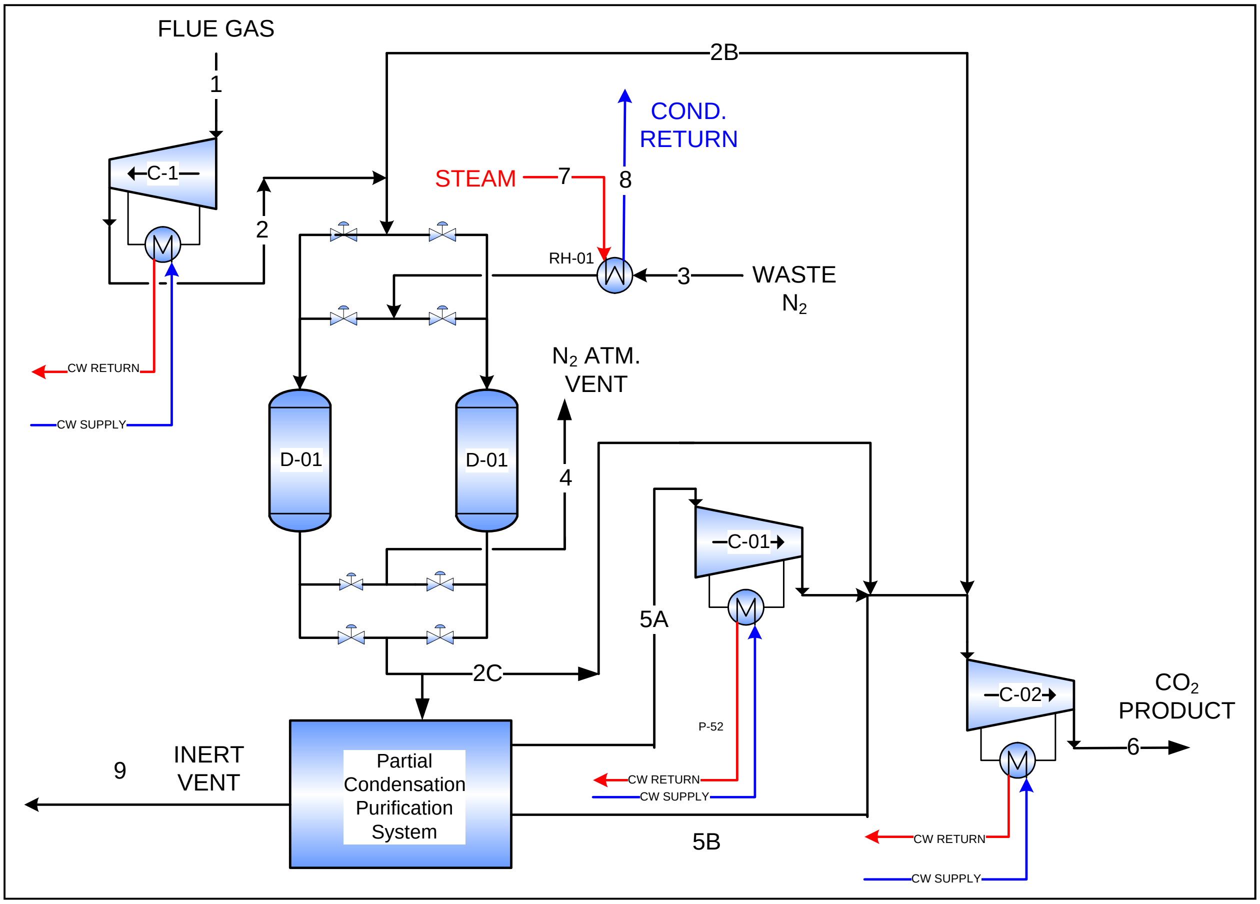
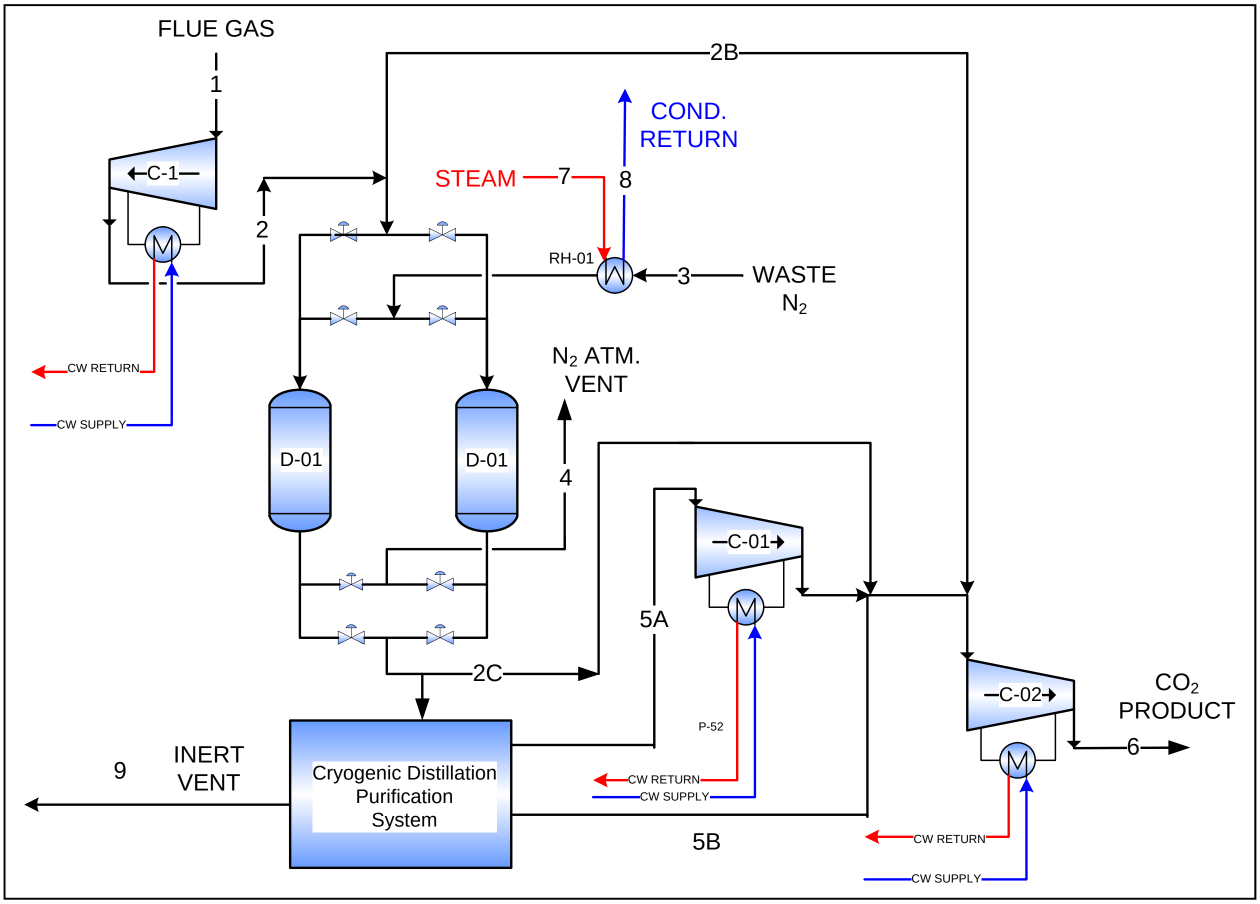


Exhibit 3-10 Oxycombustion CO_2 Recovery with a Cryogenic Distillation Purification System – Case 3a



In cases where only water removal is required (Option 1, Exhibit 3-8), the compression/drying-only system consists of LP and HP sections, four stages each, arranged upstream and downstream from the Drying Unit. The centrifugal compressors are driven by electric motors and include intercoolers between the compression stages. The dryer unit utilizes a front end TSA–type process and consists of two radial flow bed vessels (D-01) containing activated alumina adsorbents. The drying unit is regenerated by the stream of dry heated waste nitrogen from the ASU.

In cases where additional CO_2 purification is required (Option 2, Exhibit 3-9) the system separates CO_2 from the inert gases using two heat exchangers operating at different pressures and temperatures. The inert gases along with air pollutants (NO_x, SO_x, etc.) are vented to the atmosphere. Depending on the pollutant concentrations in the inert vent stream, appropriate pollution control systems could be added if/as required. However, specified BACT emission rates were achieved for these oxycombustion cases without additional vent stream treatment.

Option 3 is utilized when high CO_2 purity is required. This process scheme is similar to that of Option 2, except a distillation column is added into the purification system (refer to Exhibit 3-10). In this purification system the flue gas is cooled and further purified to meet the EOR specifications. Purified CO_2 stream is then sent to HP compressors (C-01 and C-02) to be compressed to a supercritical state (2,215 psia) for delivery (stream 6). The incondensable inert gases (along with air pollutants) are separated and vented to the atmosphere (stream 9).

3.7 STEAM TURBINE GENERATOR SYSTEM

The steam turbine configuration selected is the same for all supercritical and ultra-supercritical cases and is the same for air-based combustion and oxycombustion cases. Specifically, it is a tandem compound type, utilizing a single-flow HP section, and double-flow intermediate pressure (IP) section in separate casings. These two high-pressure sections are combined with the two double-flow LP sections [52]. The single reheat steam conditions are 3500 psig/1100°F/1100°F for the supercritical models, and 4000 psig/1200°F/1200°F for the ultra-supercritical models [53].

The turbine drives a hydrogen-cooled generator. The turbine has DC motor-operated lube oil pumps, and main lube oil pumps, which are driven off the turbine shaft. The turbine is designed for 576,600 to 797,000 kW (varies among cases) at the generator terminals. The exhaust pressure is 2-in Hg in the single pressure condenser. The condenser is two-shell, transverse, single pressure with divided waterbox for each shell.

3.7.1.1 Operation Description

Main steam from the boiler passes through the stop valves and control valves and enters the turbine at 3500 psig and 1100ºF for the supercritical cases, and 4000 psig and 1,200ºF for the ultra-supercritical cases. The steam initially enters the high-pressure section of the turbine, 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 double-flow IP section at 1100ºF for the supercritical cases and 1200°F for the ultra-supercritical cases. After passing through the IP section, the steam enters crossover piping, which transports the steam to the two LP sections. The steam divides into two paths and flows through the LP sections, exhausting downward into the condenser.

Turbine bearings are lubricated by a closed-loop, water-cooled, pressurized oil system. Turbine shafts are sealed against air in-leakage or steam blowout using a labyrinth gland arrangement connected to a low-pressure steam seal system. The generator stator is cooled with a closed-loop 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.

The turbine stop valves, control valves, reheat stop valves, and intercept valves are controlled by an electro-hydraulic control system.

3.7.1.2 Supercritical Steam Turbine Cycle

The steam turbine for the supercritical cases is equipped with six non-automatic steam extractions, which, along with the HP and IP section exhausts, provide steam for four low-pressure feedwater heaters, deaerator, and three high-pressure feedwater heaters. All feedwater heaters (except the deaerator) are closed type. The condensate drains from the low-pressure heater (#1 through #4) are cascaded to the condenser. The condensate drains from the high-pressure heaters (#6 through #8) are cascaded to the deaerator. The deaerator storage tank provides suction to the boiler feedwater pumps. The deaerator is assumed to be placed at high elevation to assure sufficient net positive suction head (NPSH) for the feedwater pumps. Heater #7 is on cold reheat extraction and heater #8 is a heater above the reheat point (HARP).

3.7.1.3 Ultra-supercritical Steam Turbine Cycle

The steam turbine for the USC cases is equipped with seven non-automatic steam extractions, which, along with the HP and IP section exhausts, provide steam for five low-pressure feedwater heaters, a deaerator, three high-pressure feedwater heaters, and a topping desuperheater. The condensate drain flow from the feedwater heater #1 is cascaded back to the condenser. Feedwater heater #2 has a heater drip pump to push the drain flow into the condensate to the heater #3, while condensate drip flow from the heater #3 is cascaded to the heater #2. Feedwater heater #4 is an open type heater and supplies the booster pump suction. Heater #5 is after the booster pump and its drains are cascaded to heater #4. Heater #6 is the deaerator operating at 170 psig. The boiler feedwater pumps are before the heater #7. Heater #8 is on cold reheat extraction, and heater #9 is an HARP. The topping desuperheater (#10) is a non-condensing steam to water heat exchanger. It is installed in the main feedwater line downstream of the highest pressure feedwater heater (#9). Extraction steam from the first extraction of the IP turbine is routed to this desuperheater, and steam leaving the desuperheater is fed to the feedwater heater #7.

3.8 BALANCE OF PLANT

3.8.1 Condensate

The function of the condensate system is to pump condensate from the condenser hotwell to the deaerator, through the gland steam condenser and the LP feedwater heaters. The condensate system for supercritical designs consists of one main condenser; two 50 percent-capacity, variable–speed, electric-motor-driven, vertical condensate pumps; one gland-steam condenser; four LP heaters; and one deaerator with storage tank. The condensate system for the ultra-supercritical designs consists of one main condenser; two 50 percent-capacity, variable–speed, electric-motor-driven, vertical condensate pumps; one gland-steam condenser; five LP heaters (four closed type and one #4 open type); condensate booster pumps; heater drip pumps; and one deaerator with storage tank.

In the supercritical designs, 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 feedwater heaters 1 through 4 are 50 percent capacity, parallel flow, and are located in the condenser neck. All remaining feedwater heaters are 100 percent capacity shell and U-tube heat exchangers. Each LP feedwater heater is provided with inlet/outlet isolation valves and a full capacity bypass. LP feedwater 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.

The ultra-supercritical designs are similar to the supercritical designs, except the feedwater heater #2 has a heater drip pump to push the drain flow into the condensate to the heater #3, and the feedwater heater #4 is an open type heater that supplies the booster pump suction.

3.8.2 Feedwater

The function of the feedwater system is to pump the feedwater from the deaerator storage tank through the HP feedwater heaters to the boiler economizer. One turbine-driven boiler feed pump sized at 100 percent capacity is provided to pump feedwater through the HP feedwater heaters. One 30-percent-motor-driven boiler feed 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 feedwater heater is provided with inlet/outlet isolation valves and a full capacity bypass. Feedwater 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 ultra-supercritical designs are equipped with a topping desuperheater. Its purpose is to improve cycle heat rate and reduce the thermal impact on the lower stage high pressure feedwater heater. The topping desuperheater is a dry non-condensing type steam to water heat exchanger. Steam exiting the topping desuperheater is used in the lower stage feedwater heating. The topping desuperheater and its lower stage feedwater heater are designed to operate together and need no additional controls or valves [54].

The deaerator is a horizontal, spray-tray type with an internal, direct–contact, stainless-steel 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.

3.8.3 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 reheater and from the boiler reheater 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 boiler feed water 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 reheater. Hot reheat steam exits the boiler reheater through a motor-operated gate valve and is routed to the IP turbine.

3.8.4 Extraction Steam

The function of the extraction steam system is to convey steam from turbine extraction points to the feedwater heaters.

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 feedwater 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.

3.8.5 Circulating Water System

It is assumed that the plant is serviced by a public water facility and has access to groundwater for use as makeup cooling water with minimal pretreatment. All filtration and treatment of the circulating water are conducted on site. A mechanical draft, counter-flow cooling tower is provided for the circulating water heat sink. Two 50-percent-circulating water pumps are provided. The circulating water system provides cooling water to the condenser and the auxiliary cooling water system.

The auxiliary cooling water system is a closed-loop system. Plate and frame heat exchangers with circulating water as the cooling medium are provided. This system provides cooling water to the lube oil coolers, turbine generator, boiler feed pumps, etc. All pumps, vacuum breakers, air release valves, instruments, controls, etc. are included for a complete operable system.

3.8.6 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 daily by the boiler. The scope of the system is from the bag house hoppers, air heater hopper collectors, and bottom ash hoppers to the hydrobins (for bottom ash) and truck filling stations (for fly ash). The system is designed to support short-term operation at the 5 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 bag house and in 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.

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.

Ash from the economizer hoppers and pyrites (rejected from the coal pulverizers) is conveyed by hydraulic means (water) to the economizer/pyrites transfer tank. This material is then sluiced, on a periodic basis, to the hydrobins.

3.8.7 Ducting and Stack

One stack is provided with a single fiberglass-reinforced plastic (FRP) liner. The stack is constructed of reinforced concrete. For the air-based cases, the stack is 500 feet high for adequate particulate dispersion. It has one FRP stack liner that is 17 to 19 feet in diameter. For the oxycombustion CO_2 capture cases, the stack size is reduced to 150 feet high and 10 to 11 feet in diameter. The stack for the oxycombustion with CO_2 capture cases is needed for startup and venting of gases released in the CO_2 purification process.

3.8.8 Waste Treatment/Miscellaneous Systems

An onsite water treatment facility will treat all runoff, cleaning wastes, blowdown, and backwash to within 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 with 50-ton lime silo, 0 to 1,000 lb/hr dry lime feeder, 5,000-gallon lime slurry tank, slurry tank mixer, and 25 gallons per minute (gpm) lime slurry feed pumps.

The oxidation system consists of a 50 standard cubic feet per minute (scfm) 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 300,000-gallon 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.

3.8.9 Buildings and Structures

A soil-bearing load of 5,000 lb/ft^2 is used for foundation design. 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

3.8.10 Accessory Electric Plant

The accessory electric plant is the same for all cases and 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.

3.8.11 Instrumentation and Control

An integrated plant-wide control and monitoring distributed control system (DCS) is provided for all cases. 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.

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4. AIR-FIRED SC AND USC NON-CAPTURE REFERENCE CASES

This section contains an evaluation of plant designs with air-fired non-capture configurations serving as reference cases for corresponding oxycombustion cases. Cases S12A and L12A are based on supercritical boiler configurations (SC) and cases S13A and L13A are based on ultra-supercritical boiler configuration (USC). All the designs have a nominal net output of 550 MWe. Both SC plants (S12A and L12A) use a single reheat 24.1MPa/593°C/593°C (3,500psig/1,100°F/1,100°F) cycle, and both USC plants (S13A and L13A) use a single reheat 27.6MPa/649°C/649°C (4,000 psig/1,200°F/1,200°F) cycle. These are non-CO_2 capture cases adopted from a low-rank PC study published earlier [55]; they are included here to provide reference bases for the relevant oxycombustion cases.

Cases S12A and L12A are very similar in terms of process, equipment, scope, and arrangement, except that a different coal is used in each case. S12A uses PRB coal while L12A uses lignite. Similar distinctions also exist for USC cases. In cases where case numbers start with an "S" (S13A and S22A), the sub-bituminous PRB coal is used. In a similar fashion, in cases where case numbers start with an "L" (L13A and L22A), the lignite coal is used.

The following sections cover the four non-capture reference cases (SC and USC). The sections are organized 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
- Key Assumptions: a summary of study and modeling assumptions relevant to Cases S12A/L12A and S13A/L13A in Section 4.2.
- Sparing Philosophy: provided for Cases S12A/L12A and S13A/L13A in Section 4.3
- Performance Results: provides the main modeling results from Cases S12A/L12A and S13A/L13A in Section 4.4, 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 4.5 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 4.6.

4.1 PROCESS DESCRIPTION

In this section, the SC and USC PC processes without CO_2 capture are described. Both the supercritical and ultra-supercritical 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 primary air (stream 4) are introduced into the boiler through the wall-fired burners. Additional combustion air, including the overfire air, is provided by the forced draft fans (stream 2). The boiler operates at a slight negative pressure so air leakage is into the boiler, and the infiltration air, modeled as 2 percent of combustion mixture, 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 SDAs. 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

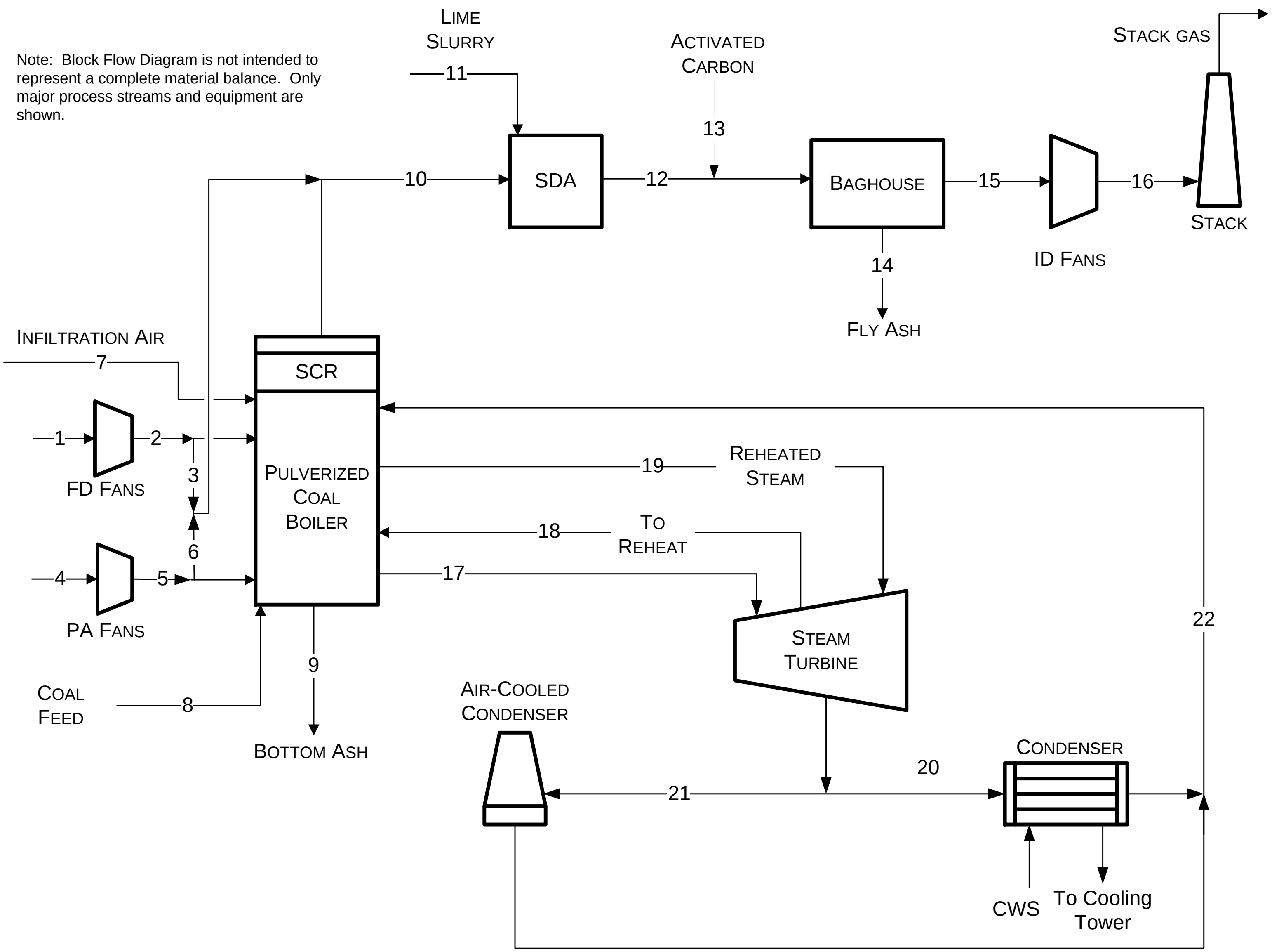

Exhibit 4-2 Case S12A Stream Table

	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)	39,030	39,030	1,474	26,020	26,020	2,104	1,152	0	0	72,996	3,120
V-L Flowrate (kg/hr)	1,127,764	1,127,764	42,588	751,843	751,843	60,791	33,273	0	0	2,148,831	56,214
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	256,992	4,208	16,833	3,913
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	200.21
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)	86,046	86,046	3,249	57,364	57,364	4,638	2,539	0	0	160,928	6,879
V-L Flowrate (lb/hr)	2,486,294	2,486,294	93,890	1,657,529	1,657,529	134,020	73,355	0	0	4,737,361	123,931
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	566,571	9,278	37,111	8,628
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)	76,035	0	0	76,035	76,035	91,336	75,709	75,709	34,525	34,525	69,963
V-L Flowrate (kg/hr)	2,201,083	0	0	2,201,083	2,201,083	1,645,449	1,363,916	1,363,916	621,971	621,971	1,260,397
Solids Flowrate (kg/hr)	24,709	42	24,751	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	0.00	0.00	1.72
Enthalpy (kJ/kg)^A	321.63	---	---	323.33	333.95	3,477.66	3,083.97	3,653.25	1,927.78	1,927.78	137.98
Density (kg/m^3)	0.8	---	---	0.8	0.9	69.2	18.7	11.6	0.0	0.0	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)	167,628	0	0	167,628	167,628	201,362	166,909	166,909	76,114	76,114	154,241
V-L Flowrate (lb/hr)	4,852,557	0	0	4,852,557	4,852,557	3,627,595	3,006,920	3,006,920	1,371,212	1,371,212	2,778,699
Solids Flowrate (lb/hr)	54,473	93	54,567	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	828.8	828.8	59.3
Density (lb/ft^3)	0.052	---	---	0.051	0.054	4.319	1.164	0.722	0.003	0.003	62.162

A - Reference conditions are 32.02 F & 0.089 PSIA

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)	40,823	40,823	1,542	27,215	27,215	2,201	1,203	0	0	79,652	3,447
V-L Flowrate (kg/hr)	1,179,686	1,179,686	44,549	786,457	786,457	63,589	34,770	0	0	2,310,239	62,103
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	343,172	6,769	27,077	4,489
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)	89,999	89,999	3,399	59,999	59,999	4,851	2,653	0	0	175,603	7,600
V-L Flowrate (lb/hr)	2,600,762	2,600,762	98,213	1,733,842	1,733,842	140,191	76,655	0	0	5,093,204	136,913
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	756,564	14,924	59,695	9,897
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)	83,006	0	0	83,006	83,006	91,651	75,972	75,972	34,643	34,643	70,203
V-L Flowrate (kg/hr)	2,367,785	0	0	2,367,785	2,367,785	1,651,110	1,368,656	1,368,656	624,110	624,110	1,264,732
Solids Flowrate (kg/hr)	36,122	65	36,188	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	0.00	0.00	1.72
Enthalpy (kJ/kg)[A]	394.50	---	---	382.07	392.19	3,477.66	3,083.95	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	0.0	0.0	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)	182,996	0	0	182,996	182,996	202,055	167,490	167,490	76,376	76,376	154,772
V-L Flowrate (lb/hr)	5,220,073	0	0	5,220,073	5,220,073	3,640,075	3,017,371	3,017,371	1,375,928	1,375,928	2,788,257
Solids Flowrate (lb/hr)	79,636	144	79,780	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

A - Reference conditions are 32.02 F & 0.089 PSIA

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)	37,865	37,865	1,430	25,244	25,244	2,041	1,117	0	0	70,817	3,027
V-L Flowrate (kg/hr)	1,094,124	1,094,124	41,317	729,416	729,416	58,977	32,277	0	0	2,084,699	54,536
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	249,294	4,082	16,329	3,760
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)	83,479	83,479	3,152	55,653	55,653	4,500	2,463	0	0	156,125	6,674
V-L Flowrate (lb/hr)	2,412,131	2,412,131	91,089	1,608,087	1,608,087	130,023	71,158	0	0	4,595,975	120,232
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	549,598	9,000	35,999	8,289
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)	73,766	0	0	73,766	73,766	94,938	71,304	71,304	28,464	28,464	57,877
V-L Flowrate (kg/hr)	2,135,392	0	0	2,135,392	2,135,392	1,710,326	1,284,558	1,284,558	512,779	512,779	1,042,662
Solids Flowrate (kg/hr)	23,932	41	23,973	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	0.00	0.00	0.86
Enthalpy (kJ/kg)[A]	321.75	---	---	323.31	333.93	3,609.84	3,270.42	3,758.29	2,251.84	2,251.84	136.90
Density (kg/m^3)	0.8	---	---	0.8	0.9	72.8	27.2	18.8	0.0	0.0	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)	162,625	0	0	162,625	162,625	209,301	157,198	157,198	62,751	62,751	127,596
V-L Flowrate (lb/hr)	4,707,734	0	0	4,707,734	4,707,734	3,770,623	2,831,966	2,831,966	1,130,485	1,130,485	2,298,676
Solids Flowrate (lb/hr)	52,761	91	52,852	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	968.1	968.1	58.9
Density (lb/ft^3)	0.052	---	---	0.051	0.054	4.542	1.698	1.176	0.002	0.002	62.139

A - Reference conditions are 32.02 F & 0.089 PSIA

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)	39,410	39,410	1,491	26,274	26,274	1,805	1,163	0	0	76,912	3,354
V-L Flowrate (kg/hr)	1,138,871	1,138,871	43,091	759,247	759,247	52,163	33,616	0	0	2,230,791	60,432
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	331,779	6,545	26,178	4,306
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	201.81
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)	86,885	86,885	3,287	57,923	57,923	3,980	2,565	0	0	169,563	7,395
V-L Flowrate (lb/hr)	2,510,781	2,510,781	95,000	1,673,854	1,673,854	115,000	74,110	0	0	4,918,051	133,229
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	731,447	14,428	57,713	9,494
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)	80,176	0	0	80,176	80,176	94,928	71,297	71,297	28,446	28,446	57,841
V-L Flowrate (kg/hr)	2,286,818	0	0	2,286,818	2,286,818	1,710,160	1,284,428	1,284,428	512,463	512,463	1,042,027
Solids Flowrate (kg/hr)	34,889	63	34,952	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	0.00	0.00	0.86
Enthalpy (kJ/kg)[A]	395.46	---	---	382.81	392.93	3,609.84	3,270.42	3,758.29	2,246.67	2,246.67	136.90
Density (kg/m^3)	0.9	---	---	0.9	0.9	72.8	27.2	18.8	0.0	0.0	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)	176,759	0	0	176,759	176,759	209,281	157,182	157,182	62,713	62,713	127,518
V-L Flowrate (lb/hr)	5,041,570	0	0	5,041,570	5,041,570	3,770,258	2,831,680	2,831,680	1,129,787	1,129,787	2,297,277
Solids Flowrate (lb/hr)	76,918	139	77,057	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	965.9	965.9	58.9
Density (lb/ft^3)	0.055	---	---	0.054	0.056	4.542	1.698	1.176	0.002	0.002	62.139

A - Reference conditions are 32.02 F & 0.089 PSIA

4.2 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	Sub-bituminous	Lignite	Sub-bituminous	Lignite
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)	9 (48)	9 (48)	9 (48)
Cooling water from condenser, °C (ºF)	20 (68)	20 (68)	20 (68)	20 (68)
FGD Outlet, °C (°F)	82 (180)	82 (180)	82 (180)	82 (180)
SO_2 Control	Spray Dryer Absorption FGD	Spray Dryer Absorption FGD	Spray Dryer Absorption FGD	Spray Dryer Absorption FGD
FGD Efficiency, % (Note A)	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, % (Note A)	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, % (Note A)	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, % (Note A)	90 plus	90	90 plus	90
CO_2 Control	N/A	N/A	N/A	N/A
CO_2 Capture, % (Note A)	N/A	N/A	N/A	N/A
CO_2 Sequestration	N/A	N/A	N/A	N/A

Note A: Equipment removal efficiencies

4.2.1 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 3.8.

4.3 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)

4.4 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 circulating water pumps, cooling tower fan, and the air-cooled condenser account for about 30 percent of the auxiliary load in all cases; and the primary air and 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% for the lignite cases. In each case the boiler heat loss is 1 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	860	1,270	830	1,230
Primary Air Fans	2,490	2,440	2,410	2,360
Forced Draft Fans	1,460	1,440	1,420	1,390
Induced Draft Fans	6,730	6,900	6,530	6,660
SCR	10	20	10	10
Baghouse	120	180	120	170
Spray Dryer FGD	2,240	2,570	2,170	2,490
Steam Turbine Auxiliaries	400	400	400	400
Condensate Pumps	800	800	330	330
Circulating Water Pump	2,400	2,400	2,340	2,330
Ground Water Pumps	250	250	240	240
Cooling Tower Fans	1,560	1,480	1,530	1,430
Air-Cooled Condenser Fans	4,990	4,730	4,880	4,560
Miscellaneous Balance of Plant[a]	2,000	2,000	2,000	2,000
Transformer Loss	1,830	1,840	1,830	1,840
TOTAL AUXILIARIES, kWe	**32,670**	**34,650**	**31,450**	**33,170**
NET POWER, kWe	**550,030**	**550,050**	**550,050**	**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)	9,307 (8,822)	9,602 (9,101)	9,028 (8,557)	9,284 (8,799)
CONDENSER COOLING DUTY GJ/hr (10^6 Btu/hr)	**2,227 (2,111)**	**2,235 (2,119)**	**2,168 (2,055)**	**2,162 (2,049)**
CONSUMABLES				
As-Received Coal Feed, kg/hr (lb/hr)	256,992 (566,571)	343,172 (756,564)	249,294 (549,598)	331,779 (731,447)
Thermal Input, kWt[b]	1,422,014	1,467,167	1,379,415	1,418,460
Raw Water Consumption, m^3/min (gpm)	10.3 (2,165)	10.4 (2,197)	10.0 (2,110)	10.1 (2,131)

[a] Includes plant control systems, lighting, heating, ventilating, and air conditioning (HVAC) and miscellaneous low voltage loads
[b] Thermal input based on as-received HHV of coal

4.4.1 Environmental Performance

The environmental targets for emissions of Hg, NO_x, SO_2, and particulate matter 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 Air Emissions for PC Cases without CO_2 Capture Air Emissions

	kg/GJ ($lb/10^6$ Btu)				Tonne/year (ton/year) 85% capacity factor				kg/MWh-gross (lb/MWh-gross)			
	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)	1,947 (2,146)	2,239 (2,468)	1,888 (2,082)	2,164 (2,386)	0.449 (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)	1,147 (1,265)	1,184 (1,305)	1,113 (1,227)	1,144 (1,261)	0.264 (0.583)	0.272 (0.599)	0.257 (0.567)	0.264 (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)	213 (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 (4.97E-6)	4.35E-6 (9.59E-6)	2.19E-6 (4.83E-6)	4.22E-6 (9.30E-6)
CO_2	92.3 (214.7)	94.4 (219.5)	92.3 (214.7)	94.4 (219.5)	3,517,661 (3,877,557)	3,710,765 (4,090,419)	3,412,283 (3,761,398)	3,587,565 (3,954,614)	811 (1,787)	852 (1,879)	788 (1,737)	826 (1,821)
CO_2 [a]									859 (1,894)	906 (1,997)	833 (1,837)	876 (1,931)

[a] 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 will be collected in the baghouse. A portion of the waste will be stored in a recycle storage silo, which will then be used to mix with lime slurry to increase the reagent utilization.

NO_x emissions are controlled to about 0.2 lb/MMBtu through the use of LNBs and OFA. An SCR unit then further reduces the NO_x 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. One hundred 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	128,671 (283,672)	135,737 (299,249)	**Ash**	42 (93)	65 (144)
Air (CO_2)	261 (575)	273 (601)	**Stack Gas**	128,932 (284,246)	136,010 (299,850)
Activated Carbon	42 (93)	65 (144)			
Total	**128,974 (284,340)**	**136,075 (299,994)**	**Total**	**128,974 (284,340)**	**136,075 (299,994)**

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	124,817 (275,174)	131,231 (289,315)	**Ash**	41 (91)	63 (139)
Air (CO_2)	253 (558)	263 (581)	**Stack Gas**	125,070 (275,731)	131,494 (289,895)
Activated Carbon	41 (91)	63 (139)			
Total	**125,111 (275,822)**	**131,557 (290,034)**	**Total**	**125,111 (275,822)**	**131,557 (290,034)**

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. The total sulfur capture is represented by the following fraction:

(Sulfur in Ash/Sulfur in the coal) or
(3,833/4,122)*100 = 93.0 percent (S12A)
(4,407/4,739)*100 = 93.0 percent (L12A)
(3,718/3,998)*100 = 93.0 percent (S13A)
(4,261/4,582)*100 = 93.0 percent (L13A)

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	1,870 (4,122)	2,150 (4,739)	**Ash**	1,739 (3,833)	1,999 (4,407)
			Stack Gas	131 (289)	150 (332)
Total	**1,870 (4,122)**	**2,150 (4,739)**	**Total**	**1,870 (4,122)**	**2,150 (4,739)**

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 (3,998)	2,078 (4,582)	**Ash**	1,687 (3,718)	1,933 (4,261)
			Stack Gas	127 (280)	145 (321)
Total	**1,813 (3,998)**	**2,078 (4,582)**	**Total**	**1,813 (3,998)**	**2,078 (4,582)**

Exhibit 4-13 and Exhibit 4-14 show the overall water balances for the plants. Raw water 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.

Exhibit 4-13 Cases S12A and 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)	
	S12A	L12A	S12A	L12A	S12A	L12A	S12A	L12A	S12A	L12A
FGD Makeup	0.94 (248)	1.04 (274)	0.0 (0)	0.0 (0)	0.94 (248)	1.04 (274)	0.00 (0)	0.00 (0)	0.94 (248)	1.04 (274)
BFW Makeup	0.27 (73)	0.28 (73)	0.0 (0)	0.0 (0)	0.27 (73)	0.28 (73)	0.00 (0)	0.00 (0)	0.27 (72)	0.28 (73)
Cooling Tower Makeup	9.3 (2,467)	9.4 (2,474)	0.27 (73)	0.28 (73)	9.1 (2,394)	9.1 (2,401)	2.1 (556)	2.11 (558)	6.98 (1,845)	7.01 (1,851)
Total	**10.5 (2,787)**	**10.7 (2,821)**	**0.27 (73)**	**0.28 (73)**	**10.3 (2,714)**	**10.4 (2,748)**	**2.1 (556)**	**2.11 (558)**	**8.20 (2,165)**	**8.32 (2,197)**

Exhibit 4-14 Cases S13A and 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)	
	S13A	L13A	S13A	L13A	S13A	L13A	S13A	L13A	S13A	L13A
FGD Makeup	0.91 (240)	1.01 (266)	0.0 (0)	0.0 (0)	0.91 (240)	1.01 (266)	0.00 (0)	0.00 (0)	0.91 (240)	1.01 (266)
BFW Makeup	0.29 (75)	0.29 (75)	0.0 (0)	0.0 (0)	0.29 (75)	0.29 (75)	0.00 (0)	0.00 (0)	0.29 (75)	0.29 (75)
Cooling Tower Makeup	9.1 (2,407)	9.1 (2,400)	0.29 (75)	0.29 (75)	8.8 (2,331)	8.8 (2,325)	2.05 (543)	2.05 (541)	6.79 (1,795)	6.77 (1,789)
Total	**10.3 (2,723)**	**10.4 (2,742)**	**0.29 (75)**	**0.29 (75)**	**10.0 (2,647)**	**10.1 (2,667)**	**2.05 (543)**	**2.05 (541)**	**7.99 (2,110)**	**8.07 (2,131)**

Heat and Mass Balance Diagrams

Heat and mass balance diagrams are shown for the following subsystems in Exhibit 4-15 through Exhibit 4-22:

- Boiler and flue gas cleanup
- Steam and feedwater

Overall plant energy balances are provided in tabular form in Exhibit 4-23 and Exhibit 4-24 for the four non-capture cases. The power out is the steam turbine power after generator losses.

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Exhibit 4-15 Case S12A Boiler and Gas Cleanup System Heat and Mass Balance Diagram

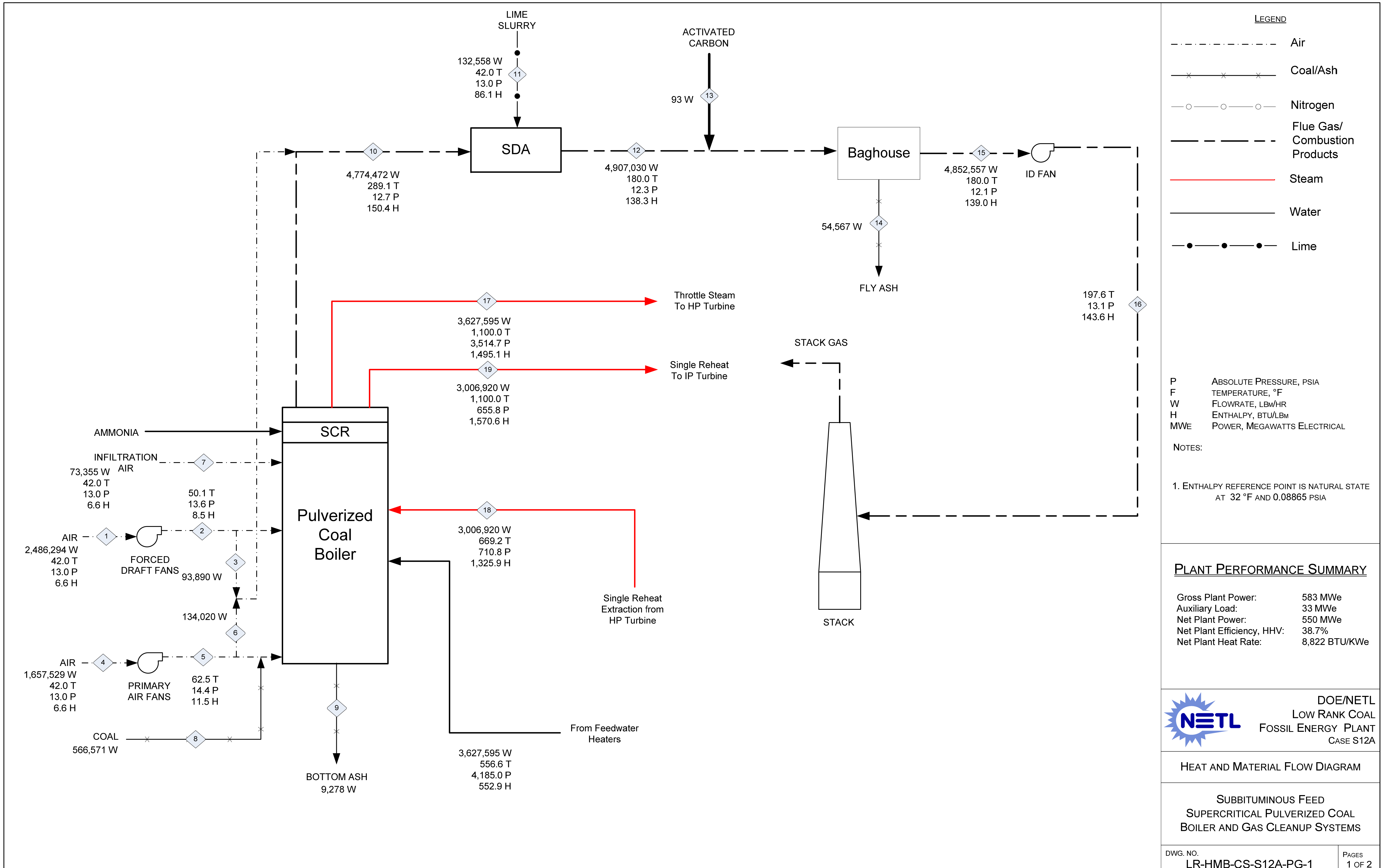

Exhibit 4-16 Case S12A Power Block System Heat and Mass Balance Diagram

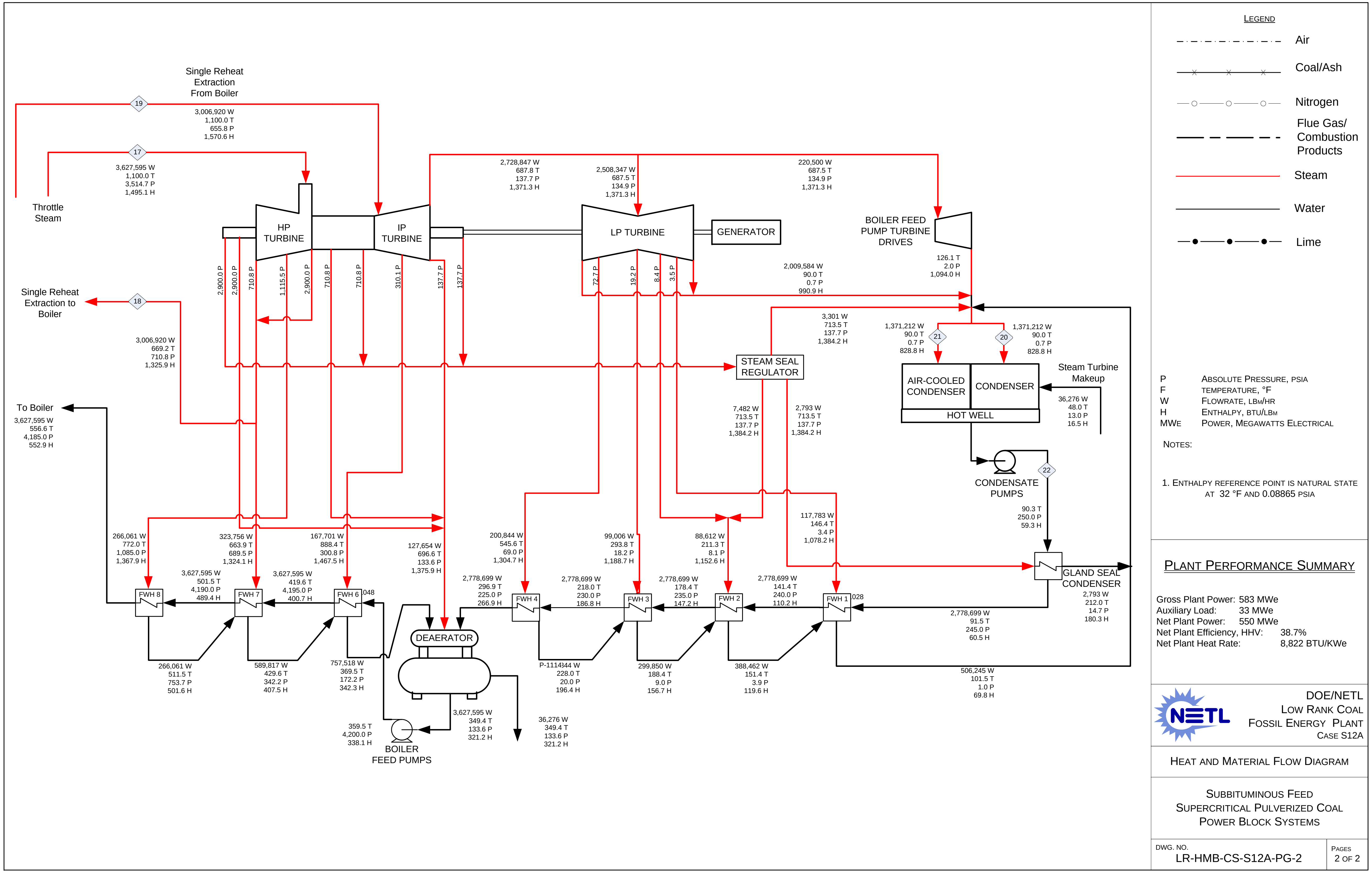

Exhibit 4-17 Case L12A Boiler and Gas Cleanup System Heat and Mass Balance Diagram

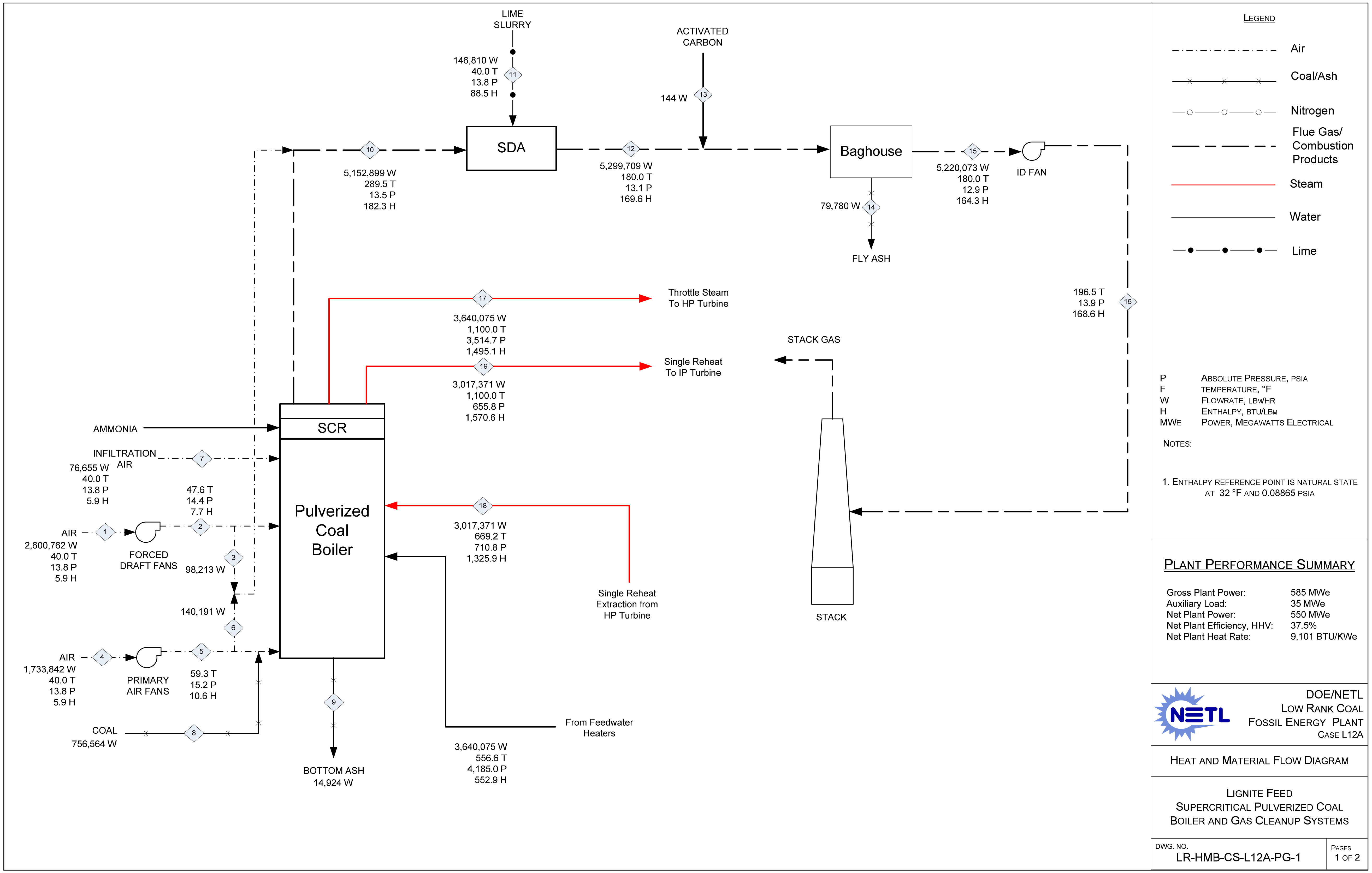

Exhibit 4-18 Case L12A Power Block System Heat and Mass Balance Diagram

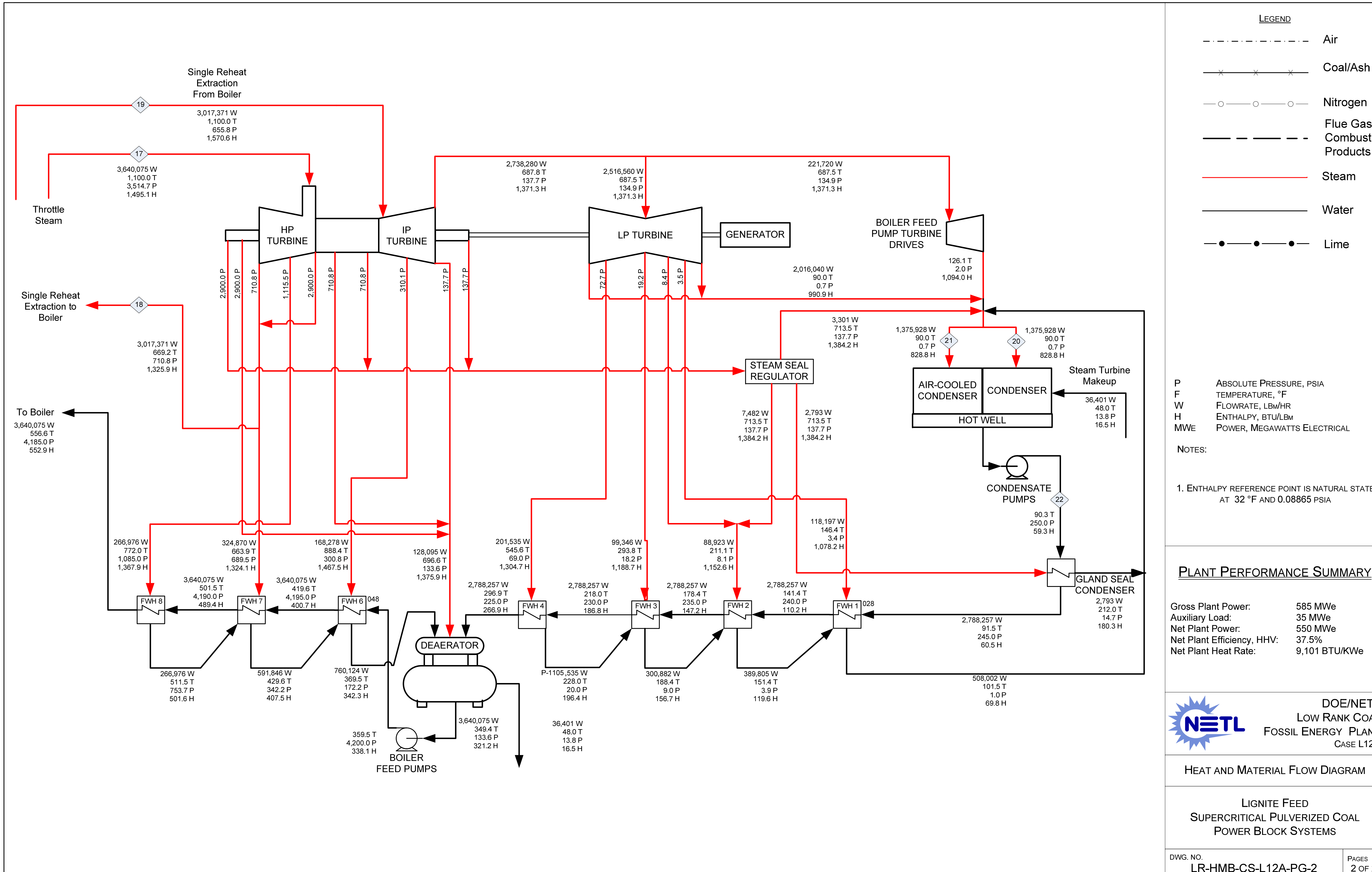

Exhibit 4-19 Case S13A Boiler and Gas Cleanup System Heat and Mass Balance Diagram

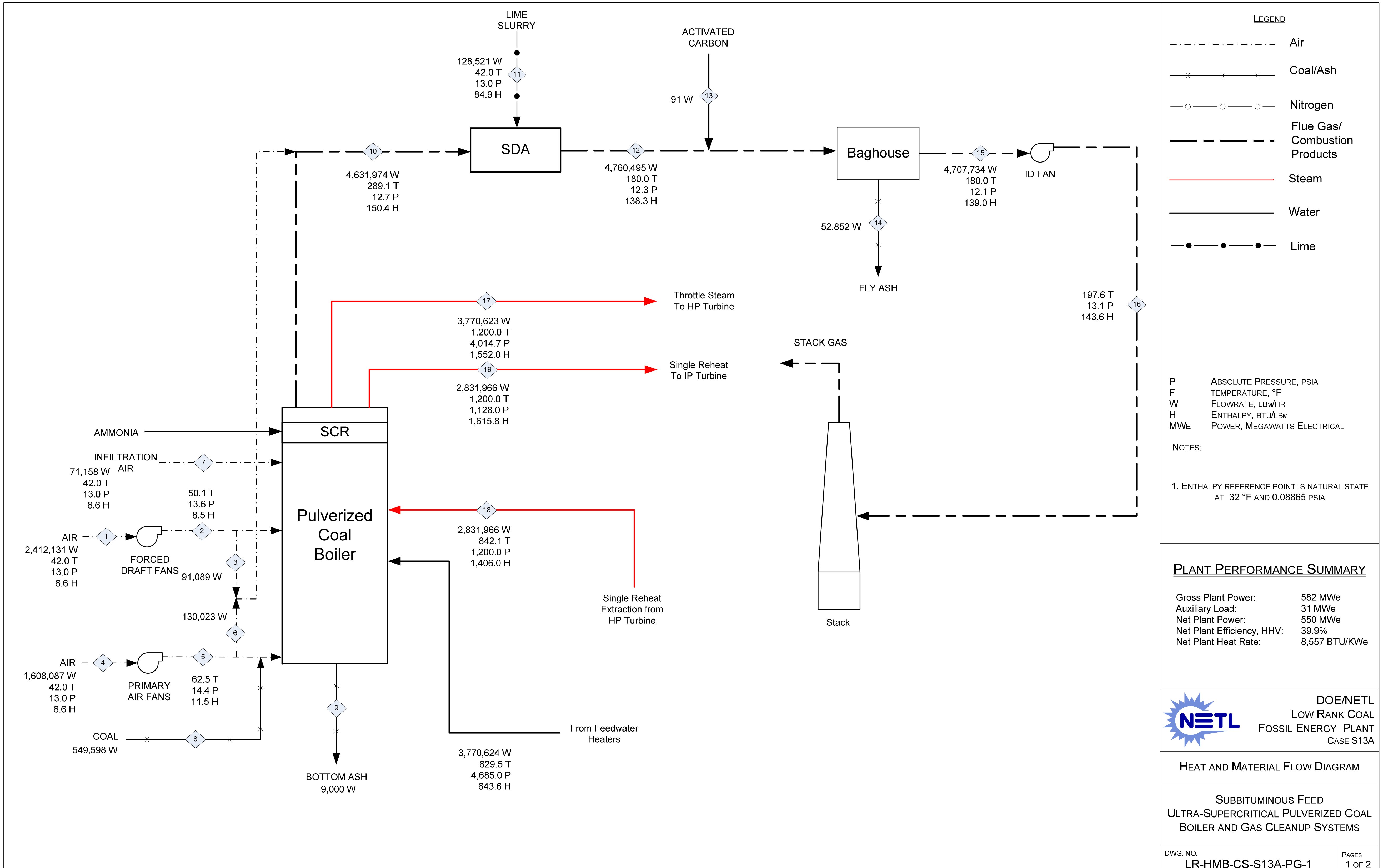

Exhibit 4-20 Case S13A Power Block System Heat and Mass Balance Diagram

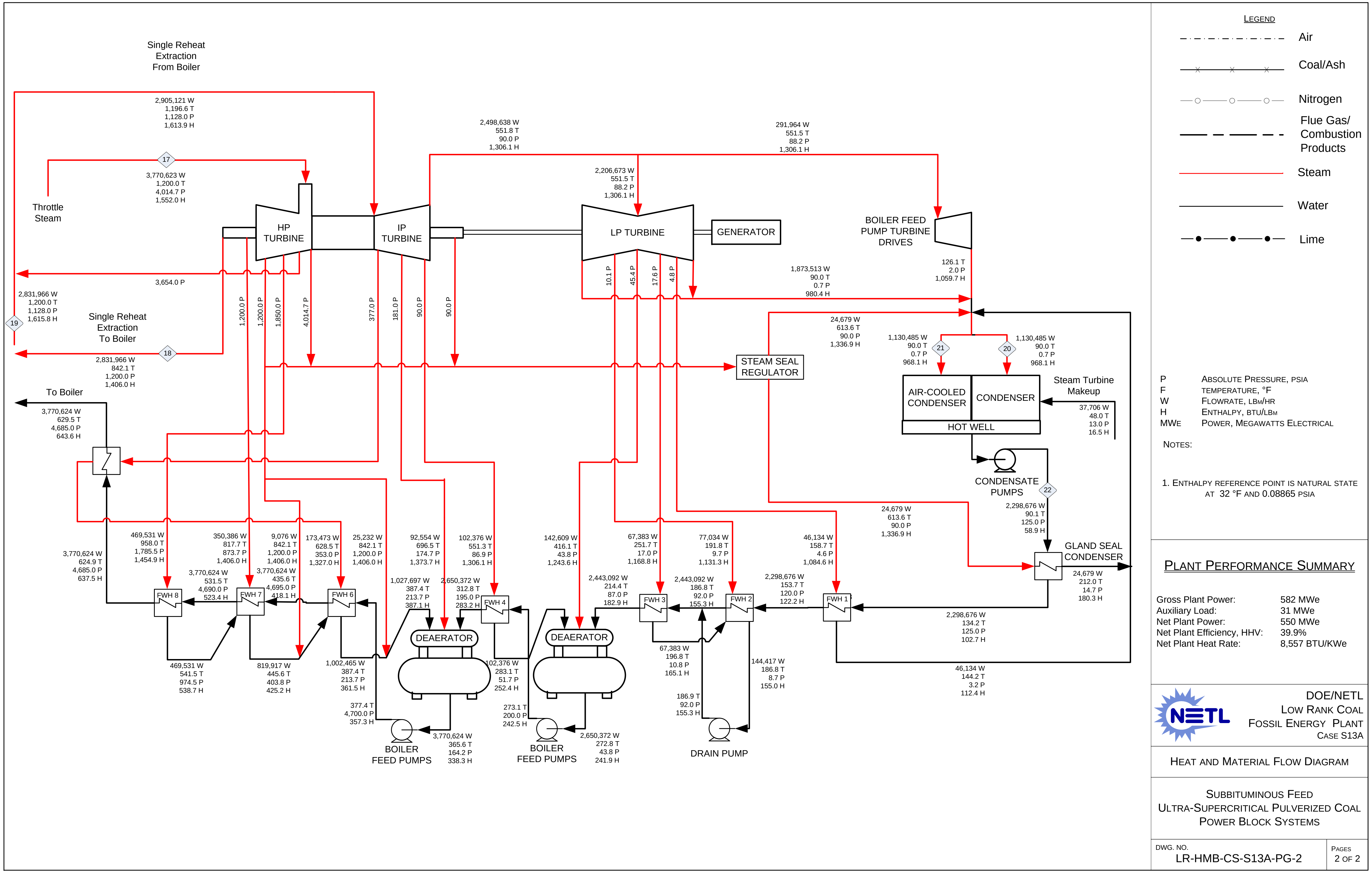

Exhibit 4-21 Case L13A Boiler and Gas Cleanup System Heat and Mass Balance Diagram

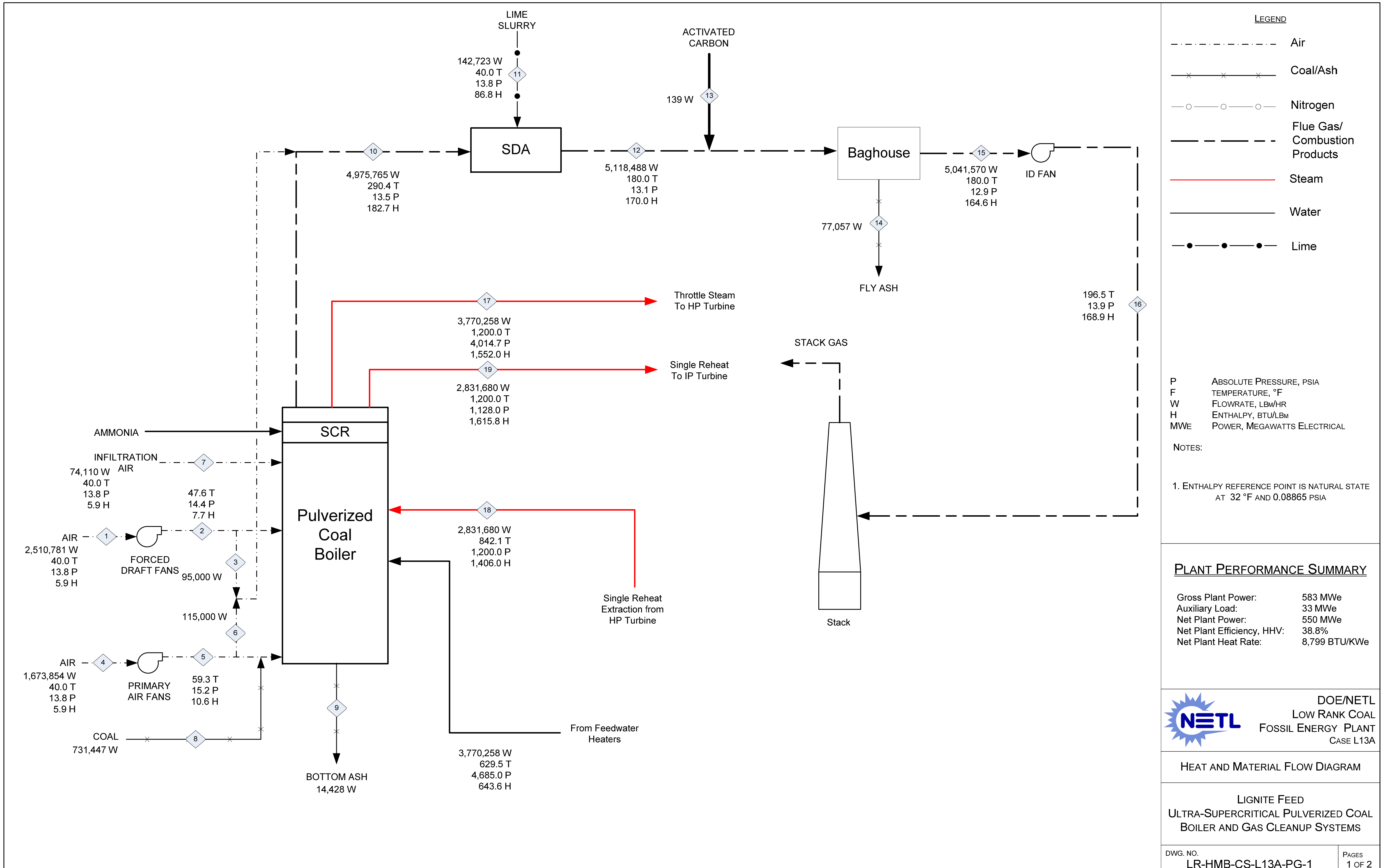

Exhibit 4-22 Case L13A Power Block System Heat and Mass Balance Diagram

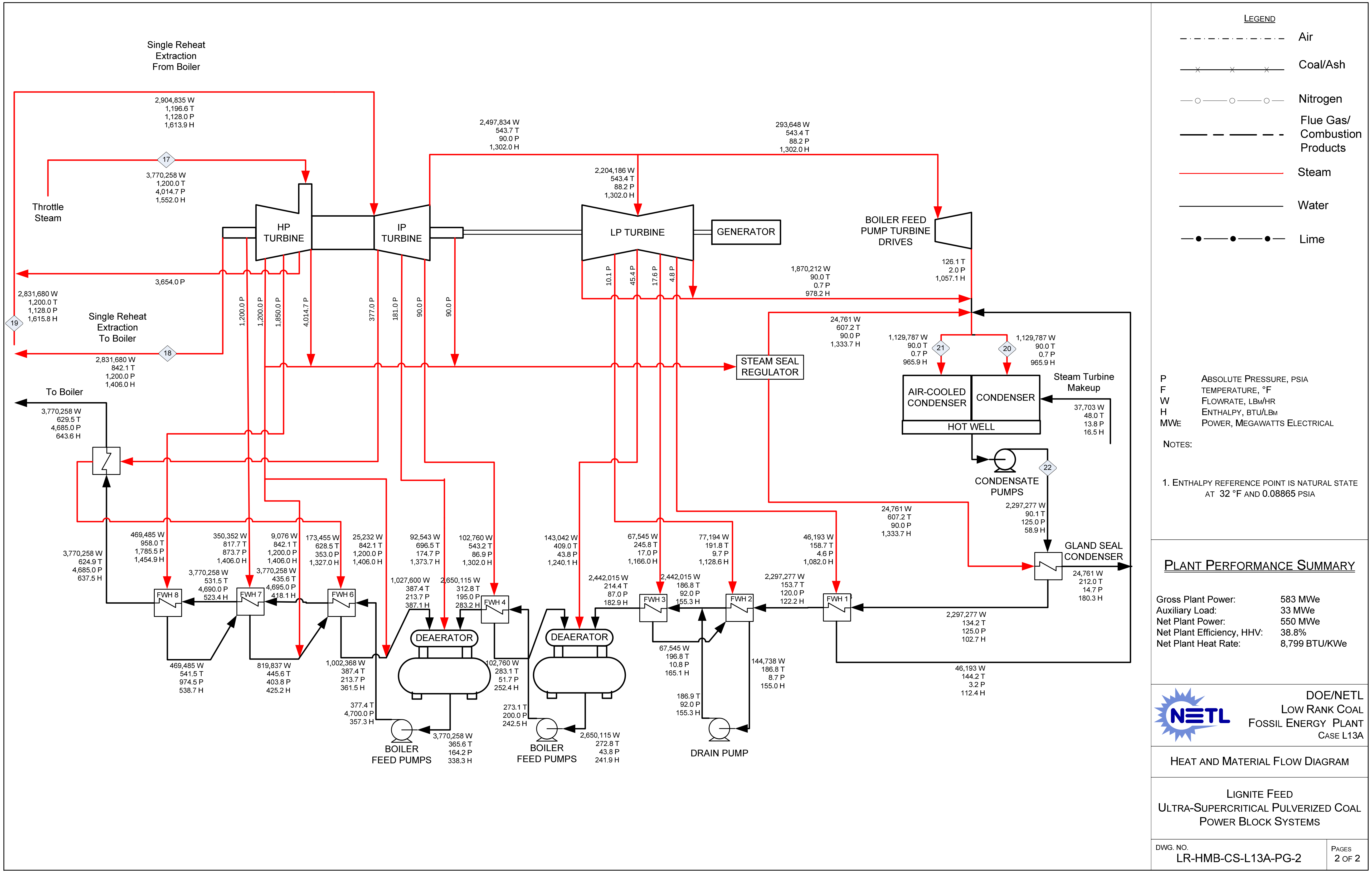

Exhibit 4-23 Cases S12A and L12A Energy Balance

	HHV		Sensible + Latent		Power		Total	
	S12A	**L12A**	**S12A**	**L12A**	**S12A**	**L12A**	**S12A**	**L12A**
Heat In, GJ/hr (MMBtu/hr)								
Coal	5,119 (4,852)	5,282 (5,006)	2.6 (2.5)	3.1 (2.9)			5,122 (4,855)	5,285 (5,009)
Combustion Air			29.2 (27.7)	27.5 (26.1)			29.2 (27.7)	27.5 (26.1)
Raw Water Makeup			14.3 (13.6)	11.6 (11.0)			14.3 (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	**5,119 (4,852)**	**5,282 (5,006)**	**46.2 (43.7)**	**42.2 (40.0)**	**118 (111)**	**125 (118)**	**5,283 (5,007)**	**5,449 (5,164)**
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			735 (697)	929 (880)			735 (697)	929 (880)
Condenser			2,227 (2,111)	2,235 (2,119)			2,227 (2,111)	2,235 (2,119)
Cooling Tower Blowdown			11.7 (11.1)	11.4 (10.8)			11.7 (11.1)	11.4 (10.8)
Process Losses[a]			209 (198)	165 (157)			209 (198)	165 (157)
Power					2,098 (1,988)	2,105 (1,995)	2,098 (1,988)	2,105 (1,995)
Totals	**0.0 (0.0)**	**0.0 (0.0)**	**3,185 (3,019)**	**3,344 (3,169)**	**2,098 (1,988)**	**2,105 (1,995)**	**5,283 (5,007)**	**5,449 (5,164)**

Notes:
Reference conditions are 0°C (32°F).
[a] Process losses including steam turbine, combustion reactions, and gas cooling are estimated to match the heat input to the plant.

Exhibit 4-24 Cases S13A and L13A Energy Balance

	HHV		Sensible + Latent		Power		Total	
	S13A	L13A	S13A	L13A	S13A	L13A	S13A	L13A
Heat In, GJ/hr (MMBtu/hr)								
Coal	4,966 (4,707)	5,106 (4,840)	2.6 (2.4)	3.0 (2.8)			4,968 (4,709)	5,109 (4,843)
Combustion Air			28.3 (26.8)	26.6 (25.2)			28.3 (26.8)	26.6 (25.2)
Raw Water Makeup			14.0 (13.2)	11.3 (10.7)			14.0 (13.2)	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	**4,966 (4,707)**	**5,106 (4,840)**	**44.9 (42.5)**	**40.8 (38.7)**	**113 (107)**	**119 (113)**	**5,124 (4,857)**	**5,267 (4,992)**
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)	899 (852)			713 (676)	899 (852)
Condenser			2,168 (2,055)	2,162 (2,049)			2,168 (2,055)	2,162 (2,049)
Cooling Tower Blowdown			11.4 (10.8)	11.1 (10.5)			11.4 (10.8)	11.1 (10.5)
Process Losses[a]			136 (129)	93 (88)			136 (129)	93 (88)
Power					2,093 (1,984)	2,100 (1,990)	2,093 (1,984)	2,100 (1,990)
Totals	**0.0 (0.0)**	**0.0 (0.0)**	**3,031 (2,872)**	**3,167 (3,002)**	**2,093 (1,984)**	**2,100 (1,990)**	**5,124 (4,857)**	**5,267 (4,992)**

Notes:
Reference conditions are 0°C (32°F).
[a] Process losses including steam turbine, combustion reactions, and gas cooling are estimated to match the heat input to the plant.

4.5 PC REFERENCE CASE 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 4.6. 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"x0 - 1-1/4"x 0)	8cm x 0 - 3cm x 0 (3"x0 - 1-1/4"x 0)	8cm x 0 - 3cm x 0 (3"x0 - 1-1/4"x 0)	8cm x 0 - 3cm x 0 (3"x0 - 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
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)

Equipment No.	Description	Type	Operating Qty. (Spares)	S12A Design Condition	L12A Design Condition	S13A Design Condition	L13A Design Condition
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[a] @ 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 7 HEAT RECOVERY STEAM GENERATOR (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

4.6 PC CASES WITHOUT CO_2 CAPTURE – COST ESTIMATING

The cost estimating methodology was described previously in Section 2.7.

The total plant cost summary organized by cost account, detailed breakdown of capital costs, and initial and annual O&M costs for the SC PC PRB case (S12A) are shown in Exhibit 4-25, Exhibit 4-26, and Exhibit 4-27, respectively. The same data for the SC PC lignite cases (L12A) are shown in Exhibit 4-28, Exhibit 4-29, and Exhibit 4-30.

The estimated TPC of the SC PC plant with no CO_2 capture using PRB coal is $1,851/kW; using lignite coal, it is $1,943/kW. Project and process contingencies represent 12.2 and 0 percent, respectively, in both cases. The 20-year LCOE is 58.8 mills/kWh for the PRB case and 67.2 mills/kWh for the lignite case, as shown in Exhibit 4-37.

The total plant cost summary organized by cost account, detailed breakdown of capital costs, and initial and annual O&M costs for the USC PC PRB case (S13A) are shown in Exhibit 4-31, Exhibit 4-32, and Exhibit 4-33, respectively. The same data for the USC PC lignite cases (L13A) are shown in Exhibit 4-34, Exhibit 4-35, and Exhibit 4-36.

The estimated TPC of the USC PC plant with no CO_2 capture using PRB coal is $1,947/kW; using lignite coal, it is $2,106/kW. Project and process contingencies represent 12.2 and 4 percent, respectively, in both cases. The process contingency is higher than for the SC plants because of process contingency on the boiler and steam turbine accounts resulting from the severe steam conditions. The 20-year LCOE is 63.8 mills/kWh for the PRB case and 72.4 mills/kWh for the lignite case, as shown in Exhibit 4-37.

Exhibit 4-25 Case S12A Total Plant Cost Summary

Client: USDOE/NETL **Report Date:** 13-Aug-08
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	$185,829	$0	$90,826	$0	$0	**$276,655**	$26,897	$0	$30,355	**$333,908**	$607
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	**$185,829**	**$0**	**$90,826**	**$0**	**$0**	**$276,655**	**$26,897**	**$0**	**$30,355**	**$333,908**	**$607**
5	FLUE GAS CLEANUP	$93,888	$0	$27,058	$0	$0	**$120,946**	$11,558	$0	$13,250	**$145,754**	$265
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	$51,825	$0	$6,895	$0	$0	**$58,719**	$5,627	$0	$6,435	**$70,781**	$129
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$61,800	$1,092	$22,228	$0	$0	**$85,120**	$7,984	$0	$16,151	**$109,255**	$199
	SUBTOTAL 8	**$113,624**	**$1,092**	**$29,123**	**$0**	**$0**	**$143,839**	**$13,611**	**$0**	**$22,586**	**$180,036**	**$327**
9	COOLING WATER SYSTEM	$7,872	$4,569	$8,088	$0	$0	**$20,529**	$1,933	$0	$3,107	**$25,569**	$46
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	$15,522	$6,364	$18,560	$0	$0	**$40,446**	$3,596	$0	$5,507	**$49,549**	$90
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	$23,380	$22,097	$0	$0	**$45,478**	$4,102	$0	$7,437	**$57,016**	$104
	TOTAL COST	**$519,718**	**$44,335**	**$264,694**	**$0**	**$0**	**$828,747**	**$78,272**	**$0**	**$111,055**	**$1,018,074**	**$1,851**

Exhibit 4-26 Case S12A Total Plant Cost Details

Client: USDOE/NETL **Report Date:** 13-Aug-08
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											
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 4-26 Case S12A Total Plant Cost Details (Continued)

Client:	USDOE/NETL	**Report Date:** 13-Aug-08
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
4	PC BOILER											
4.1	PC Boiler & Accessories	$185,829	$0	$90,826	$0	$0	$276,655	$26,897	$0	$30,355	$333,908	$607
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.	**$185,829**	**$0**	**$90,826**	**$0**	**$0**	**$276,655**	**$26,897**	**$0**	**$30,355**	**$333,908**	**$607**
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$73,214	$0	$15,864	$0	$0	$89,078	$8,493	$0	$9,757	$107,328	$195
5.2	Other FGD	$945	$0	$487	$0	$0	$1,433	$138	$0	$157	$1,727	$3
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	$19,728	$0	$10,706	$0	$0	$30,435	$2,927	$0	$3,336	$36,698	$67
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.	**$93,888**	**$0**	**$27,058**	**$0**	**$0**	**$120,946**	**$11,558**	**$0**	**$13,250**	**$145,754**	**$265**
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 4-26 Case S12A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 13-Aug-08
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
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$51,825	$0	$6,895	$0	$0	$58,719	$5,627	$0	$6,435	$70,781	$129
8.2	Turbine Plant Auxiliaries	$348	$0	$746	$0	$0	$1,094	$107	$0	$120	$1,321	$2
8.3a	Condenser & Auxiliaries	$4,096	$0	$2,295	$0	$0	$6,391	$615	$0	$701	$7,706	$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	$20,380	$0	$10,049	$0	$0	$30,428	$2,557	$0	$4,948	$37,933	$69
8.9	TG Foundations	$0	$1,092	$1,726	$0	$0	$2,818	$267	$0	$617	$3,702	$7
	SUBTOTAL 8.	**$113,624**	**$1,092**	**$29,123**	**$0**	**$0**	**$143,839**	**$13,611**	**$0**	**$22,586**	**$180,036**	**$327**
9	COOLING WATER SYSTEM											
9.1	Cooling Towers	$5,717	$0	$1,780	$0	$0	$7,498	$717	$0	$821	$9,036	$16
9.2	Circulating Water Pumps	$1,185	$0	$115	$0	$0	$1,300	$110	$0	$141	$1,551	$3
9.3	Circ.Water System Auxiliaries	$361	$0	$48	$0	$0	$409	$39	$0	$45	$493	$1
9.4	Circ.Water Piping	$0	$2,864	$2,776	$0	$0	$5,640	$528	$0	$925	$7,093	$13
9.5	Make-up Water System	$323	$0	$431	$0	$0	$754	$72	$0	$124	$951	$2
9.6	Component Cooling Water Sys	$286	$0	$227	$0	$0	$513	$49	$0	$84	$647	$1
9.9	Circ.Water System Foundations& Structures	$0	$1,705	$2,709	$0	$0	$4,414	$418	$0	$966	$5,797	$11
	SUBTOTAL 9.	**$7,872**	**$4,569**	**$8,088**	**$0**	**$0**	**$20,529**	**$1,933**	**$0**	**$3,107**	**$25,569**	**$46**
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 4-26 Case S12A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 13-Aug-08
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	$271	$0	$923	$0	$0	$1,195	$117	$0	$131	$1,443	$3
11.7	Standby Equipment	$1,279	$0	$29	$0	$0	$1,308	$120	$0	$143	$1,571	$3
11.8	Main Power Transformers	$6,118	$0	$173	$0	$0	$6,291	$479	$0	$677	$7,446	$14
11.9	Electrical Foundations	$0	$312	$765	$0	$0	$1,077	$103	$0	$236	$1,416	$3
	SUBTOTAL 11.	**$15,522**	**$6,364**	**$18,560**	**$0**	**$0**	**$40,446**	**$3,596**	**$0**	**$5,507**	**$49,549**	**$90**
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**

Exhibit 4-26 Case S12A Total Plant Cost Details (Continued)

Client: USDOE/NETL — **Report Date:** 13-Aug-08
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
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	$357	$294	$0	$0	$651	$58	$0	$106	$815	$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	$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**	**$23,380**	**$22,097**	**$0**	**$0**	**$45,478**	**$4,102**	**$0**	**$7,437**	**$57,016**	**$104**
	TOTAL COST	**$519,718**	**$44,335**	**$264,694**	**$0**	**$0**	**$828,747**	**$78,272**	**$0**	**$111,055**	**$1,018,074**	**$1,851**

Exhibit 4-27 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):**	8,822
					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					$7,229,479	$13.144
Administrative & Support Labor					$3,188,449	$5.797
TOTAL FIXED OPERATING COSTS					**$15,942,247**	**$28.984**
VARIABLE OPERATING COSTS						
						$/kWh-net
Maintenance Material Cost					**$10,844,218**	**$0.00265**
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)	66,213	9,459	0.17	$11,459	$507,895	$0.00012
Lime (ton)	729	104	75.00	$54,671	$2,423,115	$0.00059
Carbon (Mercury Removal) (lb)	15,624	2,232	1.05	$16,408	$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	158	23	129.80	$20,531	$909,959	$0.00022
Subtotal Chemicals				**$103,070**	**$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				**$103,070**	**$20,541,774**	**$0.00502**
Fuel(ton)	203,976	6,799	12.96	**$2,643,275**	**$27,335,871**	**$0.00667**

Exhibit 4-28 Case L12A Total Plant Cost Summary

Client: USDOE/NETL | **Report Date:** 13-Aug-08

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 (June)** 2007 ($x1000)

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	$20,203	$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	$206,725	$0	$92,349	$0	$0	**$299,074**	$29,058	$0	$32,813	**$360,945**	$656
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	**$206,725**	**$0**	**$92,349**	**$0**	**$0**	**$299,074**	**$29,058**	**$0**	**$32,813**	**$360,945**	**$656**
5	FLUE GAS CLEANUP	$96,204	$0	$26,276	$0	$0	**$122,480**	$11,699	$0	$13,418	**$147,597**	$268
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	$51,901	$0	$6,906	$0	$0	**$58,807**	$5,636	$0	$6,444	**$70,887**	$129
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$62,042	$1,095	$22,295	$0	$0	**$85,432**	$8,015	$0	$16,217	**$109,664**	$199
	SUBTOTAL 8	**$113,943**	**$1,095**	**$29,201**	**$0**	**$0**	**$144,239**	**$13,650**	**$0**	**$22,661**	**$180,550**	**$328**
9	COOLING WATER SYSTEM	$7,889	$4,593	$8,115	$0	$0	**$20,598**	$1,939	$0	$3,118	**$25,654**	$47
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	$15,681	$6,512	$18,978	$0	$0	**$41,172**	$3,662	$0	$5,611	**$50,445**	$92
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	$24,424	$23,017	$0	$0	**$47,440**	$4,278	$0	$7,758	**$59,477**	$108
	TOTAL COST	**$550,904**	**$46,755**	**$272,402**	**$0**	**$0**	**$870,061**	**$82,166**	**$0**	**$116,347**	**$1,068,575**	**$1,943**

Exhibit 4-29 Case L12A Total Plant Cost Details

	Client:	USDOE/NETL							Report Date:	13-Aug-08		
	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 (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	$4,927	$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 4-29 Case L12A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 13-Aug-08
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 (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	$206,725	$0	$92,349	$0	$0	$299,074	$29,058	$0	$32,813	$360,945	$656
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.	**$206,725**	**$0**	**$92,349**	**$0**	**$0**	**$299,074**	**$29,058**	**$0**	**$32,813**	**$360,945**	**$656**
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$76,430	$0	$15,960	$0	$0	$92,390	$8,806	$0	$10,120	$111,316	$202
5.2	Other FGD	$987	$0	$490	$0	$0	$1,477	$142	$0	$162	$1,781	$3
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	$18,787	$0	$9,825	$0	$0	$28,612	$2,751	$0	$3,136	$34,500	$63
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.	**$96,204**	**$0**	**$26,276**	**$0**	**$0**	**$122,480**	**$11,699**	**$0**	**$13,418**	**$147,597**	**$268**
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 4-29 Case L12A Total Plant Cost Details (Continued)

Client:	USDOE/NETL
Project:	Low Rank (Western) Coal Baseline Study
Report Date:	13-Aug-08

TOTAL PLANT COST SUMMARY

Case:	Case L12A - 1x550 MWnet SuperCritical 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
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$51,901	$0	$6,906	$0	$0	$58,807	$5,636	$0	$6,444	$70,887	$129
8.2	Turbine Plant Auxiliaries	$349	$0	$748	$0	$0	$1,097	$107	$0	$120	$1,324	$2
8.3a	Condenser & Auxiliaries	$4,093	$0	$2,301	$0	$0	$6,394	$615	$0	$701	$7,710	$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	$20,401	$0	$10,059	$0	$0	$30,460	$2,559	$0	$4,953	$37,972	$69
8.9	TG Foundations	$0	$1,095	$1,730	$0	$0	$2,825	$267	$0	$619	$3,711	$7
	SUBTOTAL 8.	**$113,943**	**$1,095**	**$29,201**	**$0**	**$0**	**$144,239**	**$13,650**	**$0**	**$22,661**	**$180,550**	**$328**
9	COOLING WATER SYSTEM											
9.1	Cooling Towers	$5,714	$0	$1,779	$0	$0	$7,493	$717	$0	$821	$9,031	$16
9.2	Circulating Water Pumps	$1,197	$0	$116	$0	$0	$1,313	$111	$0	$142	$1,566	$3
9.3	Circ.Water System Auxiliaries	$364	$0	$49	$0	$0	$413	$39	$0	$45	$498	$1
9.4	Circ.Water Piping	$0	$2,889	$2,800	$0	$0	$5,689	$533	$0	$933	$7,155	$13
9.5	Make-up Water System	$326	$0	$435	$0	$0	$761	$73	$0	$125	$959	$2
9.6	Component Cooling Water Sys	$288	$0	$229	$0	$0	$518	$49	$0	$85	$652	$1
9.9	Circ.Water System Foundations& Structures	$0	$1,704	$2,707	$0	$0	$4,411	$417	$0	$966	$5,794	$11
	SUBTOTAL 9.	**$7,889**	**$4,593**	**$8,115**	**$0**	**$0**	**$20,598**	**$1,939**	**$0**	**$3,118**	**$25,654**	**$47**
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 4-29 Case L12A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 13-Aug-08
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 (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	$1,605	$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	$277	$0	$941	$0	$0	$1,218	$119	$0	$134	$1,470	$3
11.7	Standby Equipment	$1,281	$0	$29	$0	$0	$1,311	$120	$0	$143	$1,574	$3
11.8	Main Power Transformers	$6,114	$0	$173	$0	$0	$6,287	$478	$0	$677	$7,442	$14
11.9	Electrical Foundations	$0	$313	$767	$0	$0	$1,080	$103	$0	$237	$1,420	$3
	SUBTOTAL 11.	**$15,681**	**$6,512**	**$18,978**	**$0**	**$0**	**$41,172**	**$3,662**	**$0**	**$5,611**	**$50,445**	**$92**
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**

Exhibit 4-29 Case L12A Total Plant Cost Details (Continued)

Client:	USDOE/NETL	Report Date:	13-Aug-08
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 (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
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	$361	$297	$0	$0	$658	$59	$0	$107	$824	$1
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**	**$24,424**	**$23,017**	**$0**	**$0**	**$47,440**	**$4,278**	**$0**	**$7,758**	**$59,477**	**$108**
	TOTAL COST	**$550,904**	**$46,755**	**$272,402**	**$0**	**$0**	**$870,061**	**$82,166**	**$0**	**$116,347**	**$1,068,575**	**$1,943**

Exhibit 4-30 Case L12A Initial and Annual O&M Costs

INITIAL & ANNUAL O&M EXPENSES						Cost Base (June)	2007
Case L12A - 1x550 MWnet SuperCritical PC						Heat Rate-net(Btu/kWh):	9,101
						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						$7,669,836	$13.944
Administrative & Support Labor						$3,298,539	$5.997
TOTAL FIXED OPERATING COSTS						**$16,492,694**	**$29.984**
VARIABLE OPERATING COSTS							
							$/kWh-net
Maintenance Material Cost						**$11,504,754**	**$0.00281**
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)	67,042	9,577		0.17	$11,603	$514,258	$0.00013
Lime (ton)	831	119		75.00	$62,351	$2,763,490	$0.00067
Carbon (Mercury Removal) (lb)	24,192	3,456		1.05	$25,406	$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	163	23		129.80	$21,174	$938,470	$0.00023
Subtotal Chemicals					**$120,534**	**$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					**$120,534**	**$23,905,925**	**$0.00584**
Fuel(ton)	272,353	9,078		11.97	**$3,260,069**	**$33,714,548**	**$0.00823**

Exhibit 4-31 Case S13A Total Plant Cost Summary

Client: USDOE/NETL **Report Date:** 13-Aug-08
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	$16,676	$5,064	$11,050	$0	$0	**$32,790**	$2,952	$0	$5,361	**$41,104**	$75
2	COAL & SORBENT PREP & FEED	$8,339	$670	$2,328	$0	$0	**$11,337**	$997	$0	$1,850	**$14,183**	$26
3	FEEDWATER & MISC. BOP SYSTEMS	$42,311	$0	$20,073	$0	$0	**$62,384**	$5,680	$0	$10,800	**$78,863**	$143
4	PC BOILER											
4.1	PC Boiler & Accessories	$200,374	$0	$98,025	$0	$0	**$298,398**	$29,011	$14,920	$32,741	**$375,070**	$682
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	**$200,374**	**$0**	**$98,025**	**$0**	**$0**	**$298,398**	**$29,011**	**$14,920**	**$32,741**	**$375,070**	**$682**
5	FLUE GAS CLEANUP	$91,216	$0	$26,918	$0	$0	**$118,134**	$11,292	$0	$12,943	**$142,368**	$259
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	$53,004	$0	$6,884	$0	$0	**$59,888**	$5,739	$2,994	$6,563	**$75,184**	$137
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$66,635	$1,091	$24,856	$0	$0	**$92,581**	$8,597	$0	$17,324	**$118,502**	$215
	SUBTOTAL 8	**$119,638**	**$1,091**	**$31,740**	**$0**	**$0**	**$152,469**	**$14,336**	**$2,994**	**$23,886**	**$193,686**	**$352**
9	COOLING WATER SYSTEM	$7,680	$4,488	$7,914	$0	$0	**$20,082**	$1,891	$0	$3,040	**$25,013**	$45
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	$15,487	$6,271	$18,295	$0	$0	**$40,053**	$3,559	$0	$5,448	**$49,060**	$89
12	INSTRUMENTATION & CONTROL	$8,765	$0	$8,888	$0	$0	**$17,652**	$1,601	$0	$2,365	**$21,617**	$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	$23,031	$21,785	$0	$0	**$44,815**	$4,042	$0	$7,329	**$56,187**	$102
	TOTAL COST	**$539,380**	**$43,668**	**$274,316**	**$0**	**$0**	**$857,364**	**$80,930**	**$17,914**	**$114,635**	**$1,070,844**	**$1,947**

Exhibit 4-32 Case S13A Total Plant Cost Details

Client:	USDOE/NETL
Project:	Low Rank (Western) Coal Baseline Study
Report Date:	13-Aug-08
Case:	Case S13A - 1x550 MWnet USC PC
Plant Size:	550.1 MW,net
Estimate Type:	Conceptual
Cost Base (June)	2007 ($x1000)

TOTAL PLANT COST DETAILS

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	$4,042	$0	$1,846	$0	$0	$5,888	$526	$0	$962	$7,376	$13
1.2	Coal Stackout & Reclaim	$5,223	$0	$1,183	$0	$0	$6,407	$561	$0	$1,045	$8,012	$15
1.3	Coal Conveyors	$4,856	$0	$1,171	$0	$0	$6,027	$528	$0	$983	$7,538	$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	$4,964	$6,262	$0	$0	$11,226	$1,054	$0	$1,842	$14,122	$26
	SUBTOTAL 1.	**$16,676**	**$5,064**	**$11,050**	**$0**	**$0**	**$32,790**	**$2,952**	**$0**	**$5,361**	**$41,104**	**$75**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$2,342	$0	$456	$0	$0	$2,799	$244	$0	$456	$3,499	$6
2.2	Coal Conveyor to Storage	$5,997	$0	$1,309	$0	$0	$7,306	$639	$0	$1,192	$9,136	$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.	**$8,339**	**$670**	**$2,328**	**$0**	**$0**	**$11,337**	**$997**	**$0**	**$1,850**	**$14,183**	**$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	$7,570	$0	$7,473	$0	$0	$15,043	$1,429	$0	$2,471	$18,943	$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.	**$42,311**	**$0**	**$20,073**	**$0**	**$0**	**$62,384**	**$5,680**	**$0**	**$10,800**	**$78,863**	**$143**

Exhibit 4-32 Case S13A Total Plant Cost Details (Continued)

	Client:	USDOE/NETL								**Report Date:**	13-Aug-08		
	Project:	Low Rank (Western) Coal Baseline Study											
		TOTAL PLANT COST DETAILS											
	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**	
4	PC BOILER												
4.1	PC Boiler & Accessories	$200,374	$0	$98,025	$0	$0	$298,398	$29,011	$14,920	$32,741	$375,070	$682	
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.	**$200,374**	**$0**	**$98,025**	**$0**	**$0**	**$298,398**	**$29,011**	**$14,920**	**$32,741**	**$375,070**	**$682**	
5	FLUE GAS CLEANUP												
5.1	Absorber Vessels & Accessories	$71,659	$0	$16,004	$0	$0	$87,664	$8,360	$0	$9,602	$105,626	$192	
5.2	Other FGD	$925	$0	$492	$0	$0	$1,417	$136	$0	$155	$1,709	$3	
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	$18,631	$0	$10,422	$0	$0	$29,053	$2,796	$0	$3,185	$35,033	$64	
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.	**$91,216**	**$0**	**$26,918**	**$0**	**$0**	**$118,134**	**$11,292**	**$0**	**$12,943**	**$142,368**	**$259**	
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**	

Exhibit 4-32 Case S13A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 13-Aug-08
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST DETAILS

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
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$53,004	$0	$6,884	$0	$0	$59,888	$5,739	$2,994	$6,563	$75,184	$137
8.2	Turbine Plant Auxiliaries	$348	$0	$745	$0	$0	$1,092	$107	$0	$120	$1,319	$2
8.3a	Condenser & Auxiliaries	$3,985	$0	$2,291	$0	$0	$6,276	$604	$0	$688	$7,569	$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	$25,998	$0	$12,819	$0	$0	$38,817	$3,261	$0	$6,312	$48,390	$88
8.9	TG Foundations	$0	$1,091	$1,723	$0	$0	$2,814	$266	$0	$616	$3,696	$7
	SUBTOTAL 8.	**$119,638**	**$1,091**	**$31,740**	**$0**	**$0**	**$152,469**	**$14,336**	**$2,994**	**$23,886**	**$193,686**	**$352**
9	COOLING WATER SYSTEM											
9.1	Cooling Towers	$5,577	$0	$1,737	$0	$0	$7,314	$699	$0	$801	$8,814	$16
9.2	Circulating Water Pumps	$1,162	$0	$115	$0	$0	$1,277	$108	$0	$139	$1,524	$3
9.3	Circ.Water System Auxiliaries	$355	$0	$47	$0	$0	$403	$38	$0	$44	$485	$1
9.4	Circ.Water Piping	$0	$2,818	$2,731	$0	$0	$5,549	$519	$0	$910	$6,979	$13
9.5	Make-up Water System	$305	$0	$407	$0	$0	$712	$68	$0	$117	$897	$2
9.6	Component Cooling Water Sys	$281	$0	$224	$0	$0	$505	$48	$0	$83	$636	$1
9.9	Circ.Water System Foundations& Structures	$0	$1,670	$2,653	$0	$0	$4,322	$409	$0	$946	$5,677	$10
	SUBTOTAL 9.	**$7,680**	**$4,488**	**$7,914**	**$0**	**$0**	**$20,082**	**$1,891**	**$0**	**$3,040**	**$25,013**	**$45**
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**

Exhibit 4-32 Case S13A Total Plant Cost Details (Continued)

	Client:	USDOE/NETL							Report Date:	13-Aug-08			
	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	
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	$268	$0	$912	$0	$0	$1,181	$115	$0	$130	$1,425	$3	
11.7	Standby Equipment	$1,278	$0	$29	$0	$0	$1,307	$120	$0	$143	$1,570	$3	
11.8	Main Power Transformers	$6,185	$0	$173	$0	$0	$6,358	$484	$0	$684	$7,526	$14	
11.9	Electrical Foundations	$0	$312	$764	$0	$0	$1,076	$103	$0	$236	$1,414	$3	
	SUBTOTAL 11.	**$15,487**	**$6,271**	**$18,295**	**$0**	**$0**	**$40,053**	**$3,559**	**$0**	**$5,448**	**$49,060**	**$89**	
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	$5,352	$496	$0	$585	$6,433	$12	
12.8	Instrument Wiring & Tubing	$2,470	$0	$4,899	$0	$0	$7,369	$628	$0	$1,200	$9,197	$17	
12.9	Other I & C Equipment	$1,287	$0	$2,922	$0	$0	$4,209	$408	$0	$462	$5,079	$9	
	SUBTOTAL 12.	**$8,765**	**$0**	**$8,888**	**$0**	**$0**	**$17,652**	**$1,601**	**$0**	**$2,365**	**$21,617**	**$39**	
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**	

Exhibit 4-32 Case S13A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 13-Aug-08
Project: Low Rank (Western) Coal Baseline Study

TOTAL PLANT COST DETAILS

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
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	$273	$225	$0	$0	$497	$45	$0	$81	$623	$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**	**$23,031**	**$21,785**	**$0**	**$0**	**$44,815**	**$4,042**	**$0**	**$7,329**	**$56,187**	**$102**
	TOTAL COST	**$539,380**	**$43,668**	**$274,316**	**$0**	**$0**	**$857,364**	**$80,930**	**$17,914**	**$114,635**	**$1,070,844**	**$1,947**

Exhibit 4-33 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):	8,557
					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					$7,535,642	$13.700
Administrative & Support Labor					$3,264,990	$5.936
TOTAL FIXED OPERATING COSTS					**$16,324,951**	**$29.679**
VARIABLE OPERATING COSTS						
						$/kWh-net
Maintenance Material Cost					**$11,303,463**	**$0.00276**
Consumables	Consumption Initial	Consumption /Day	Unit Cost	Initial Cost		
Water(/1000 gallons)	0	1,906	1.08	**$0**	**$639,581**	**$0.00016**
Chemicals						
MU & WT Chem.(lb)	64,578	9,225	0.17	$11,176	$495,357	$0.00012
Lime (ton)	696	99	75.00	$52,221	$2,314,496	$0.00057
Carbon (Mercury Removal) (lb)	15,288	2,184	1.05	$16,055	$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	153	22	129.80	$19,899	$881,930	$0.00022
Subtotal Chemicals				**$99,351**	**$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				**$99,351**	**$20,681,614**	**$0.00505**
Fuel(ton)	197,856	6,595	12.96	**$2,563,968**	**$26,515,706**	**$0.00647**

Exhibit 4-34 Case L13A Total Plant Cost Summary

Client: USDOE/NETL **Report Date:** 13-Aug-08
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	$19,891	$6,071	$13,235	$0	$0	**$39,197**	$3,530	$0	$6,409	**$49,136**	$89
2	COAL & SORBENT PREP & FEED	$10,133	$814	$2,828	$0	$0	**$13,775**	$1,211	$0	$2,248	**$17,234**	$31
3	FEEDWATER & MISC. BOP SYSTEMS	$43,386	$0	$21,068	$0	$0	**$64,455**	$5,877	$0	$11,149	**$81,480**	$148
4	PC BOILER											
4.1	PC Boiler & Accessories	$241,475	$0	$109,261	$0	$0	**$350,736**	$34,081	$17,537	$38,482	**$440,836**	$801
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	**$241,475**	**$0**	**$109,261**	**$0**	**$0**	**$350,736**	**$34,081**	**$17,537**	**$38,482**	**$440,836**	**$801**
5	FLUE GAS CLEANUP	$93,938	$0	$24,936	$0	$0	**$118,874**	$11,412	$0	$12,615	**$142,902**	$260
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	$53,078	$0	$6,894	$0	$0	**$59,973**	$5,747	$2,999	$6,572	**$75,290**	$137
8.2-8.9	Turbine Plant Auxiliaries and Steam Piping	$66,629	$1,093	$24,867	$0	$0	**$92,589**	$8,597	$0	$17,326	**$118,512**	$215
	SUBTOTAL 8	**$119,707**	**$1,093**	**$31,761**	**$0**	**$0**	**$152,561**	**$14,344**	**$2,999**	**$23,897**	**$193,802**	**$352**
9	COOLING WATER SYSTEM	$7,650	$4,475	$7,881	$0	$0	**$20,007**	$1,883	$0	$3,029	**$24,919**	$45
10	ASH/SPENT SORBENT HANDLING SYS	$7,043	$224	$9,416	$0	$0	**$16,683**	$1,604	$0	$1,882	**$20,169**	$37
11	ACCESSORY ELECTRIC PLANT	$15,590	$6,380	$18,604	$0	$0	**$40,574**	$3,607	$0	$5,523	**$49,704**	$90
12	INSTRUMENTATION & CONTROL	$8,723	$0	$8,845	$0	$0	**$17,568**	$1,593	$0	$2,353	**$21,515**	$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	$24,037	$22,672	$0	$0	**$46,709**	$4,213	$0	$7,638	**$58,560**	$106
	TOTAL COST	**$591,114**	**$45,989**	**$290,496**	**$0**	**$0**	**$927,599**	**$87,692**	**$20,535**	**$122,674**	**$1,158,500**	**$2,106**

Exhibit 4-35 Case L13A Total Plant Cost Details

	Client:	USDOE/NETL							Report Date:	13-Aug-08		
	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	$4,853	$0	$2,217	$0	$0	$7,070	$632	$0	$1,155	$8,857	$16
1.2	Coal Stackout & Reclaim	$6,272	$0	$1,421	$0	$0	$7,693	$673	$0	$1,255	$9,621	$17
1.3	Coal Conveyors	$5,831	$0	$1,406	$0	$0	$7,237	$634	$0	$1,181	$9,052	$16
1.4	Other Coal Handling	$1,526	$0	$325	$0	$0	$1,851	$162	$0	$302	$2,315	$4
1.5	Sorbent Receive & Unload	$53	$0	$16	$0	$0	$69	$6	$0	$11	$87	$0
1.6	Sorbent Stackout & Reclaim	$862	$0	$158	$0	$0	$1,020	$89	$0	$166	$1,276	$2
1.7	Sorbent Conveyors	$308	$67	$75	$0	$0	$450	$39	$0	$73	$562	$1
1.8	Other Sorbent Handling	$186	$44	$97	$0	$0	$327	$29	$0	$53	$409	$1
1.9	Coal & Sorbent Hnd.Foundations	$0	$5,960	$7,519	$0	$0	$13,480	$1,266	$0	$2,212	$16,958	$31
	SUBTOTAL 1.	**$19,891**	**$6,071**	**$13,235**	**$0**	**$0**	**$39,197**	**$3,530**	**$0**	**$6,409**	**$49,136**	**$89**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$2,846	$0	$555	$0	$0	$3,400	$296	$0	$555	$4,251	$8
2.2	Coal Conveyor to Storage	$7,287	$0	$1,591	$0	$0	$8,877	$776	$0	$1,448	$11,101	$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	$814	$683	$0	$0	$1,497	$139	$0	$245	$1,881	$3
	SUBTOTAL 2.	**$10,133**	**$814**	**$2,828**	**$0**	**$0**	**$13,775**	**$1,211**	**$0**	**$2,248**	**$17,234**	**$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	$2,752	$0	$886	$0	$0	$3,638	$344	$0	$796	$4,778	$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	$539	$0	$294	$0	$0	$833	$78	$0	$182	$1,094	$2
3.5	Other Boiler Plant Systems	$8,525	$0	$8,417	$0	$0	$16,942	$1,609	$0	$2,783	$21,334	$39
3.6	FO Supply Sys & Nat Gas	$256	$0	$320	$0	$0	$576	$54	$0	$94	$724	$1
3.7	Waste Treatment Equipment	$1,866	$0	$1,064	$0	$0	$2,930	$285	$0	$643	$3,858	$7
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	$2,716	$0	$830	$0	$0	$3,545	$341	$0	$777	$4,664	$8
	SUBTOTAL 3.	**$43,386**	**$0**	**$21,068**	**$0**	**$0**	**$64,455**	**$5,877**	**$0**	**$11,149**	**$81,480**	**$148**

Exhibit 4-35 Case L13A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 13-Aug-08

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
4	PC BOILER											
4.1	PC Boiler & Accessories	$241,475	$0	$109,261	$0	$0	$350,736	$34,081	$17,537	$38,482	$440,836	$801
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.	**$241,475**	**$0**	**$109,261**	**$0**	**$0**	**$350,736**	**$34,081**	**$17,537**	**$38,482**	**$440,836**	**$801**
5	FLUE GAS CLEANUP											
5.1	Absorber Vessels & Accessories	$74,634	$0	$14,927	$0	$0	$89,561	$8,598	$0	$9,590	$107,749	$196
5.2	Other FGD	$959	$0	$470	$0	$0	$1,428	$137	$0	$148	$1,714	$3
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	$18,345	$0	$9,540	$0	$0	$27,885	$2,677	$0	$2,877	$33,439	$61
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.	**$93,938**	**$0**	**$24,936**	**$0**	**$0**	**$118,874**	**$11,412**	**$0**	**$12,615**	**$142,902**	**$260**
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**

Exhibit 4-35 Case L13A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 13-Aug-08
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
8	STEAM TURBINE GENERATOR											
8.1	Steam TG & Accessories	$53,078	$0	$6,894	$0	$0	$59,973	$5,747	$2,999	$6,572	$75,290	$137
8.2	Turbine Plant Auxiliaries	$348	$0	$746	$0	$0	$1,094	$107	$0	$120	$1,321	$2
8.3a	Condenser & Auxiliaries	$3,973	$0	$2,295	$0	$0	$6,269	$603	$0	$687	$7,560	$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	$26,003	$0	$12,821	$0	$0	$38,825	$3,262	$0	$6,313	$48,400	$88
8.9	TG Foundations	$0	$1,093	$1,726	$0	$0	$2,819	$267	$0	$617	$3,703	$7
	SUBTOTAL 8.	**$119,707**	**$1,093**	**$31,761**	**$0**	**$0**	**$152,561**	**$14,344**	**$2,999**	**$23,897**	**$193,802**	**$352**
9	COOLING WATER SYSTEM											
9.1	Cooling Towers	$5,561	$0	$1,732	$0	$0	$7,293	$697	$0	$799	$8,790	$16
9.2	Circulating Water Pumps	$1,159	$0	$115	$0	$0	$1,274	$108	$0	$138	$1,520	$3
9.3	Circ.Water System Auxiliaries	$354	$0	$47	$0	$0	$402	$38	$0	$44	$484	$1
9.4	Circ.Water Piping	$0	$2,810	$2,724	$0	$0	$5,534	$518	$0	$908	$6,959	$13
9.5	Make-up Water System	$295	$0	$395	$0	$0	$690	$66	$0	$113	$870	$2
9.6	Component Cooling Water Sys	$281	$0	$223	$0	$0	$504	$48	$0	$83	$634	$1
9.9	Circ.Water System Foundations& Structures	$0	$1,665	$2,645	$0	$0	$4,310	$408	$0	$944	$5,661	$10
	SUBTOTAL 9.	**$7,650**	**$4,475**	**$7,881**	**$0**	**$0**	**$20,007**	**$1,883**	**$0**	**$3,029**	**$24,919**	**$45**
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	$942	$0	$2,904	$0	$0	$3,846	$377	$0	$422	$4,646	$8
10.7	Ash Transport & Feed Equipment	$6,100	$0	$6,249	$0	$0	$12,349	$1,181	$0	$1,353	$14,883	$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	$224	$264	$0	$0	$488	$46	$0	$107	$640	$1
	SUBTOTAL 10.	**$7,043**	**$224**	**$9,416**	**$0**	**$0**	**$16,683**	**$1,604**	**$0**	**$1,882**	**$20,169**	**$37**

Exhibit 4-35 Case L13A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 13-Aug-08
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
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	$272	$0	$925	$0	$0	$1,197	$117	$0	$131	$1,446	$3
11.7	Standby Equipment	$1,279	$0	$29	$0	$0	$1,309	$120	$0	$143	$1,572	$3
11.8	Main Power Transformers	$6,168	$0	$172	$0	$0	$6,340	$482	$0	$682	$7,505	$14
11.9	Electrical Foundations	$0	$312	$765	$0	$0	$1,077	$103	$0	$236	$1,416	$3
	SUBTOTAL 11.	**$15,590**	**$6,380**	**$18,604**	**$0**	**$0**	**$40,574**	**$3,607**	**$0**	**$5,523**	**$49,704**	**$90**
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	$904	$2
12.7	Distributed Control System Equipment	$4,534	$0	$792	$0	$0	$5,327	$494	$0	$582	$6,403	$12
12.8	Instrument Wiring & Tubing	$2,458	$0	$4,876	$0	$0	$7,334	$625	$0	$1,194	$9,153	$17
12.9	Other I & C Equipment	$1,281	$0	$2,908	$0	$0	$4,189	$406	$0	$460	$5,055	$9
	SUBTOTAL 12.	**$8,723**	**$0**	**$8,845**	**$0**	**$0**	**$17,568**	**$1,593**	**$0**	**$2,353**	**$21,515**	**$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	$4,907	$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**

Exhibit 4-35 Case L13A Total Plant Cost Details (Continued)

	Client:	USDOE/NETL								**Report Date:**	13-Aug-08		
	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		**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**	
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	$263	$217	$0	$0	$480	$43	$0	$79	$602	$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**	**$24,037**	**$22,672**	**$0**	**$0**	**$46,709**	**$4,213**	**$0**	**$7,638**	**$58,560**	**$106**	
	TOTAL COST	**$591,114**	**$45,989**	**$290,496**	**$0**	**$0**	**$927,599**	**$87,692**	**$20,535**	**$122,674**	**$1,158,500**	**$2,106**	

Exhibit 4-36 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):	8,799
					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					$8,465,229	$15.390
Administrative & Support Labor					$3,497,387	$6.359
TOTAL FIXED OPERATING COSTS					**$17,486,935**	**$31.793**
VARIABLE OPERATING COSTS						
						$/kWh-net
Maintenance Material Cost					**$12,697,843**	**$0.00310**
Consumables	Consumption Initial	Consumption /Day	Unit Cost	Initial Cost		
Water(/1000 gallons)	0	1,920	1.08	**$0**	**$644,333**	**$0.00016**
Chemicals						
MU & WT Chem.(lb)	66,677	9,525	0.17	$11,540	$511,451	$0.00012
Lime (ton)	804	114	75.00	$60,316	$2,652,638	$0.00065
Carbon (Mercury Removal) (lb)	23,688	3,336	1.05	$24,876	$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	159	23	129.80	$20,629	$914,308	$0.00022
Subtotal Chemicals				**$117,361**	**$5,165,316**	**$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	$4,656,309	$0.00115
Bottom Ash(ton)	0	173	16.23	$0	$870,856	$0.00021
Subtotal-Waste Disposal				**$0**	**$5,527,165**	**$0.00136**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	$0.00000
Subtotal By-Products				**$0**	**$0**	**$0.00000**
TOTAL VARIABLE OPERATING COSTS				**$117,361**	**$24,699,082**	**$0.00604**
Fuel(ton)	265,785	8,777	11.97	**$3,181,448**	**$32,596,431**	**$0.00796**

Exhibit 4-37 Cost and Performance Results for Reference Cases

Case	S12A	L12A	S13A	L13A
Gross Power Output, MW_e	582.7	584.7	581.5	583.2
Net Power Output, MW_e	550.0	550.1	550.1	550.0
Net Plant Efficiency, % (HHV)	38.7	37.5	39.9	38.8
Net Plant Heat Rate, Btu/kWh (HHV)	8,822	9,101	8,557	8,799
Total Plant Cost, $x1000	1,018,074	1,101,890	1,070,844	1,158,500
Total Plant Cost, $/kW	1,851	2,003	1,947	2,106
Levelized Cost of Electricity, ¢/kWh (85% Capacity Factor)	5.88	6.72	6.38	7.24
Total CO_2 Emitted, lb/MWh_{net}	1,894	2,039	1,837	1,931

5. AIR-FIRED CIRCULATING FLUIDIZED BED COMBUSTION NON-CAPTURE REFERENCE CASES

This section contains an evaluation of plant designs for Cases S22A and L22A, which are based on supercritical CFB plants. All the designs have a nominal net output of 550 MWe. Both CFB plants use a single reheat 24.1 MPa/593°C/593°C (3,500 psig/1,100°F/1,100°F) cycle. Case L22A differs from Case S22A only through the use of a different coal type (lignite instead of PRB).

The sections are organized as follows:

- Process and System Description provides an overview of the technology operation as applied to Cases S22A and L22A in Section 5.1.
- Key Assumptions is a summary of study and modeling assumptions relevant to Cases S22A and L22A in Section 5.2.
- Sparing Philosophy is provided for Cases S22A and L22A in Section 5.3.
- Performance Results provide the main modeling results from Cases S22A and L22A in Section 5.4, 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 5.5, 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 5.6.

5.1 PROCESS DESCRIPTION

In this section, the supercritical CFB process without CO_2 capture is described. The supercritical 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 primary air (stream 4) is introduced through bubble caps in a grid to fluidize the bed. Additional combustion air, including staged air for NO_x and combustion control, is provided by the forced draft 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 NO_x 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 13). The flue gas passes to the plant stack and is discharged to the atmosphere.

Exhibit 5-1 Cases S22A and L22A Process Flow Diagram

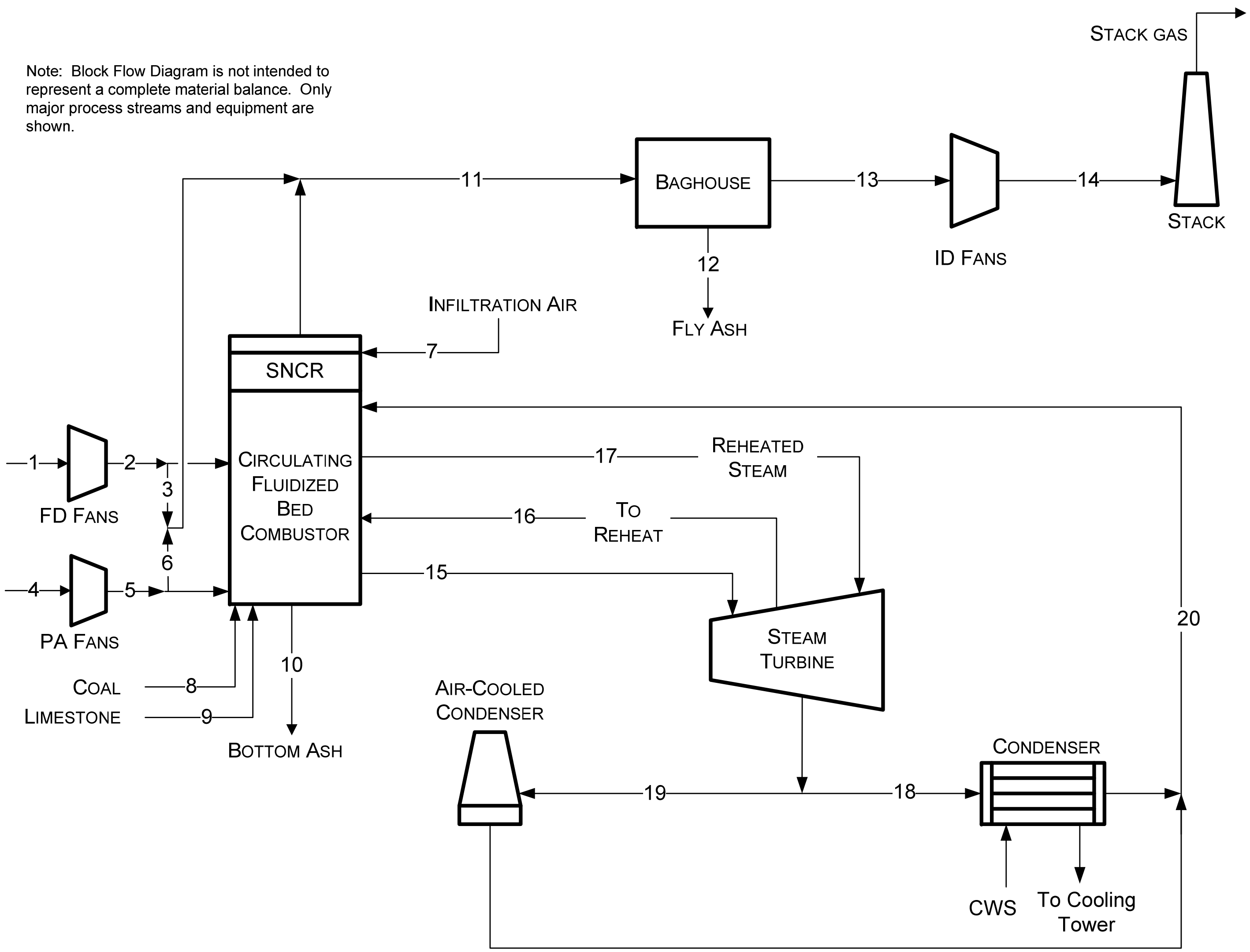

Exhibit 5-2 Case S22A Stream Table

	1	2	3	4	5	6	7	8	9	10
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
CO_2	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	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	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0000	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
O_2	0.2081	0.2081	0.2081	0.2081	0.2081	0.2081	0.2081	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	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000
V-L Flowrate (kg_{mol}/hr)	26,843	26,843	1,584	40,265	40,265	2,107	1,144	0	0	0
V-L Flowrate (kg/hr)	775,640	775,640	45,770	1,163,460	1,163,460	60,880	33,057	0	0	0
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	255,324	17,296	13,173
Temperature (°C)	6	10	10	6	18	18	6	6	6	149
Pressure (MPa, abs)	0.09	0.09	0.09	0.09	0.10	0.10	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	---	---	---
Density (kg/m^3)	1.1	1.2	1.2	1.1	1.2	1.2	1.1	---	---	---
V-L Molecular Weight	28.895	28.895	28.895	28.895	28.895	28.895	28.895	---	---	---
V-L Flowrate (lb_{mol}/hr)	59,179	59,179	3,492	88,769	88,769	4,645	2,522	0	0	0
V-L Flowrate (lb/hr)	1,709,994	1,709,994	100,907	2,564,990	2,564,990	134,218	72,879	0	0	0
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	562,894	38,132	29,043
Temperature (°F)	42	51	51	42	64	64	42	42	42	300
Pressure (psia)	13.0	13.6	13.6	13.0	14.5	14.5	13.0	13.0	13.0	13.0
Enthalpy (Btu/lb)[A]	6.6	8.7	8.7	6.6	11.7	11.7	6.6	---	---	---
Density (lb/ft^3)	0.070	0.072	0.072	0.070	0.075	0.075	0.070	---	---	---

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 5-2 Case S22A Stream Table (Continued)

	11	12	13	14	15	16	17	18	19	20
V-L Mole Fraction										
Ar	0.0085	0.0000	0.0085	0.0085	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.1412	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	0.1104	0.0000	0.1104	0.1104	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.7082	0.0000	0.7082	0.7082	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0317	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	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	74,867	0	74,867	74,867	89,510	75,381	75,381	34,359	34,359	69,614
V-L Flowrate (kg/hr)	2,200,867	0	2,200,867	2,200,867	1,612,545	1,358,011	1,358,011	618,996	618,996	1,254,117
Solids Flowrate (kg/hr)	30,738	30,738	0	0	0	0	0	0	0	0
Temperature (°C)	127	127	127	137	593	354	593	32	32	32
Pressure (MPa, abs)	0.09	0.08	0.08	0.09	24.23	4.90	4.52	0.00	0.00	1.72
Enthalpy (kJ/kg)[A]	258.98	---	302.89	313.72	3,476.62	3,082.95	3,652.22	1,927.19	1,927.19	136.94
Density (kg/m^3)	0.8	---	0.7	0.8	69.2	18.7	11.6	0.0	0.0	995.7
V-L Molecular Weight	29.397	---	29.397	29.397	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	165,053	0	165,053	165,053	197,335	166,187	166,187	75,750	75,750	153,473
V-L Flowrate (lb/hr)	4,852,080	0	4,852,080	4,852,080	3,555,054	2,993,901	2,993,901	1,364,652	1,364,652	2,764,855
Solids Flowrate (lb/hr)	67,766	67,766	0	0	0	0	0	0	0	0
Temperature (°F)	260	260	260	279	1,100	669	1,100	90	90	90
Pressure (psia)	12.4	12.2	12.2	13.1	3,514.7	710.8	655.8	0.7	0.7	250.0
Enthalpy (Btu/lb)[A]	111.3	---	130.2	134.9	1,494.7	1,325.4	1,570.2	828.5	828.5	58.9
Density (lb/ft^3)	0.047	---	0.047	0.049	4.319	1.164	0.722	0.003	0.003	62.162

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 5-3 Case L22A Stream Table

	1	2	3	4	5	6	7	8	9	10
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
CO_2	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	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	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062	0.0000	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
O_2	0.2082	0.2082	0.2082	0.2082	0.2082	0.2082	0.2082	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	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000
V-L Flowrate (kg_{mol}/hr)	28,020	28,020	1,653	42,029	42,029	2,199	1,178	0	0	0
V-L Flowrate (kg/hr)	809,699	809,699	47,780	1,214,548	1,214,548	63,553	34,042	0	0	0
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	335,981	19,618	17,530
Temperature (°C)	4	9	9	4	16	16	4	4	4	149
Pressure (MPa, abs)	0.10	0.10	0.10	0.10	0.11	0.11	0.10	0.10	0.10	0.10
Enthalpy (kJ/kg)[A]	13.75	18.42	18.42	13.75	25.07	25.07	13.75	---	---	---
Density (kg/m^3)	1.2	1.2	1.2	1.2	1.3	1.3	1.2	---	---	---
V-L Molecular Weight	28.898	28.898	28.898	28.898	28.898	28.898	28.898	---	---	---
V-L Flowrate (lb_{mol}/hr)	61,772	61,772	3,645	92,659	92,659	4,849	2,597	0	0	0
V-L Flowrate (lb/hr)	1,785,080	1,785,080	105,337	2,677,621	2,677,621	140,111	75,049	0	0	0
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	740,711	43,251	38,648
Temperature (°F)	40	48	48	40	60	60	40	40	40	300
Pressure (psia)	13.8	14.4	14.4	13.8	15.3	15.3	13.8	13.8	13.8	13.8
Enthalpy (Btu/lb)[A]	5.9	7.9	7.9	5.9	10.8	10.8	5.9	---	---	---
Density (lb/ft^3)	0.074	0.076	0.076	0.074	0.079	0.079	0.074	---	---	---

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 5-3 Case L22A Stream Table (Continued)

	11	12	13	14	15	16	17	18	19	20
V-L Mole Fraction										
Ar	0.0081	0.0000	0.0081	0.0081	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.1359	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	0.1429	0.0000	0.1429	0.1429	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.6811	0.0000	0.6811	0.6811	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0318	0.0000	0.0318	0.0318	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	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	81,265	0	81,265	81,265	89,405	75,292	75,292	34,319	34,319	69,533
V-L Flowrate (kg/hr)	2,355,454	0	2,355,454	2,355,454	1,610,663	1,356,409	1,356,409	618,273	618,273	1,252,653
Solids Flowrate (kg/hr)	40,904	40,904	0	0	0	0	0	0	0	0
Temperature (°C)	127	127	127	137	593	354	593	32	32	32
Pressure (MPa, abs)	0.09	0.09	0.09	0.10	24.23	4.90	4.52	0.00	0.00	1.72
Enthalpy (kJ/kg)^A	322.94	---	358.29	368.62	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	0.8	69.2	18.7	11.6	0.0	0.0	995.7
V-L Molecular Weight	28.985	---	28.985	28.985	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	179,159	0	179,159	179,159	197,105	165,991	165,991	75,661	75,661	153,294
V-L Flowrate (lb/hr)	5,192,886	0	5,192,886	5,192,886	3,550,903	2,990,370	2,990,370	1,363,059	1,363,059	2,761,628
Solids Flowrate (lb/hr)	90,178	90,178	0	0	0	0	0	0	0	0
Temperature (°F)	261	261	261	278	1,100	669	1,100	90	90	90
Pressure (psia)	13.2	13.0	13.0	13.9	3,514.7	710.8	655.8	0.7	0.7	250.0
Enthalpy (Btu/lb)^A	138.8	---	154.0	158.5	1,494.7	1,325.4	1,570.2	827.4	827.4	58.9
Density (lb/ft^3)	0.050	---	0.049	0.051	4.319	1.164	0.722	0.003	0.003	62.162

A - Reference conditions are 32.02 F & 0.089 PSIA

5.2 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	Sub-bituminous	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)	9 (48)
Cooling water from condenser, °C (ºF)	20 (68)	20 (68)
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, % (A)	46	46
Ammonia Slip, ppmv	2	2
Particulate Control	Fabric Filter	Fabric Filter
Fabric Filter efficiency, % (A)	99.9	99.9
Ash Distribution, Fly/Bottom	70% / 30%	70% / 30%
Mercury Control	Co-benefit Capture	Co-benefit Capture
Mercury removal efficiency, % (A)	57	57
CO_2 Control	N/A	N/A
CO_2 Capture, % (A)	N/A	N/A
CO_2 Sequestration	N/A	N/A

Note A: Equipment removal efficiencies

5.2.1 Balance of Plant – Cases S22A and L22A

The balance of plant assumptions are common to all cases and were presented previously in Section 3.8.

5.3 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 supercritical 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)

5.4 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 38.3 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 circulating water pumps, cooling tower fan, and the air-cooled condenser, account for about 30 percent of the auxiliary load in all cases; and the primary air and 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% 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**	**578,600**
AUXILIARY LOAD SUMMARY, kWe		
Coal Handling and Conveying	500	590
Pulverizers / Crushers	120	160
Sorbent Handling & Reagent Preparation	80	90
Ash Handling	1,300	1,730
Primary Air Fans	4,030	3,960
Forced Draft Fans	1,110	1,090
Induced Draft Fans	6,860	7,000
SNCR	10	20
Baghouse	150	200
Steam Turbine Auxiliaries	400	400
Condensate Pumps	790	790
Circulating Water Pump	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[a]	2,000	2,000
Transformer Loss	1,810	1,810
TOTAL AUXILIARIES, kWe	**28,320**	**28,560**
NET POWER, kWe	**550,080**	**550,030**
Plant Capacity Factor, %	85%	85%
Net Plant Efficiency, % (HHV)	38.9%	38.3%
Net Plant Heat Rate, kJ/kWh (Btu/kWh)	9,246 (8,763)	9,401 (8,911)
CONDENSER COOLING DUTY GJ/hr (10^6 Btu/hr)	**2,217 (2,101)**	**2,211 (2,096)**
CONSUMABLES		
As-Received Coal Feed, kg/hr (lb/hr)	255,324 (562,894)	335,981 (740,711)
Thermal Input, kWt[b]	1,412,786	1,436,424
Raw Water Withdrawal, m^3/min (gpm)	9.3 (2,456)	9.3 (2,450)

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

5.4.1 Environmental Performance

The environmental targets for emissions of Hg, NO_x, SO_2, and particulate matter 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)	1,658 (1,827)	1,879 (2,071)	0.385 (0.85)	0.436 (0.96)
NO_X	0.030 (0.070)	0.030 (0.070)	1,140 (1,256)	1,159 (1,277)	0.265 (0.583)	0.269 (0.593)
Particulates	0.006 (0.0130)	0.006 (0.0130)	212 (233)	215 (237)	0.049 (0.108)	0.050 (0.110)
Hg	1.3E-6 (3.02E-6)	2.07E-6 (4.82E-6)	0.049 (0.054)	0.080 (0.088)	11.4E-6 (25.2E-6)	18.5E-6 (40.8E-6)
CO_2	91.5 (212.8)	94.0 (218.7)	3,464,223 (3,818,653)	3,620,008 (3,990,376)	804 (1,773)	840 (1,852)
CO_2 [a]					846 (1,865)	884 (1,949)

[a] 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 93 percent. The waste will be collected in the baghouse.

NO_x emissions from CFB combustors are inherently low because of the relatively low bed operating temperature of 1,600°F. CFB temperature is controlled by adjusting coal/primary air feed rates and by rate of heat transfer to steam piping submerged in bed. NO_x 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 NO_x concentration by 46 percent to 0.07 lb/MMBtu.

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

Co-benefit capture of Hg from a CFB with SNCR and a fabric filter is estimated to be 57 percent for either sub-bituminous or lignite coal[18]. Hg emissions are reduced to approximately 25 percent of NSPS limits without the use of carbon injection.

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. 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	127,836 (281,831)	132,893 (292,978)	**Ash**	2,887 (6,364)	2,481 (5,469)
Air (CO_2)	269 (593)	281 (619)	**Stack Gas**	126,973 (279,928)	132,683 (292,517)
Limestone	1,755 (3,869)	1,991 (4,389)			
Total	**129,860 (286,292)**	**135,164 (297,986)**	**Total**	**129,860 (286,292)**	**135,164 (297,986)**

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. The total sulfur capture is represented by the following fraction:

(Sulfur in Ash/Sulfur in the coal) or
(33849/4,095)*100 = 94.0 percent (S22A)
(4,362/4,640)*100 = 94.0 percent (L22A)

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	1,857 (4,095)	2,105 (4,640)	**Ash**	1,746 (3,849)	1,978 (4,362)
			Stack Gas	111 (246)	126 (278)
Total	**1,857 (4,095)**	**2,105 (4,640)**	**Total**	**1,857 (4,095)**	**2,105 (4,640)**

Exhibit 5-9 shows the overall water balances for the plants. Raw water 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 makeup is the difference between water demand and internal recycle.

Exhibit 5-9 Cases S22A and 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)	
	S22A	L22A	S22A	L22A	S22A	L22A	S22A	L22A	S22A	L22A
BFW Makeup	0.27 (71)	0.27 (71)	0.0 (0)	0.0 (0)	0.27 (71)	0.27 (71)	0.00 (0.00)	0.00 (0.00)	0.27 (71)	0.27 (71)
Cooling Tower Makeup	9.3 (2,456)	9.3 (2,450)	0.27 (71)	0.27 (71)	9.0 (2,385)	9.0 (2,379)	2.09 (551)	2.09 (551)	6.92 (1828)	6.92 (1828)
Total	**9.6 (2,527)**	**9.3 (2,521)**	**0.27 (71)**	**0.27 (71)**	**9.3 (2,456)**	**9.3 (2,450)**	**2.09 (551)**	**2.09 (551)**	**7.19 (1899)**	**7.19 (1899)**

Heat and Mass Balance Diagrams

Heat and mass balance diagrams are shown for the following subsystems in Exhibit 5-10 through Exhibit 5-13:

- Combustor and flue gas cleanup
- Steam and feedwater

Overall plant energy balances are provided in tabular form in Exhibit 5-14 for the two CFB non-capture cases. The power out is the steam turbine power after generator losses.

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Exhibit 5-10 Cases S22A Combustor and Gas Cleanup System Heat and Mass Balance Diagram

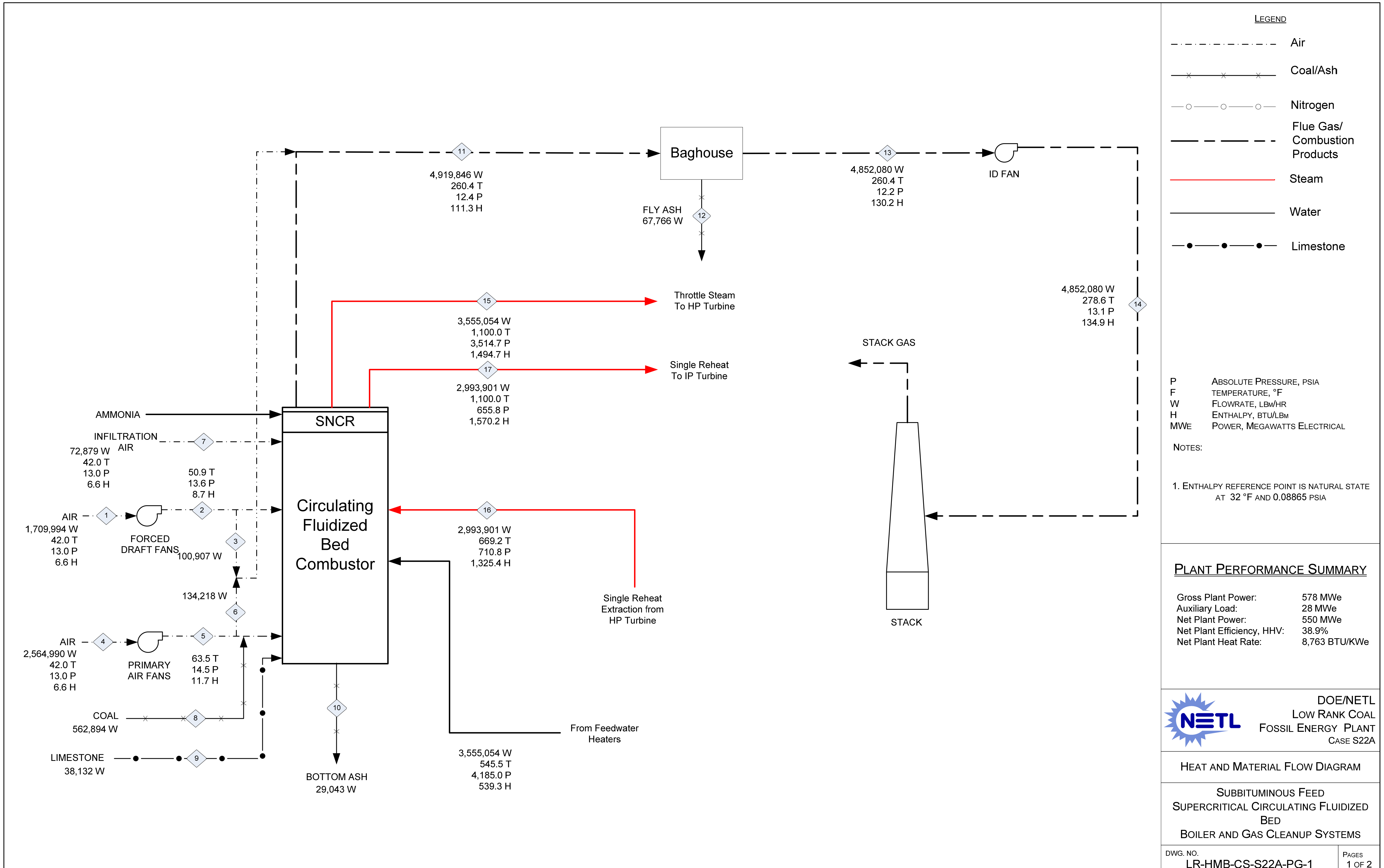

Exhibit 5-11 Cases S22A Power Block System Heat and Mass Balance Diagram

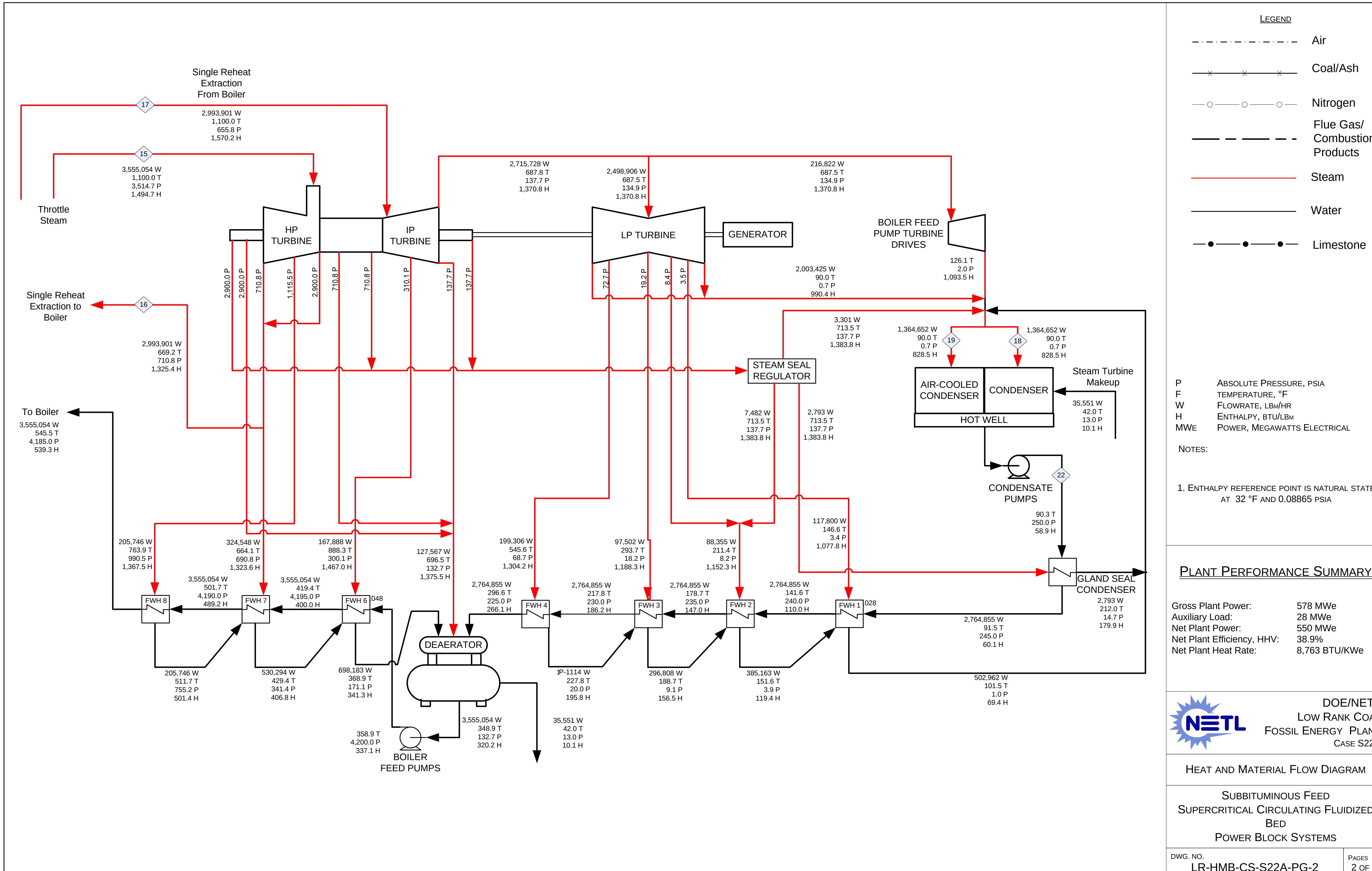

Exhibit 5-12 Cases L22A Combustor and Gas Cleanup System Heat and Mass Balance Diagram

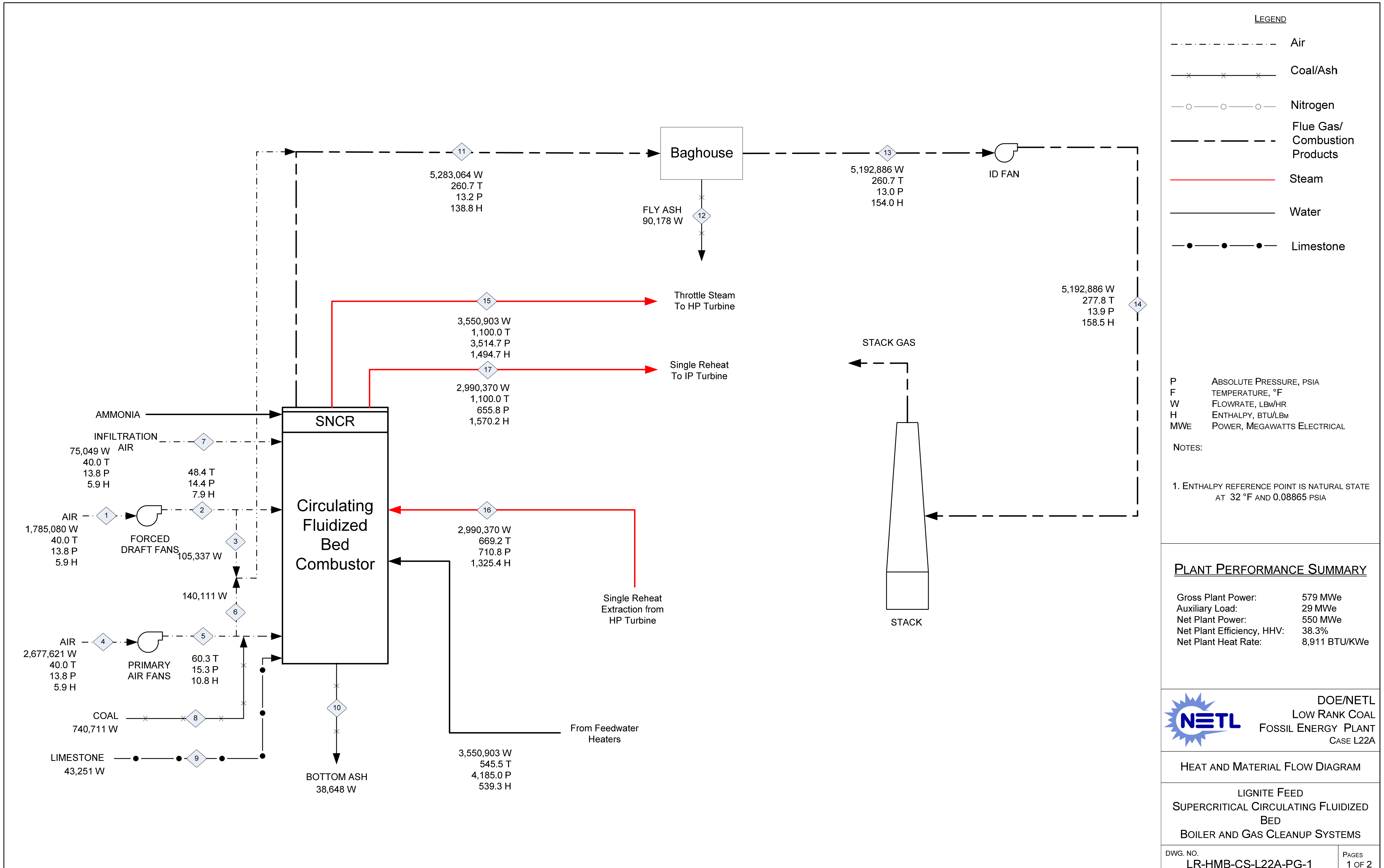

Exhibit 5-13 Cases L22A Power Block System Heat and Mass Balance Diagram

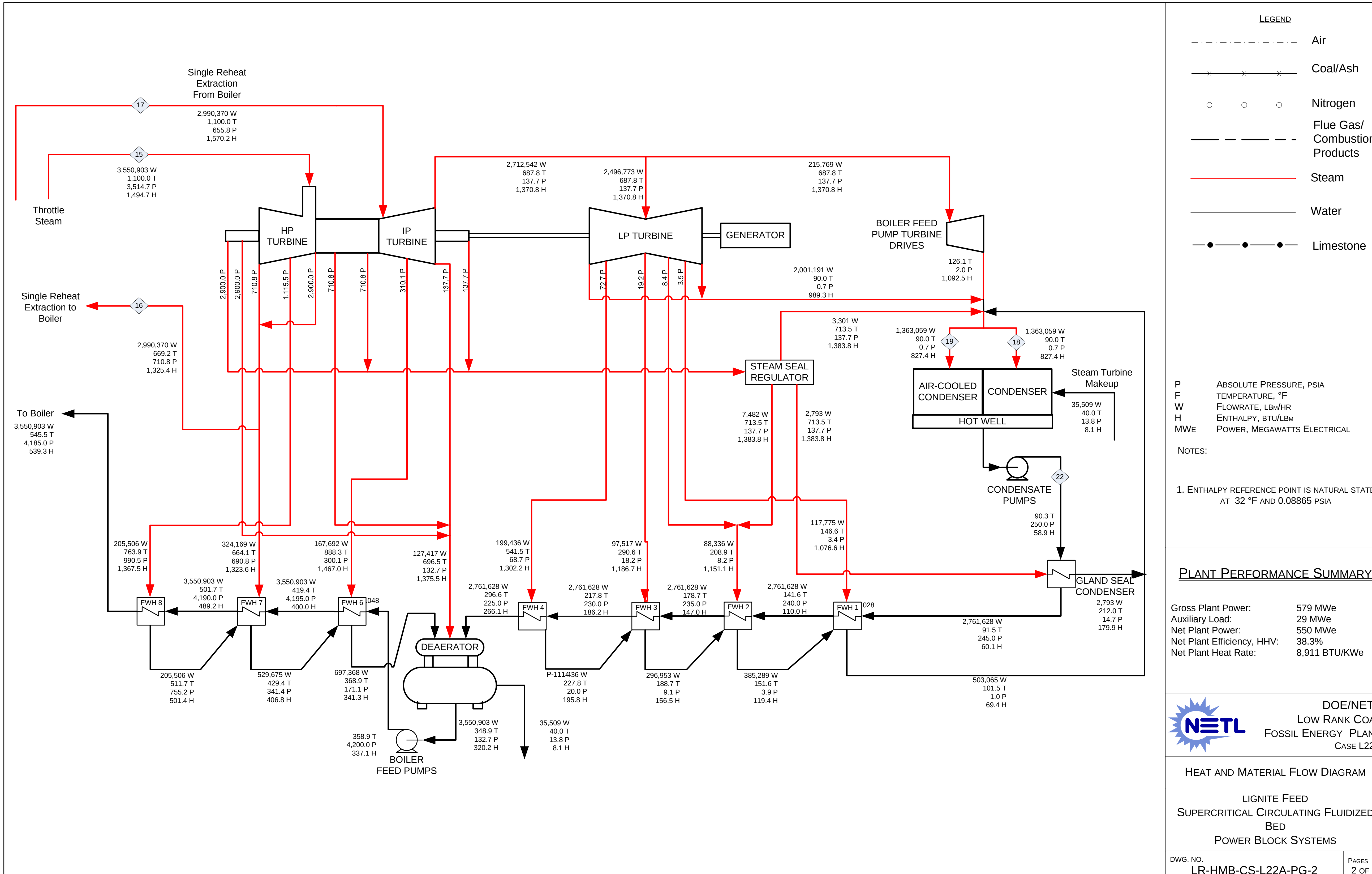

Exhibit 5-14 Cases S22A and L22A Energy Balance

	HHV		Sensible + Latent		Power		Total	
	S22A	**L22A**	**S22A**	**L22A**	**S22A**	**L22A**	**S22A**	**L22A**
Heat In, GJ/hr (MMBtu/hr)								
Coal	5,086 (4,821)	5,171 (4,901)	2.6 (2.5)	3.0 (2.8)			5,089 (4,823)	5,174 (4,904)
Combustion Air			30.1 (28.5)	28.3 (26.8)			30.1 (28.5)	28.3 (26.8)
Raw Water Makeup			13.0 (12.3)	10.3 (9.8)			13.0 (12.3)	10.3 (9.8)
Limestone			0.14 (0.13)	0.12 (0.12)			0.14 (0.13)	0.12 (0.12)
Auxiliary Power					102 (97)	103 (97)	102 (97)	103 (97)
Totals	**5,086 (4,821)**	**5,171 (4,901)**	**45.8 (43.4)**	**41.8 (39.6)**	**102 (97)**	**103 (97)**	**5,234 (4,961)**	**5,316 (5,038)**
Heat Out, GJ/hr (MMBtu/hr)								
Bottom Ash			11.6 (11.0)	14.7 (13.9)			11.6 (11.0)	14.7 (13.9)
Fly Ash + Sorbent			3.6 (3.4)	4.6 (4.4)			3.6 (3.4)	4.6 (4.4)
Flue Gas			690 (654)	868 (823)			690 (654)	868 (823)
Condenser			2,217 (2,101)	2,211 (2,096)			2,217 (2,101)	2,211 (2,096)
Cooling Tower Blowdown			11.6 (11.0)	11.3 (10.7)			11.6 (11.0)	11.3 (10.7)
Process Losses [a]			*217 (206)*	*123 (116)*			*217 (206)*	*123 (116)*
Power					2,082 (1,974)	2,083 (1,974)	2,082 (1,974)	2,083 (1,974)
Totals	**0.0 (0.0)**	**0.0 (0.0)**	**3,152 (2,987)**	**3,233 (3,064)**	**2,082 (1,974)**	**2,083 (1,974)**	**5,234 (4,961)**	**5,316 (5,038)**

Notes:

Reference conditions are 0°C (32°F).

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

5.5 CFB REFERENCE CASE 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 5.6. 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"x0 - 3/4"x 0)	8cm x 0 - 3cm x 0 (3"x0 - 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)

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 FEEDWATER 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

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
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)

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
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)
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)	--	--

Equipment No.	Description	Type	Operating Qty. (Spares)	S22A Design Condition	L22A Design Condition
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

5.6 CFB CASES WITHOUT CO_2 CAPTURE – COST ESTIMATING

Costs Results

The cost estimating methodology was described previously in Section 2.7.

The total plant cost summary organized by cost account, detailed breakdown of capital costs, and initial and annual O&M costs for the SC CFB PRB case (S22A) are shown in Exhibit 5-15, Exhibit 5-16, and Exhibit 5-17, respectively. The same data for the SC CFB lignite cases (L22A) are shown in Exhibit 5-18, Exhibit 5-19, and Exhibit 5-20.

The estimated TPC of the CFB plant with no CO_2 capture using PRB coal is $1,938/kW and using lignite coal is $2,048/kW. Project and process contingencies represent 10.9 and 5.3 percent, respectively, in both cases. The 20-year LCOE is 63.8 mills/kWh for the PRB case and 70.8 mills/kWh for the lignite case, as shown in Exhibit 5-21

Exhibit 5-15 Case S22A Total Plant Cost Summary

Client: USDOE/NETL **Report Date:** 15-Oct-08
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	$20,416	$5,412	$12,227	$0	$0	$38,055	$3,415	$0	$6,221	$47,691	$87
2	COAL & SORBENT PREP & FEED	$9,631	$695	$3,381	$0	$0	$13,707	$1,572	$0	$2,262	$17,541	$32
3	FEEDWATER & MISC. BOP SYSTEMS	$40,618	$0	$20,411	$0	$0	$61,029	$5,578	$0	$10,560	$77,168	$140
4	CFB BOILER											
4.1	CFB Boiler & Accesories	$271,114	$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	**$271,114**	**$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	$61,297	$1,086	$21,985	$0	$0	$84,368	$7,920	$0	$16,032	$108,320	$197
	SUBTOTAL 8	**$112,812**	**$1,086**	**$28,835**	**$0**	**$0**	**$142,733**	**$13,513**	**$0**	**$22,428**	**$178,674**	**$325**
9	COOLING WATER SYSTEM	$7,742	$4,513	$7,955	$0	$0	$20,210	$1,903	$0	$3,059	$25,171	$46
10	ASH/SPENT SORBENT HANDLING SYS	$7,016	$223	$9,380	$0	$0	$16,619	$1,598	$0	$1,875	$20,092	$37
11	ACCESSORY ELECTRIC PLANT	$15,124	$6,017	$17,576	$0	$0	$38,717	$3,439	$0	$5,259	$47,415	$86
12	INSTRUMENTATION & CONTROL	$8,734	$0	$8,856	$0	$0	$17,590	$1,595	$0	$2,356	$21,541	$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	$23,252	$21,981	$0	$0	$45,232	$4,080	$0	$7,397	$56,709	$103
	TOTAL COST	**$518,639**	**$44,195**	**$253,739**	**$0**	**$0**	**$816,572**	**$77,526**	**$55,953**	**$115,834**	**$1,065,885**	**$1,938**

Exhibit 5-16 Case S22A Total Plant Cost Details

Client: USDOE/NETL **Report Date:** 15-Oct-08
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	$4,069	$0	$1,859	$0	$0	$5,928	$530	$0	$969	$7,426	$14
1.2	Coal Stackout & Reclaim	$5,259	$0	$1,192	$0	$0	$6,451	$564	$0	$1,052	$8,067	$15
1.3	Coal Conveyors	$4,889	$0	$1,179	$0	$0	$6,068	$532	$0	$990	$7,590	$14
1.4	Other Coal Handling	$1,279	$0	$273	$0	$0	$1,552	$136	$0	$253	$1,941	$4
1.5	Sorbent Receive & Unload	$128	$0	$39	$0	$0	$167	$15	$0	$27	$209	$0
1.6	Sorbent Stackout & Reclaim	$3,605	$0	$777	$0	$0	$4,381	$383	$0	$715	$5,479	$10
1.7	Sorbent Conveyors	$739	$160	$181	$0	$0	$1,081	$93	$0	$176	$1,350	$2
1.8	Other Sorbent Handling	$447	$105	$234	$0	$0	$785	$69	$0	$128	$983	$2
1.9	Coal & Sorbent Hnd.Foundations	$0	$5,148	$6,494	$0	$0	$11,642	$1,093	$0	$1,910	$14,645	$27
	SUBTOTAL 1.	**$20,416**	**$5,412**	**$12,227**	**$0**	**$0**	**$38,055**	**$3,415**	**$0**	**$6,221**	**$47,691**	**$87**
2	COAL & SORBENT PREP & FEED											
2.1	Coal Crushing & Drying	$2,359	$0	$460	$0	$0	$2,819	$246	$0	$460	$3,525	$6
2.2	Coal Conveyor to Storage	$6,041	$0	$1,319	$0	$0	$7,359	$643	$0	$1,200	$9,203	$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	$1,231	$0	$256	$0	$0	$1,486	$130	$0	$242	$1,859	$3
2.6	Sorbent Storage & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.7	Sorbent Injection System	$0	$0	$764	$0	$0	$764	$435	$0	$150	$1,348	$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	$695	$583	$0	$0	$1,278	$118	$0	$210	$1,606	$3
	SUBTOTAL 2.	**$9,631**	**$695**	**$3,381**	**$0**	**$0**	**$13,707**	**$1,572**	**$0**	**$2,262**	**$17,541**	**$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	$9,049	$0	$8,934	$0	$0	$17,984	$1,708	$0	$2,954	$22,646	$41
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.	**$40,618**	**$0**	**$20,411**	**$0**	**$0**	**$61,029**	**$5,578**	**$0**	**$10,560**	**$77,168**	**$140**

Exhibit 5-16 Case S22A Total Plant Cost Details (Continued)

Client:	USDOE/NETL	Report Date:	15-Oct-08
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
4	CFB BOILER											
4.1	CFB Boiler & Accesories	$271,114	$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.	**$271,114**	**$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 5-16 Case S22A Total Plant Cost Details (Continued)

	Client:	USDOE/NETL								Report Date:	15-Oct-08		
	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**	
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	$19,940	$0	$9,832	$0	$0	$29,772	$2,501	$0	$4,841	$37,114	$67	
8.9	TG Foundations	$0	$1,086	$1,716	$0	$0	$2,803	$265	$0	$614	$3,681	$7	
	SUBTOTAL 8.	**$112,812**	**$1,086**	**$28,835**	**$0**	**$0**	**$142,733**	**$13,513**	**$0**	**$22,428**	**$178,674**	**$325**	
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	$115	$0	$0	$1,283	$109	$0	$139	$1,531	$3	
9.3	Circ.Water System Auxiliaries	$357	$0	$48	$0	$0	$404	$38	$0	$44	$487	$1	
9.4	Circ.Water Piping	$0	$2,829	$2,742	$0	$0	$5,571	$522	$0	$914	$7,006	$13	
9.5	Make-up Water System	$295	$0	$394	$0	$0	$689	$66	$0	$113	$869	$2	
9.6	Component Cooling Water Sys	$282	$0	$225	$0	$0	$507	$48	$0	$83	$638	$1	
9.9	Circ.Water System Foundations& Structures	$0	$1,684	$2,676	$0	$0	$4,360	$412	$0	$954	$5,727	$10	
	SUBTOTAL 9.	**$7,742**	**$4,513**	**$7,955**	**$0**	**$0**	**$20,210**	**$1,903**	**$0**	**$3,059**	**$25,171**	**$46**	
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	$939	$0	$2,893	$0	$0	$3,831	$376	$0	$421	$4,628	$8	
10.7	Ash Transport & Feed Equipment	$6,077	$0	$6,225	$0	$0	$12,302	$1,176	$0	$1,348	$14,826	$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	$263	$0	$0	$486	$46	$0	$106	$638	$1	
	SUBTOTAL 10.	**$7,016**	**$223**	**$9,380**	**$0**	**$0**	**$16,619**	**$1,598**	**$0**	**$1,875**	**$20,092**	**$37**	

Exhibit 5-16 Case S22A Total Plant Cost Details (Continued)

	Client:	USDOE/NETL							**Report Date:**	15-Oct-08		
	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	$259	$0	$882	$0	$0	$1,142	$111	$0	$125	$1,378	$3
11.7	Standby Equipment	$1,275	$0	$29	$0	$0	$1,304	$120	$0	$142	$1,566	$3
11.8	Main Power Transformers	$6,100	$0	$172	$0	$0	$6,272	$477	$0	$675	$7,424	$13
11.9	Electrical Foundations	$0	$310	$761	$0	$0	$1,071	$102	$0	$235	$1,409	$3
	SUBTOTAL 11.	**$15,124**	**$6,017**	**$17,576**	**$0**	**$0**	**$38,717**	**$3,439**	**$0**	**$5,259**	**$47,415**	**$86**
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	$4,540	$0	$793	$0	$0	$5,333	$494	$0	$583	$6,411	$12
12.8	Instrument Wiring & Tubing	$2,461	$0	$4,882	$0	$0	$7,343	$626	$0	$1,195	$9,165	$17
12.9	Other I & C Equipment	$1,283	$0	$2,911	$0	$0	$4,194	$407	$0	$460	$5,061	$9
	SUBTOTAL 12.	**$8,734**	**$0**	**$8,856**	**$0**	**$0**	**$17,590**	**$1,595**	**$0**	**$2,356**	**$21,541**	**$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**

Exhibit 5-16 Case S22A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 15-Oct-08
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
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	$321	$265	$0	$0	$586	$53	$0	$96	$735	$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**	**$23,252**	**$21,981**	**$0**	**$0**	**$45,232**	**$4,080**	**$0**	**$7,397**	**$56,709**	**$103**
	TOTAL COST	**$518,639**	**$44,195**	**$253,739**	**$0**	**$0**	**$816,572**	**$77,526**	**$55,953**	**$115,834**	**$1,065,885**	**$1,938**

Exhibit 5-17 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):**	8,763
					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					$7,267,927	$13.212
Administrative & Support Labor					$3,198,061	$5.814
TOTAL FIXED OPERATING COSTS					**$15,990,307**	**$29.069**
VARIABLE OPERATING COSTS						
						$/kWh-net
Maintenance Material Cost					**$10,901,890**	**$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)	59,919	8,560	0.17	$10,370	$459,613	$0.00011
Limestone (ton)	3,203	458	21.63	$69,296	$3,071,318	$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	157	22	129.80	$20,353	$902,066	$0.00022
Subtotal Chemicals				**$100,019**	**$4,432,997**	**$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	$4,093,485	$0.00100
Bottom Ash (ton)	0	349	16.23	$0	$1,754,377	$0.00043
Subtotal-Waste Disposal				**$0**	**$5,847,861**	**$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				**$100,019**	**$21,776,179**	**$0.00532**
Fuel(ton)	202,642	6,755	12.96	**$2,626,238**	**$27,159,681**	**$0.00663**

Exhibit 5-18 Case L22A Total Plant Cost Summary

	Client:	USDOE/NETL								**Report Date:**	15-Oct-08		
	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	$23,760	$6,405	$14,404	$0	$0	**$44,569**	$4,002	$0	$7,286	**$55,856**	$102	
2	COAL & SORBENT PREP & FEED	$11,433	$835	$3,947	$0	$0	**$16,215**	$1,825	$0	$2,673	**$20,713**	$38	
3	FEEDWATER & MISC. BOP SYSTEMS	$41,606	$0	$21,403	$0	$0	**$63,010**	$5,767	$0	$10,885	**$79,661**	$145	
4	CFB BOILER												
4.1	CFB Boiler & Accesories	$291,965	$0	$111,012	$0	$0	**$402,977**	$39,111	$60,447	$50,253	**$552,788**	$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	**$291,965**	**$0**	**$111,012**	**$0**	**$0**	**$402,977**	**$39,111**	**$60,447**	**$50,253**	**$552,788**	**$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	$61,049	$1,087	$21,941	$0	$0	**$84,076**	$7,891	$0	$15,970	**$107,937**	$196	
	SUBTOTAL 8	**$112,564**	**$1,087**	**$28,792**	**$0**	**$0**	**$142,442**	**$13,484**	**$0**	**$22,366**	**$178,292**	**$324**	
9	COOLING WATER SYSTEM	$7,710	$4,505	$7,932	$0	$0	**$20,147**	$1,897	$0	$3,049	**$25,093**	$46	
10	ASH/SPENT SORBENT HANDLING SYS	$8,331	$265	$11,139	$0	$0	**$19,735**	$1,897	$0	$2,226	**$23,858**	$43	
11	ACCESSORY ELECTRIC PLANT	$15,144	$6,035	$17,626	$0	$0	**$38,805**	$3,447	$0	$5,271	**$47,523**	$86	
12	INSTRUMENTATION & CONTROL	$8,708	$0	$8,830	$0	$0	**$17,538**	$1,590	$0	$2,349	**$21,478**	$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	$24,247	$22,856	$0	$0	**$47,103**	$4,248	$0	$7,703	**$59,054**	$107	
	TOTAL COST	**$546,748**	**$46,381**	**$269,238**	**$0**	**$0**	**$862,367**	**$81,915**	**$60,447**	**$121,987**	**$1,126,715**	**$2,048**	

Exhibit 5-19 Case L22A Total Plant Cost Details

	Client:	USDOE/NETL								**Report Date:**	15-Oct-08		
	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**	
1	COAL & SORBENT HANDLING												
1.1	Coal Receive & Unload	$4,836	$0	$2,209	$0	$0	$7,045	$630	$0	$1,151	$8,825	$16	
1.2	Coal Stackout & Reclaim	$6,250	$0	$1,416	$0	$0	$7,666	$671	$0	$1,250	$9,587	$17	
1.3	Coal Conveyors	$5,810	$0	$1,401	$0	$0	$7,212	$632	$0	$1,177	$9,020	$16	
1.4	Other Coal Handling	$1,520	$0	$324	$0	$0	$1,844	$161	$0	$301	$2,306	$4	
1.5	Sorbent Receive & Unload	$139	$0	$42	$0	$0	$181	$16	$0	$30	$227	$0	
1.6	Sorbent Stackout & Reclaim	$3,916	$0	$844	$0	$0	$4,759	$416	$0	$776	$5,952	$11	
1.7	Sorbent Conveyors	$803	$174	$197	$0	$0	$1,174	$101	$0	$191	$1,467	$3	
1.8	Other Sorbent Handling	$485	$114	$254	$0	$0	$853	$75	$0	$139	$1,068	$2	
1.9	Coal & Sorbent Hnd.Foundations	$0	$6,117	$7,717	$0	$0	$13,835	$1,299	$0	$2,270	$17,404	$32	
	SUBTOTAL 1.	**$23,760**	**$6,405**	**$14,404**	**$0**	**$0**	**$44,569**	**$4,002**	**$0**	**$7,286**	**$55,856**	**$102**	
2	COAL & SORBENT PREP & FEED												
2.1	Coal Crushing & Drying	$2,835	$0	$552	$0	$0	$3,388	$295	$0	$552	$4,235	$8	
2.2	Coal Conveyor to Storage	$7,259	$0	$1,585	$0	$0	$8,844	$773	$0	$1,442	$11,059	$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	$1,339	$0	$278	$0	$0	$1,617	$141	$0	$264	$2,022	$4	
2.6	Sorbent Storage & Feed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
2.7	Sorbent Injection System	$0	$0	$831	$0	$0	$831	$473	$0	$163	$1,467	$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	$835	$701	$0	$0	$1,536	$142	$0	$252	$1,930	$4	
	SUBTOTAL 2.	**$11,433**	**$835**	**$3,947**	**$0**	**$0**	**$16,215**	**$1,825**	**$0**	**$2,673**	**$20,713**	**$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	$10,064	$0	$9,936	$0	$0	$20,001	$1,900	$0	$3,285	$25,186	$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.	**$41,606**	**$0**	**$21,403**	**$0**	**$0**	**$63,010**	**$5,767**	**$0**	**$10,885**	**$79,661**	**$145**	

Exhibit 5-19 Case L22A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 15-Oct-08
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
4	CFB BOILER											
4.1	CFB Boiler & Accesories	$291,965	$0	$111,012	$0	$0	$402,977	$39,111	$60,447	$50,253	$552,788	$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.	**$291,965**	**$0**	**$111,012**	**$0**	**$0**	**$402,977**	**$39,111**	**$60,447**	**$50,253**	**$552,788**	**$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 5-19 Case L22A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 15-Oct-08
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
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	$19,940	$0	$9,832	$0	$0	$29,772	$2,501	$0	$4,841	$37,114	$67
8.9	TG Foundations	$0	$1,087	$1,717	$0	$0	$2,803	$265	$0	$614	$3,682	$7
	SUBTOTAL 8.	**$112,564**	**$1,087**	**$28,792**	**$0**	**$0**	**$142,442**	**$13,484**	**$0**	**$22,366**	**$178,292**	**$324**
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	$115	$0	$0	$1,283	$109	$0	$139	$1,531	$3
9.3	Circ.Water System Auxiliaries	$357	$0	$48	$0	$0	$404	$38	$0	$44	$487	$1
9.4	Circ.Water Piping	$0	$2,829	$2,742	$0	$0	$5,571	$522	$0	$914	$7,006	$13
9.5	Make-up Water System	$295	$0	$394	$0	$0	$688	$66	$0	$113	$867	$2
9.6	Component Cooling Water Sys	$282	$0	$225	$0	$0	$507	$48	$0	$83	$638	$1
9.9	Circ.Water System Foundations& Structures	$0	$1,676	$2,663	$0	$0	$4,339	$411	$0	$950	$5,700	$10
	SUBTOTAL 9.	**$7,710**	**$4,505**	**$7,932**	**$0**	**$0**	**$20,147**	**$1,897**	**$0**	**$3,049**	**$25,093**	**$46**
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	$1,115	$0	$3,435	$0	$0	$4,550	$447	$0	$500	$5,496	$10
10.7	Ash Transport & Feed Equipment	$7,216	$0	$7,392	$0	$0	$14,608	$1,397	$0	$1,601	$17,606	$32
10.8	Misc. Ash Handling Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.9	Ash/Spent Sorbent Foundation	$0	$265	$312	$0	$0	$577	$54	$0	$126	$757	$1
	SUBTOTAL 10.	**$8,331**	**$265**	**$11,139**	**$0**	**$0**	**$19,735**	**$1,897**	**$0**	**$2,226**	**$23,858**	**$43**

Exhibit 5-19 Case L22A Total Plant Cost Details (Continued)

	Client:	USDOE/NETL								**Report Date:**	15-Oct-08		
	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**	
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	$260	$0	$884	$0	$0	$1,144	$112	$0	$126	$1,382	$3	
11.7	Standby Equipment	$1,275	$0	$29	$0	$0	$1,304	$120	$0	$142	$1,566	$3	
11.8	Main Power Transformers	$6,100	$0	$171	$0	$0	$6,271	$477	$0	$675	$7,424	$13	
11.9	Electrical Foundations	$0	$311	$761	$0	$0	$1,072	$102	$0	$235	$1,409	$3	
	SUBTOTAL 11.	**$15,144**	**$6,035**	**$17,626**	**$0**	**$0**	**$38,805**	**$3,447**	**$0**	**$5,271**	**$47,523**	**$86**	
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	$269	$0	$0	$717	$68	$0	$118	$902	$2	
12.7	Distributed Control System Equipment	$4,527	$0	$791	$0	$0	$5,318	$493	$0	$581	$6,392	$12	
12.8	Instrument Wiring & Tubing	$2,454	$0	$4,868	$0	$0	$7,322	$624	$0	$1,192	$9,137	$17	
12.9	Other I & C Equipment	$1,279	$0	$2,903	$0	$0	$4,182	$405	$0	$459	$5,046	$9	
	SUBTOTAL 12.	**$8,708**	**$0**	**$8,830**	**$0**	**$0**	**$17,538**	**$1,590**	**$0**	**$2,349**	**$21,478**	**$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**	

Exhibit 5-19 Case L22A Total Plant Cost Details (Continued)

Client: USDOE/NETL **Report Date:** 15-Oct-08
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
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	$321	$264	$0	$0	$585	$52	$0	$96	$733	$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**	**$24,247**	**$22,856**	**$0**	**$0**	**$47,103**	**$4,248**	**$0**	**$7,703**	**$59,054**	**$107**
	TOTAL COST	**$546,748**	**$46,381**	**$269,238**	**$0**	**$0**	**$862,367**	**$81,915**	**$60,447**	**$121,987**	**$1,126,715**	**$2,048**

Exhibit 5-20 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):	8,911
					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					$7,764,007	$14.115
Administrative & Support Labor					$3,322,081	$6.040
TOTAL FIXED OPERATING COSTS					**$16,610,407**	**$30.199**
VARIABLE OPERATING COSTS						
						$/kWh-net
Maintenance Material Cost					**$11,646,010**	**$0.00284**
Consumables	Consumption Initial	Consumption /Day	Unit Cost	Initial Cost		
Water(/1000 gallons)	0	1,764	1.08	**$0**	**$591,981**	**$0.00014**
Chemicals						
MU & WT Chem.(lbs)	59,772	8,539	0.17	$10,345	$458,490	$0.00011
Limestone (ton)	3,633	519	21.63	$78,595	$3,483,423	$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	161	23	129.80	$20,898	$926,228	$0.00023
Subtotal Chemicals				**$109,837**	**$4,868,141**	**$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	$5,447,308	$0.00133
Bottom Ash(ton)	0	464	16.23	$0	$2,334,699	$0.00057
Subtotal-Waste Disposal				**$0**	**$7,782,007**	**$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				**$109,837**	**$24,888,138**	**$0.00608**
Fuel(ton)	266,656	8,889	11.97	**$3,191,872**	**$33,009,275**	**$0.00806**

Exhibit 5-21 Cost and Performance Results for CFB Reference Cases

Case	S22A	L22A
Gross Power Output, MW_e	578.4	672.0
Net Power Output, MW_e	550.1	550.2
Net Plant Efficiency, % (HHV)	38.9	38.3
Net Plant Heat Rate, Btu/kWh (HHV)	8,763	8,909
Total Plant Cost, $x1000	1,065,885	1,126,715
Total Plant Cost, $/kW	1,938	2,048
Levelized Cost of Electricity, ¢/kWh (85% Capacity Factor)	6.38	7.08
Total CO_2 Emitted, lb/MWh_{net}	1,865	1,948

6. SUPERCRITICAL OXYCOMBUSTION CASES

Five SC, PC-fired, Rankine–cycle, oxycombustion power plant configurations were evaluated and are presented in this section. All plant designs employ a cryogenic distillation air separation unit to generate the oxygen. Four cases (S12C, S12D, S12E and S12F) utilize Montana PRB coal and one case (L12F) utilizes North Dakota lignite coal.

6.1 PLANT CONFIGURATION SUMMARY

All the designs have a nominal net output of 550 MWe. All five SC oxycombustion plants use a single reheat 24.1 MPa/593°C/593°C (3,500 psig/1,100°F/1,100°F) cycle. Case L12F differs from Case S12F only through the use of a different coal type (lignite instead of PRB). This section covers the following cases:

Case S12C – This case includes an SC PC oxycombustion plant with co-sequestration of all flue gas constituents except water that is removed by a dryer system. No FGD unit, SO_2 polishing scrubber, or CPU is utilized. Rosebud PRB coal is the fuel and the plant is located in Montana.

Case S12D – This case is the same as Case S12C, except it includes a dry FGD and a SO_2 polishing scrubber before the CO_2 rich product stream enters the compression section.

Case S12E – This case includes an SC PC oxycombustion plant with a dry FGD, SO_2 polishing scrubber, and a partial condensation CPU to reduce oxygen levels in the CO_2 product stream to approximately 0.4 mol%. Rosebud PRB coal is the fuel and the plant is located in Montana.

Case S12F – This case is the same as Case S12E, except it includes a cryogenic distillation CPU to reduce the oxygen concentration in the CO_2 product stream to 1 ppm.

Case L12F – This case is the same as Case S12F, except it uses North Dakota lignite coal as the fuel and the plant is located in North Dakota.

Oxycombustion PC plants are assumed to be built on a greenfield site and utilize flue gas recycle for flame temperature control. Major systems for each plant (described in Section 3) include the following:

1. Oxycombustion optimized ASU (except case S12E, which uses a conventional ASU design that consumes more energy per unit weight of oxygen produced as compared to the design optimized for oxycombustion)
2. USC PC Boiler/Generator
3. DRY FGD (FGD is present for all cases except case S12C)
4. CO_2 Recovery. CO_2 specification is "1a" for cases from S12C to S12DSen1, "2a" for case S12E, and "2b" for S12F (refer Section 3.6.1 for more information).
5. Steam Turbine

Support facilities include coal handling (receiving, crushing, storing, and drying), limestone handling (including receiving, crushing, storing, and feeding), solid waste disposal, circulating water system with evaporative mechanical draft cooling towers, wastewater treatment, and other ancillary systems equipment necessary for an efficient, highly available, and completely operable facility.

The plant designs are based on using components suitable for a 30-year life, with provision for periodic maintenance and replacement of critical parts. All equipment is based on compliance with the latest applicable codes and standards. ASME, ANSI, IEEE, NFPA, CAA, state regulations, and OSHA codes are all adhered to in the design approach.

6.2 MODEL ASSUMPTIONS FOR SC OXYCOMBUSTION CASES

The modeling assumptions that were used to generate the SC oxycombustion PC case material and energy balances are summarized in Exhibit 6-1.

Exhibit 6-1 Supercritical Oxycombustion Cases Modeling Assumptions

	PRB				Lignite
	S12C	S12D	S12E	S12F	L12F
Throttle pressure, psig	3500	3500	3500	3500	3500
Throttle temperature, ºF	1100	1100	1100	1100	1100
Reheat temperature, ºF	1100	1100	1100	1100	1100
Condenser pressure, in Hg	1.4	1.4	1.4	1.4	1.4
Cooling water to condenser, ºF	60	60	60	60	60
Cooling water from condenser, ºF	80	80	80	80	80
CO_2 Purifier Vent temperature, °F	N/A	N/A	70	48	48
Coal HHV (PRB and Lignite), Btu/lb	8,564	8,564	8,564	8,564	6,617
FGD efficiency, %	98	93	93	93	93
SOx emissions, lb/MMBtu	0.1	0.1	0.1	0.1	0.1
NOx emissions, lb/MMBtu	0.07	0.07	0.07	0.07	0.07
Baghouse efficiency, %	99.8	99.8	99.8	99.8	99.8
Particulate emissions PM/PM_{10}, lb/MMBtu	0.015	0.015	0.015	0.015	0.015
Mercury removal, %	15%	90	90	90	90
ASU Oxygen Purity, %	95	95	95	95	95
CO_2 Capture Efficiency, %[a]	100	100	91.0	90.9	90.9
Product CO_2 Condition, psia/°F	2199/95	2199/95	2220/81	2220/81	2220/81
Product CO_2 Specification	1a[b]	1a[b]	2a[b]	3b[b]	3b[b]

[a] Percentage of CO_2 in flue gas

[b] Refer to Section 3.6.1 for more description of product CO_2 specifications.

Material and energy balance information, environmental performance, and a major equipment list for the two CO_2 capture cases are summarized in Section 6.3

6.3 PERFORMANCE RESULTS FOR CASES S12C AND S12D

A process block flow diagram for the SC CO_2 co-sequestration case S12C is shown in Exhibit 6-2, and the corresponding stream tables are shown in Exhibit 6-3.

A process block flow diagram for the SC CO_2 capture (with dry only CO_2 purification option) case S12D is shown in Exhibit 6-4, and the corresponding stream tables are shown in Exhibit 6-5.

Overall performance for case S12C and S12D is summarized in Exhibit 6-7, which includes auxiliary power requirements.

6.3.1 Block Flow Diagram and Stream Table

Exhibit 6-2 Case S12C SC PC Oxycombustion Co-Sequestration Block Flow Diagram

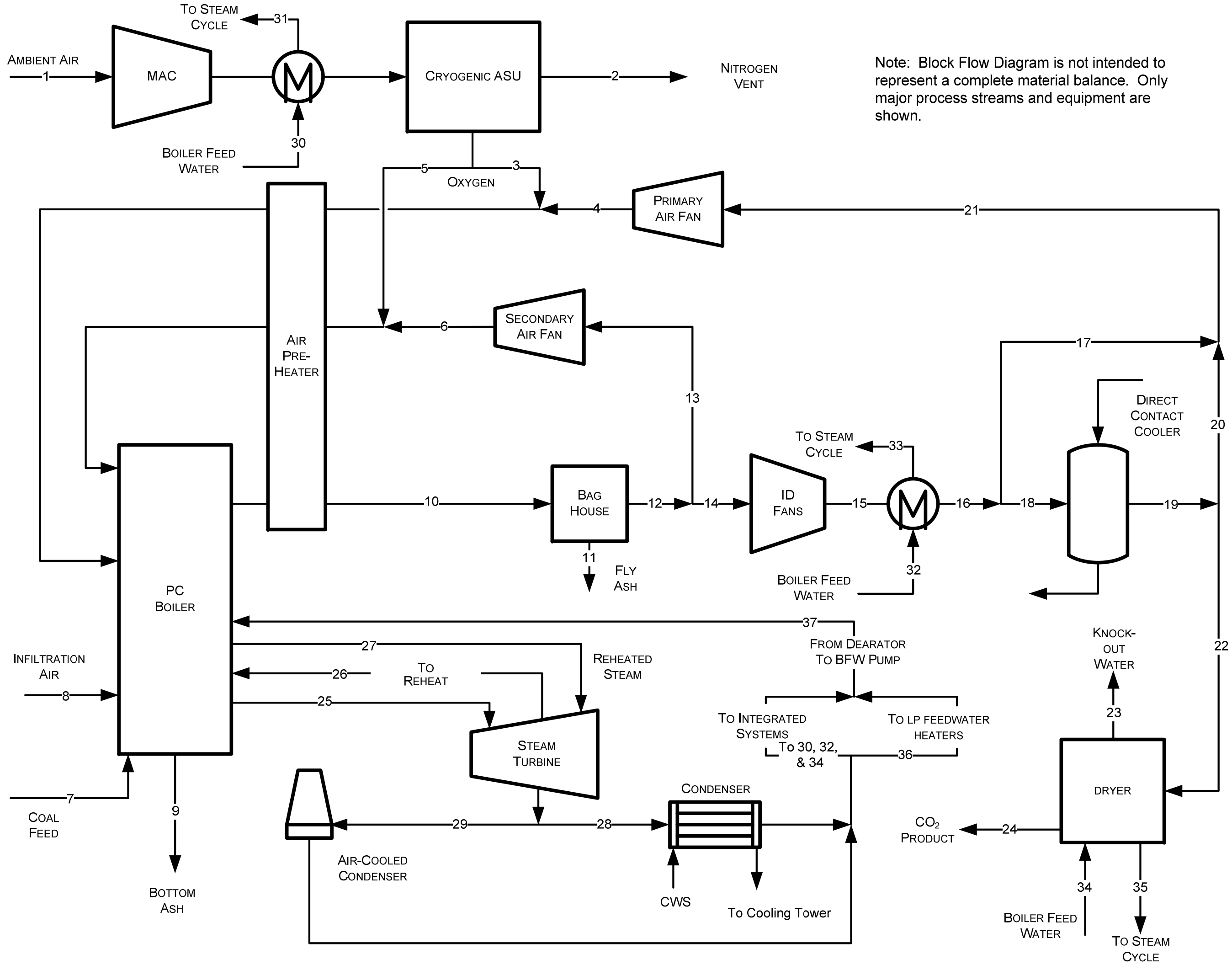

Exhibit 6-3 Case S12C SC PC Oxycombustion Co-Sequestration Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
V-L Mole Fraction																				
Ar	0.0093	0.0025	0.0343	0.0285	0.0343	0.0247	0.0000	0.0093	0.0000	0.0247	0.0000	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0293	0.0293
CO_2	0.0003	0.0004	0.0000	0.6797	0.0000	0.5877	0.0000	0.0003	0.0000	0.5877	0.0000	0.5877	0.5877	0.5877	0.5877	0.5877	0.5877	0.5877	0.6991	0.6991
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	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0064	0.0081	0.0000	0.1919	0.0000	0.3013	0.0000	0.0064	0.0000	0.3013	0.0000	0.3013	0.3013	0.3013	0.3013	0.3013	0.3013	0.3013	0.1688	0.1688
N_2	0.7759	0.9826	0.0162	0.0740	0.0162	0.0640	0.0000	0.7759	0.0000	0.0640	0.0000	0.0640	0.0640	0.0640	0.0640	0.0640	0.0640	0.0640	0.0761	0.0761
O_2	0.2081	0.0064	0.9495	0.0221	0.9495	0.0191	0.0000	0.2081	0.0000	0.0191	0.0000	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191	0.0228	0.0228
SO_2	0.0000	0.0000	0.0000	0.0037	0.0000	0.0032	0.0000	0.0000	0.0000	0.0032	0.0000	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032	0.0038	0.0038
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	74,094	58,242	5,548	19,853	10,304	22,103	0	1,427	0	67,657	0	67,657	22,103	45,554	45,554	45,554	3,462	42,092	35,384	16,391
V-L Flowrate (kg/hr)	2,140,956	1,630,418	178,688	745,075	331,850	771,130	0	41,242	0	2,360,442	0	2,360,442	771,130	1,589,312	1,589,312	1,589,312	120,788	1,468,524	1,347,672	624,284
Solids Flowrate (kg/hr)	0	0	0	0	0	0	318,538	0	5,216	20,864	20,864	0	0	0	0	0	0	0	0	0
Temperature (°C)	6	17	14	72	14	188	6	6	177	177	177	177	177	177	189	93	93	93	57	57
Pressure (MPa, abs)	0.09	0.10	0.14	0.10	0.14	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Enthalpy (kJ/kg)[A]	15.26	30.70	12.15	297.91	12.15	587.52	---	15.26	---	651.36	---	575.11	575.11	575.11	588.38	483.86	483.86	483.86	252.23	252.23
Density (kg/m^3)	1.1	1.2	1.9	1.3	1.9	0.9	---	1.1	---	0.8	---	0.8	0.8	0.8	0.9	1.1	1.1	1.1	1.3	1.3
V-L Molecular Weight	28.895	27.994	32.207	37.529	32.207	34.889	---	28.895	---	34.889	---	34.889	34.889	34.889	34.889	34.889	34.889	34.889	38.087	38.087
V-L Flowrate (lb_{mol}/hr)	163,350	128,402	12,232	43,769	22,716	48,728	0	3,147	0	149,158	0	149,158	48,728	100,429	100,429	100,429	7,633	92,797	78,008	36,136
V-L Flowrate (lb/hr)	4,720,000	3,594,457	393,940	1,642,609	731,603	1,700,050	0	90,923	0	5,203,884	0	5,203,884	1,700,050	3,503,834	3,503,834	3,503,834	266,291	3,237,542	2,971,108	1,376,311
Solids Flowrate (lb/hr)	0	0	0	0	0	0	702,256	0	11,500	45,998	45,998	0	0	0	0	0	0	0	0	0
Temperature (°F)	42	63	57	161	57	370	42	42	350	350	350	350	350	350	371	200	200	200	135	135
Pressure (psia)	13.0	14.7	20.3	14.4	20.3	13.6	13.0	13.0	12.7	12.7	12.5	12.5	12.5	12.5	13.7	13.5	13.5	13.5	13.3	13.3
Enthalpy (Btu/lb)[A]	6.6	13.2	5.2	128.1	5.2	252.6	---	6.6	---	280.0	---	247.3	247.3	247.3	253.0	208.0	208.0	208.0	108.4	108.4
Density (lb/ft^3)	0.070	0.073	0.118	0.081	0.118	0.053	---	0.070	---	0.051	---	0.050	0.050	0.050	0.054	0.067	0.067	0.067	0.080	0.080

Exhibit 6-3 Case S12C SC PC Oxycombustion Co-Sequestration Stream Table (Continued)

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
V-L Mole Fraction																	
Ar	0.0285	0.0293	0.0000	0.0353	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
CO_2	0.6797	0.6991	0.0000	0.8411	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_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	0.0000	0.0000	0.0000
H_2O	0.1919	0.1688	1.0000	0.0000	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
N_2	0.0740	0.0761	0.0000	0.0916	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
O_2	0.0221	0.0228	0.0000	0.0274	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
SO_2	0.0037	0.0038	0.0000	0.0046	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	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	19,853	18,993	3,206	15,787	115,969	96,337	96,337	43,369	43,369	23,865	23,865	20,685	20,685	28,050	28,050	15,297	117,129
V-L Flowrate (kg/hr)	745,072	723,387	57,761	665,626	2,089,222	1,735,535	1,735,535	781,301	781,301	429,930	429,930	372,654	372,654	505,327	505,327	275,582	2,110,114
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	64	57	38	35	593	354	593	32	32	52	141	52	157	52	146	52	176
Pressure (MPa, abs)	0.09	0.09	0.10	15.16	24.23	4.90	4.52	0.00	0.00	1.65	1.63	1.65	1.63	1.65	1.64	1.65	0.91
Enthalpy (kJ/kg)[A]	289.78	252.23	59.88	-152.41	3,476.62	3,082.03	3,652.22	2,265.52	2,265.52	217.35	591.45	217.35	663.09	217.35	616.44	217.35	744.69
Density (kg/m^3)	1.2	1.3	980.5	584.0	69.2	18.7	11.6	0.0	0.0	988.0	926.1	988.0	910.6	988.0	920.8	988.0	891.1
V-L Molecular Weight	37.529	38.087	18.015	42.164	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	43,768	41,872	7,069	34,804	255,669	212,386	212,386	95,612	95,612	52,613	52,613	45,604	45,604	61,839	61,839	33,724	258,226
V-L Flowrate (lb/hr)	1,642,603	1,594,796	127,342	1,467,454	4,605,947	3,826,200	3,826,200	1,722,473	1,722,473	947,834	947,834	821,562	821,562	1,114,055	1,114,055	607,554	4,652,006
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	146	135	101	95	1,100	669	1,100	90	90	125	285	125	315	125	296	125	349
Pressure (psia)	13.3	13.3	14.7	2,199.0	3,514.7	710.8	655.8	0.7	0.7	240.0	237.1	240.0	237.1	240.0	238.5	240.0	132.7
Enthalpy (Btu/lb)[A]	124.6	108.4	25.7	-65.5	1,494.7	1,325.0	1,570.2	974.0	974.0	93.4	254.3	93.4	285.1	93.4	265.0	93.4	320.2
Density (lb/ft^3)	0.077	0.080	61.214	36.456	4.319	1.165	0.722	0.002	0.002	61.678	57.814	61.678	56.846	61.678	57.484	61.678	55.627

Exhibit 6-4 Case S12D SC PC Oxycombustion with Drying Only Block Flow Diagram

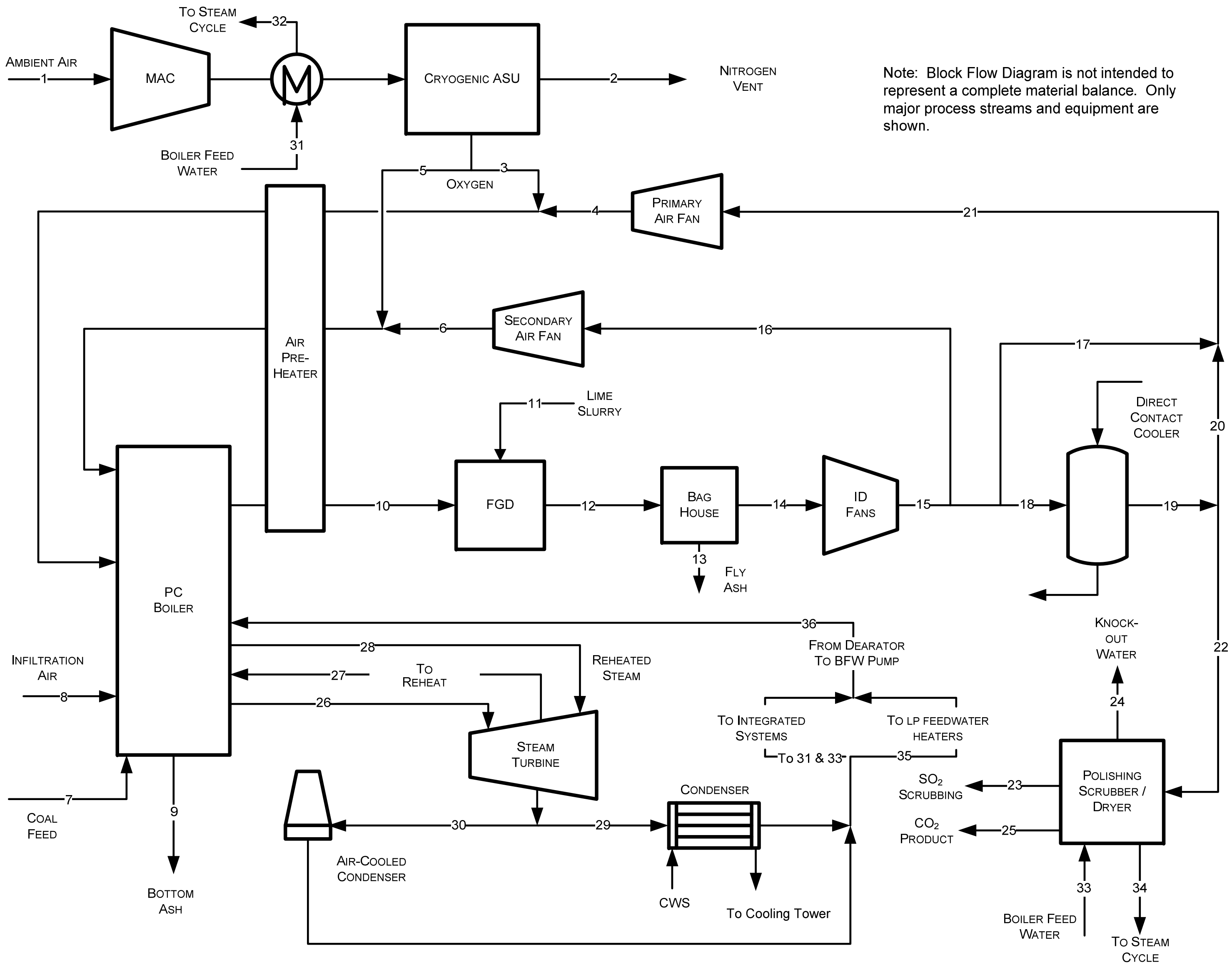

Exhibit 6-5 Case S12D SC PC Oxycombustion with Drying Only Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
V-L Mole Fraction																				
Ar	0.0093	0.0025	0.0343	0.0285	0.0343	0.0231	0.0000	0.0093	0.0000	0.0242	0.0000	0.0231	0.0000	0.0231	0.0231	0.0231	0.0231	0.0231	0.0293	0.0293
CO_2	0.0003	0.0004	0.0000	0.6804	0.0000	0.5499	0.0000	0.0003	0.0000	0.5762	0.0000	0.5499	0.0000	0.5499	0.5499	0.5499	0.5499	0.5499	0.6996	0.6996
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	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0064	0.0081	0.0000	0.1953	0.0000	0.3496	0.0000	0.0064	0.0000	0.3175	1.0000	0.3496	0.0000	0.3496	0.3496	0.3496	0.3496	0.3496	0.1726	0.1726
N_2	0.7759	0.9826	0.0162	0.0741	0.0162	0.0599	0.0000	0.7759	0.0000	0.0627	0.0000	0.0599	0.0000	0.0599	0.0599	0.0599	0.0599	0.0599	0.0762	0.0762
O_2	0.2081	0.0064	0.9495	0.0216	0.9495	0.0174	0.0000	0.2081	0.0000	0.0183	0.0000	0.0174	0.0000	0.0174	0.0174	0.0174	0.0174	0.0174	0.0222	0.0222
SO_2	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0011	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	75,310	59,198	5,639	20,281	10,473	21,560	0	1,452	0	67,971	3,352	71,216	0	71,216	71,216	21,560	2,594	47,062	36,994	17,687
V-L Flowrate (kg/hr)	2,176,081	1,657,167	181,620	758,007	337,294	725,748	0	41,950	0	2,342,100	60,389	2,397,254	0	2,397,254	2,397,254	725,748	87,312	1,584,194	1,402,817	670,695
Solids Flowrate (kg/hr)	0	0	0	0	0	0	324,009	0	5,306	21,223	5,140	31,598	31,598	0	0	0	0	0	0	0
Temperature (°C)	6	14	14	73	14	105	6	6	149	149	6	91	91	91	101	101	101	101	57	57
Pressure (MPa, abs)	0.09	0.31	0.14	0.10	0.14	0.09	0.09	0.09	0.09	0.09	0.10	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09
Enthalpy (kJ/kg)[A]	15.26	20.01	12.15	304.78	12.15	578.15	---	15.26	---	650.88	259.10	635.32	---	563.74	574.31	574.31	574.31	574.31	257.89	257.89
Density (kg/m^3)	1.1	3.7	1.9	1.3	1.9	1.0	---	1.1	---	0.9	1,012.1	0.9	---	0.9	1.0	1.0	1.0	1.0	1.2	1.2
V-L Molecular Weight	28.895	27.994	32.207	37.375	32.207	33.662	---	28.895	---	34.457	18.015	33.662	---	33.662	33.662	33.662	33.662	33.662	37.920	37.920
V-L Flowrate (lb_{mol}/hr)	166,030	130,509	12,432	44,712	23,088	47,532	0	3,201	0	149,851	7,390	157,004	0	157,004	157,004	47,532	5,718	103,754	81,558	38,994
V-L Flowrate (lb/hr)	4,797,437	3,653,428	400,403	1,671,120	743,606	1,600,000	0	92,484	0	5,163,447	133,134	5,285,040	0	5,285,040	5,285,040	1,600,000	192,491	3,492,549	3,092,682	1,478,630
Solids Flowrate (lb/hr)	0	0	0	0	0	0	714,319	0	11,697	46,788	11,331	69,661	69,661	0	0	0	0	0	0	0
Temperature (°F)	42	57	57	164	57	220	42	42	300	300	42	197	196	196	214	214	214	214	135	135
Pressure (psia)	13.0	45.0	20.3	14.4	20.3	13.6	13.0	13.0	12.7	12.7	15.0	12.3	12.1	12.1	13.2	13.2	13.2	13.2	13.0	13.0
Enthalpy (Btu/lb)[A]	6.6	8.6	5.2	131.0	5.2	248.6	---	6.6	---	279.8	111.4	273.1	---	242.4	246.9	246.9	246.9	246.9	110.9	110.9
Density (lb/ft^3)	0.070	0.229	0.118	0.081	0.118	0.063	---	0.070	---	0.054	63.181	0.059	---	0.058	0.062	0.062	0.062	0.062	0.077	0.077

Exhibit 6-5 continued
Case S12D SC PC Oxycombustion with Drying Only Stream Table

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
V-L Mole Fraction																
Ar	0.0285	0.0293	0.0003	0.0000	0.0354	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.6804	0.6996	0.0067	0.0000	0.8455	0.0000	0.0000	0.0000	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	0.0000	0.0000	0.0000
H_2O	0.1953	0.1726	0.9923	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.0741	0.0762	0.0000	0.0000	0.0922	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0216	0.0222	0.0000	0.0000	0.0269	0.0000	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	0.0006	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	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	20,281	19,307	2,880	476	15,952	118,061	98,088	98,088	43,979	43,979	21,056	21,056	28,258	28,258	39,823	119,242
V-L Flowrate (kg/hr)	758,008	732,122	52,485	8,572	671,065	2,126,903	1,767,089	1,767,089	792,287	792,287	379,337	379,337	509,083	509,083	717,423	2,148,172
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	63	57	57	40	35	593	354	593	32	32	52	141	52	146	52	176
Pressure (MPa, abs)	0.09	0.09	0.09	0.10	15.16	24.23	4.90	4.52	0.00	0.00	1.65	1.63	1.65	1.64	1.65	0.91
Enthalpy (kJ/kg)[A]	294.33	257.89	147.23	65.20	-150.83	3,476.62	3,081.97	3,652.22	2,178.55	2,178.55	217.35	591.45	217.35	616.44	217.35	744.69
Density (kg/m^3)	1.2	1.2	60.9	979.4	577.5	69.2	18.7	11.6	0.0	0.0	988.0	926.1	988.0	920.8	988.0	891.1
V-L Molecular Weight	37.375	37.920	18.227	18.015	42.068	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	44,712	42,565	6,348	1,049	35,168	260,280	216,248	216,248	96,956	96,956	46,421	46,421	62,299	62,299	87,795	262,883
V-L Flowrate (lb/hr)	1,671,121	1,614,052	115,710	18,898	1,479,444	4,689,019	3,895,765	3,895,765	1,746,695	1,746,695	836,296	836,296	1,122,337	1,122,337	1,581,647	4,735,909
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	145	135	135	103	95	1,100	669	1,100	90	90	125	285	125	296	125	349
Pressure (psia)	13.0	13.0	13.0	14.7	2,199.0	3,514.7	710.8	655.8	0.7	0.7	240.0	237.1	240.0	238.5	240.0	132.7
Enthalpy (Btu/lb)[A]	126.5	110.9	63.3	28.0	-64.8	1,494.7	1,325.0	1,570.2	936.6	936.6	93.4	254.3	93.4	265.0	93.4	320.2
Density (lb/ft^3)	0.075	0.077	3.802	61.142	36.051	4.319	1.165	0.722	0.003	0.003	61.678	57.814	61.678	57.484	61.678	55.627

6.3.2 Plant Power Summary

Exhibit 6-6 Case S12C and S12D Plant Power Summary

Plant Output			
	Case S12C	**Case S12D**	
Steam Turbine Power	768,200	770,300	kW_e
Total	**768,200**	**770,300**	kW_e
Auxiliary Load			
Coal Handling and Conveying	570	580	kW_e
Pulverizers	4,780	4,860	kW_e
Sorbent Handling & Reagent Preparation	0	180	kW_e
Ash Handling	770	1,090	kW_e
Primary Air Fans	1,740	2,280	kW_e
Forced Draft Fans	2,760	820	kW_e
Induced Draft Fans	6,070	7,290	kW_e
Main Air Compressor	93,670	95,340	kW_e
ASU Auxiliaries	1,000	1,000	kW_e
Baghouse	100	150	kW_e
Spray Dryer FGD	0	2,960	kW_e
CO_2 Purification and Compression	86,790	84,080	kW_e
Miscellaneous Balance of Plant[b,c]	2,000	2,000	kW_e
Steam Turbine Auxiliaries	400	400	kW_e
Condensate Pumps	1,000	1,010	kW_e
Circulating Water Pumps	3,510	3,440	kW_e
Ground Water Pumps	320	340	kW_e
Cooling Tower Fans	2,270	2,210	kW_e
Air Cooled Condenser Fans	7,470	7,260	kW_e
Transformer Losses	2,900	2,910	kW_e
Total	218,120	220,200	kW_e
Plant Performance			
Net Auxiliary Load	218,120	220,200	kW_e
Net Plant Power	550,080	550,100	kW_e
Net Exported Power Efficiency (HHV)	31.2%	30.7%	
Net Plant Heat Rate (HHV)	11,535 (10,933)	11,733 (11,121)	kJ/kWhr (Btu/kWhr)
Coal Feed Flow Rate	318,538 (702,256)	324,009 (714,319)	kg/hr (lb/hr)
Thermal Input[a]	1,762,566	1,792,840	kW_{th}
Condenser Duty	3,327 (3,154)	3,236 (3,067)	GJ/hr (MMBtu/hr)
Raw Water Withdrawal	13.5 (3,579)	14.2 (3,753)	m^3/min (gpm)

[a] HHV of As Received Rosebud PRB coal is 19,920 kJ/kg (8,564 Btu/lb)
[b] Boiler feed pumps are turbine driven
[c] Includes plant control systems, lighting, HVAC, and miscellaneous low voltage loads

6.3.3 Energy Balance

An overall energy balance for the two plants is shown in Exhibit 6-7.

Exhibit 6-7
Cases S12C and S12D Overall Energy Balance

	HHV		Sensible + Latent		Power		Total	
	S12C	**S12D**	**S12C**	**S12D**	**S12C**	**S12D**	**S12C**	**S12D**
Heat In, GJ/hr (MMBtu/hr)								
Coal	6,345 (6,014)	6,454 (6,117)	3.3 (3.1)	3.3 (3.1)			6,348 (6,017)	6,458 (6,121)
Combustion/ Infiltration Air			33.3 (31.6)	33.8 (32.1)			33.3 (31.6)	33.8 (32.1)
Raw Water Makeup			18.9 (17.9)	19.8 (18.8)			18.9 (17.9)	19.8 (18.8)
Lime			0.00 (0.00)	0.02 (0.02)			0.00 (0.00)	0.02 (0.02)
Auxiliary Power					785 (744)	793 (751)	785 (744)	793 (751)
Totals	**6,345 (6,014)**	**6,454 (6,117)**	**55.4 (52.5)**	**57.0 (54.0)**	**785 (744)**	**793 (751)**	**7,186 (6,811)**	**7,304 (6,923)**
Heat Out, GJ/hr (MMBtu/hr)								
Boiler Loss			56.4 (53.4)	57.4 (54.4)			56.4 (53.4)	57.4 (54.4)
Air Heater Loss			4.6 (4.4)	5.4 (5.1)			4.6 (4.4)	5.4 (5.1)
CO_2 Cooling Duty			300.6 (284.9)	134.8 (127.8)			300.6 (284.9)	134.8 (127.8)
DCC Cooling Duty			229.4 (217.4)	396.3 (375.6)			229.4 (217.4)	396.3 (375.6)
SO_2 Polishing Scrubber Cooling Duty			0.0 (0.0)	154.6 (146.5)			0.0 (0.0)	154.6 (146.5)
ASU Cold Box Pre-Cooling			156.0 (147.9)	181.9 (172.5)			156.0 (147.9)	181.9 (172.5)
Bottom Ash			0.7 (0.7)	0.6 (0.6)			0.7 (0.7)	0.6 (0.6)
Fly Ash + FGD Ash			2.9 (2.7)	2.3 (2.2)			2.9 (2.7)	2.3 (2.2)
Knockout Water			26.0 (24.6)	27.6 (26.2)			26.0 (24.6)	27.6 (26.2)

	HHV		Sensible + Latent		Power		Total	
	S12C	S12D	S12C	S12D	S12C	S12D	S12C	S12D
CPU Vent			0 (0)	0 (0)			0 (0)	0 (0)
ASU Vent Stream			50 (47)	33 (31)			50 (49)	33 (31)
Condenser			3,327 (3,154)	3,236 (3,067)			3,327 (3,154)	3,236 (3,067)
CO_2			-101 (-96)	-101 (-96)			-101 (-96)	-101 (96)
Cooling Tower Blowdown			17.0 (16.1)	16.5 (15.7)			17.0 (16.1)	16.5 (15.7)
Process Losses[a]			280.5 (265.9)	314.6 (298.2)			280.5 (265.9)	314.6 (298.2)
ST Generator/Exhaust Losses					70 (67)	71 (67)	70 (67)	71 (67)
Power					2,766 (2,621)	2,773 (2628)	2,766 (2,621)	2,773 (2,628)
Totals			**4,350 (4,123)**	**4,460 (4,227)**	**2,836 (2,688)**	**2,844 (2,695)**	**7,186 (6,811)**	**7,304 (6,923)**

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

6.3.4 Water Balance

An overall water balance for Cases S12C and S12D is shown in Exhibit 6-8. Raw water 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 is re-used as internal recycle. The difference between demand and recycle is raw water withdrawal. The difference between water withdrawal and process water discharge is defined as water consumption, and can be represented by the portion of the raw water withdrawn that is evaporated, transpired, incorporated into products or otherwise not returned to the water source from which it was withdrawn. Water consumption represents the net impact of the plant process on the water source balance.

Exhibit 6-8
Case S12C and S12D Water Balance

Water Use	Water Demand, m^3/min (gpm)		Internal Recycle, m^3/min (gpm)		Raw Water Withdrawl, m^3/min (gpm)	
	S12C	S12D	S12C	S12D	S12C	S12D
FGD Makeup	0.00 (0.00)	1.01 (266)	0.0 (0)	0.0 (0)	0.00 (0.00)	1.01 (266)
BFW Makeup	0.35 (92)	0.35 (94)	0.0 (0)	0.0 (0)	0.35 (92)	0.35 (94)
Cooling Tower Makeup	13.55 (3,579)	13.20 (3,487)	0.35 (92)	0.36 (94)	13.20 (3,487)	12.84 (3,393)
Total	**13.9 (3,671)**	**14.6 (3,847)**	**0.35 (92)**	**0.36 (94)**	**13.5 (3,579)**	**14.2 (3,753)**

Exhibit 6-8 Case S12C and S12D Water Balance (Continued)

Water Use	Process Water Discharge, m^3/min (gpm)		Raw Water Consumption, m^3/min (gpm)	
	S12C	S12D	S12C	S12D
FGD Makeup	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.99 (260.27)
BFW Makeup	0.00 (0.00)	0.00 (0.00)	0.35 (93.01)	0.36 (94.57)
Cooling Tower Makeup	4.30 (1136.38)	4.55 (1200.90)	11.47 (3029.22)	12.16 (3213.16)
Total	**4.30 (1136.38)**	**4.55 (1200.90)**	**11.82 (3122.23)**	**13.51 (3568.01)**

6.3.5 Carbon Balance

The carbon balances for the two oxycombustion PC cases with drying only are shown in Exhibit 6-9. The carbon input to the plant consists of carbon in the air entering the ASU and the infiltration air entering the boiler in addition to carbon in the coal. Most of the carbon entering the ASU is removed before entering the boiler island. Carbon leaves the plant as CO_2 product. The percent of total carbon sequestered is defined as the amount of carbon product produced divided by the carbon in the coal feedstock, expressed as a percentage.

% Captured = Carbon in Product for Sequestration / Carbon in the Coal

or
351,618/351,607 * 100= 100.0% (S12C)
357,142/357,646 *100 = 100.0% (S12D)

Exhibit 6-9
Case S12C and S12D Carbon Balance

Carbon In, kg/hr (lb/hr)			Carbon Out, kg/hr (lb/hr)		
	S12C	S12D		S12C	S12D
Coal	159,486 (351,607)	162,226 (357,646)	ASU Vent	292 (643)	297 (654)
Air (CO_2)	297 (656)	302 (666)	CPU Vent	0 (0)	0 (0)
			CO_2 Product	159,491 (351,618)	161,997 (357,142)
			SO_2 Scrubber	0 (0)	233 (513)
			DCC Discharge	1 (2)	2 (3)
			Convergence Tolerance	-1 (-1)	0 (0)
Total	159,784 (352,262)	162,258 (358,313)	Total	159,784 (352,262)	162,528 (358,313)

6.3.6 Sulfur Balance

Exhibit 6-10 shows the sulfur balances for the two oxycombustion PC cases with drying only. Sulfur input comes solely from the sulfur in the coal. Sulfur output is the sulfur combined with lime in the ash (except Case S12C), the discharge from the DCC and polishing scrubber, and the sulfur sequestered in the CO_2 product stream. The total sulfur capture is represented by the following fraction:

(Sulfur in Ash + Sulfur co-sequestered + Sulfur in waste discharge streams)/Sulfur in the coal or
(0 + 5,106 + 2)/5,109*100 = 100% (S12C)
(5,065 + 131 + 0)/5,196*100 = 100% (S12D)

Exhibit 6-10
Case S12C and S12D Sulfur Balance

Sulfur In, kg/hr (lb/hr)			Sulfur Out, kg/hr (lb/hr)		
	S12C	**S12D**		**S12C**	**S12D**
Coal	2,317 (5,109)	2,357 (5,196)	**Ash**	0 (0)	2,297 (5,065)
			SO_2 Polishing Scrubber	0 (0)	60 (131)
			CPU Vent	0 (0)	0 (0)
			CO_2 Product	2,316 (5,106)	0 (0)
			DCC Discharge	1 (2)	0 (0)
			Convergence Tolerance*	1 (2)	0 (0)
Total	2,317 (5,109)	2,357 (5,196)	**Total**	2,317 (5,109)	2,357 (5,196)

6.3.7 Air Emissions

Both Case S12C and S12D have no recorded emissions because all pollutants are assumed to be removed by the environmental control systems or co-sequestered with the CO_2.

Exhibit 6-11 Cases S12C and S12D Estimated Air Emissions

	kg/GJ ($lb/10^6$ Btu)		Tonne/year (ton/year) 85% capacity factor		kg/MWh (lb/MWh)	
	S12C	**S12D**	**S12C**	**S12D**	**S12C**	**S12D**
SO_2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
NO_X	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Particulates	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Hg	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
CO_2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
CO_2[a]	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

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

6.3.8 Heat and Mass Balance Diagrams

Heat and mass balance diagrams are shown for the following subsystems in Exhibit 6-12 through Exhibit 6-15:

- Boiler and gas cleanup system
- Power block system

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Exhibit 6-12 Cases S12C Boiler and Gas Cleanup System Heat and Mass Balance Diagram

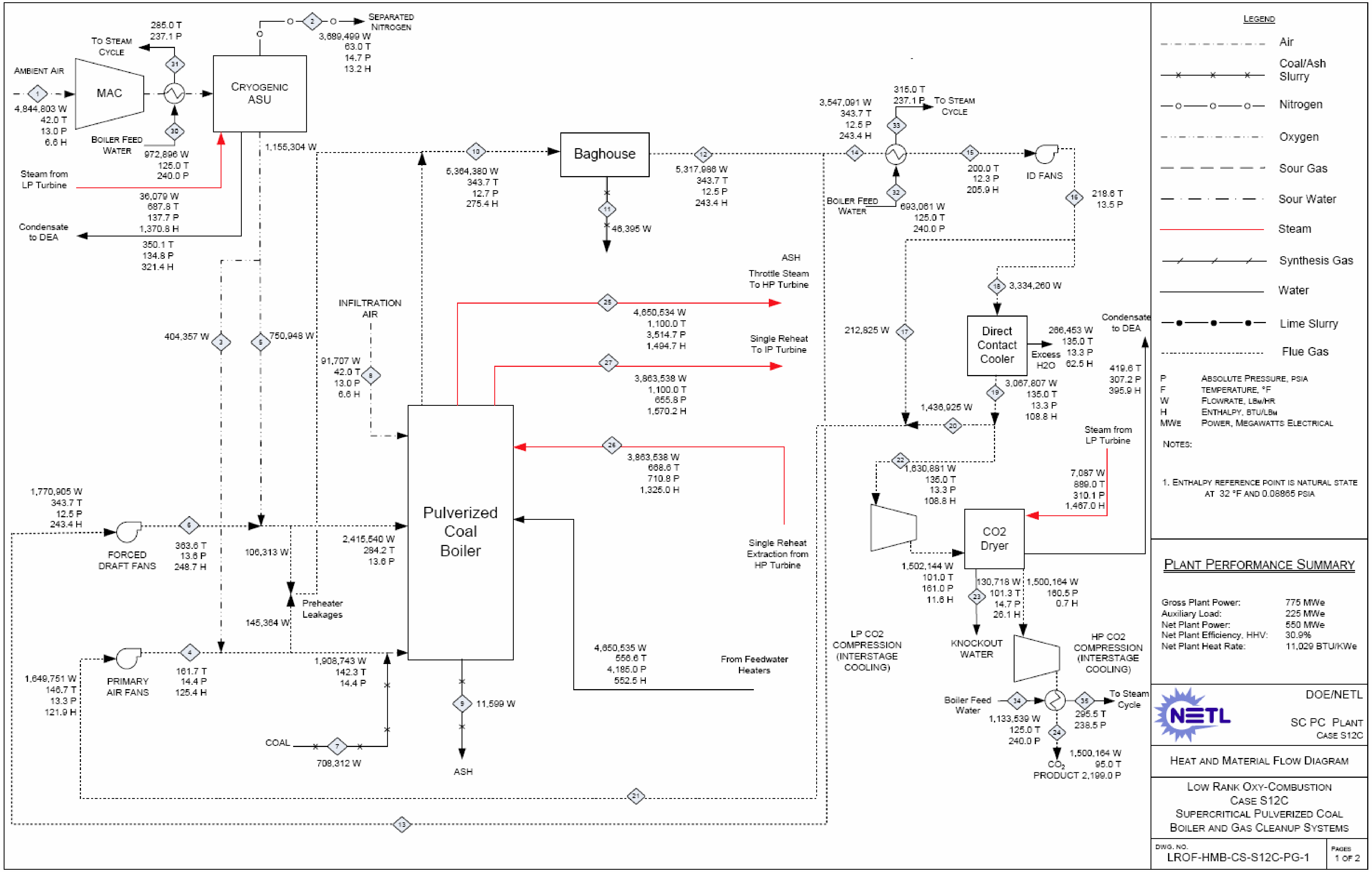


Exhibit 6-13 Cases S12C Power Block System Heat and Mass Balance Diagram

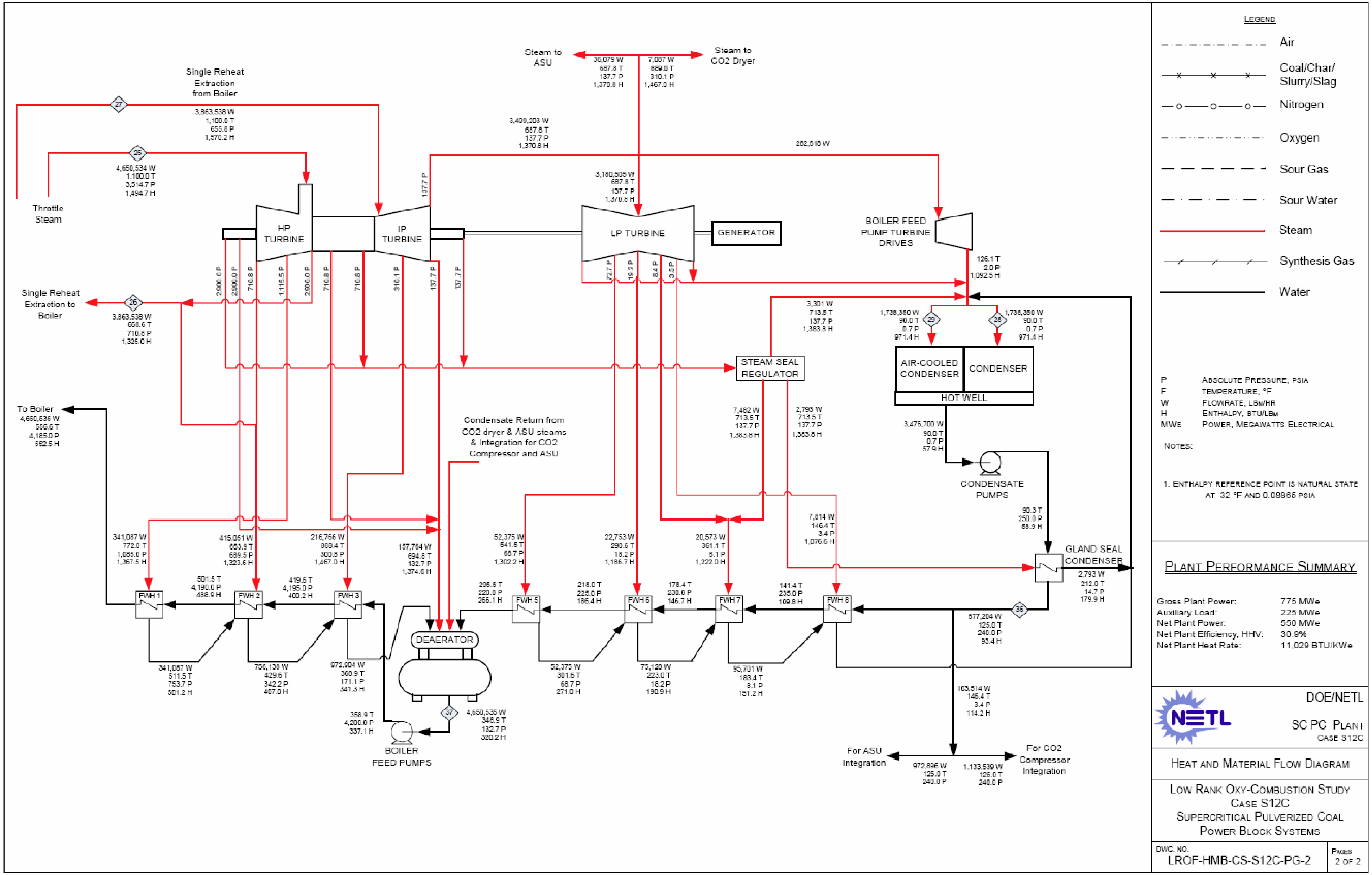


Exhibit 6-14 Case S12D Boiler and Gas Cleanup system Heat and Mass Balance Diagram

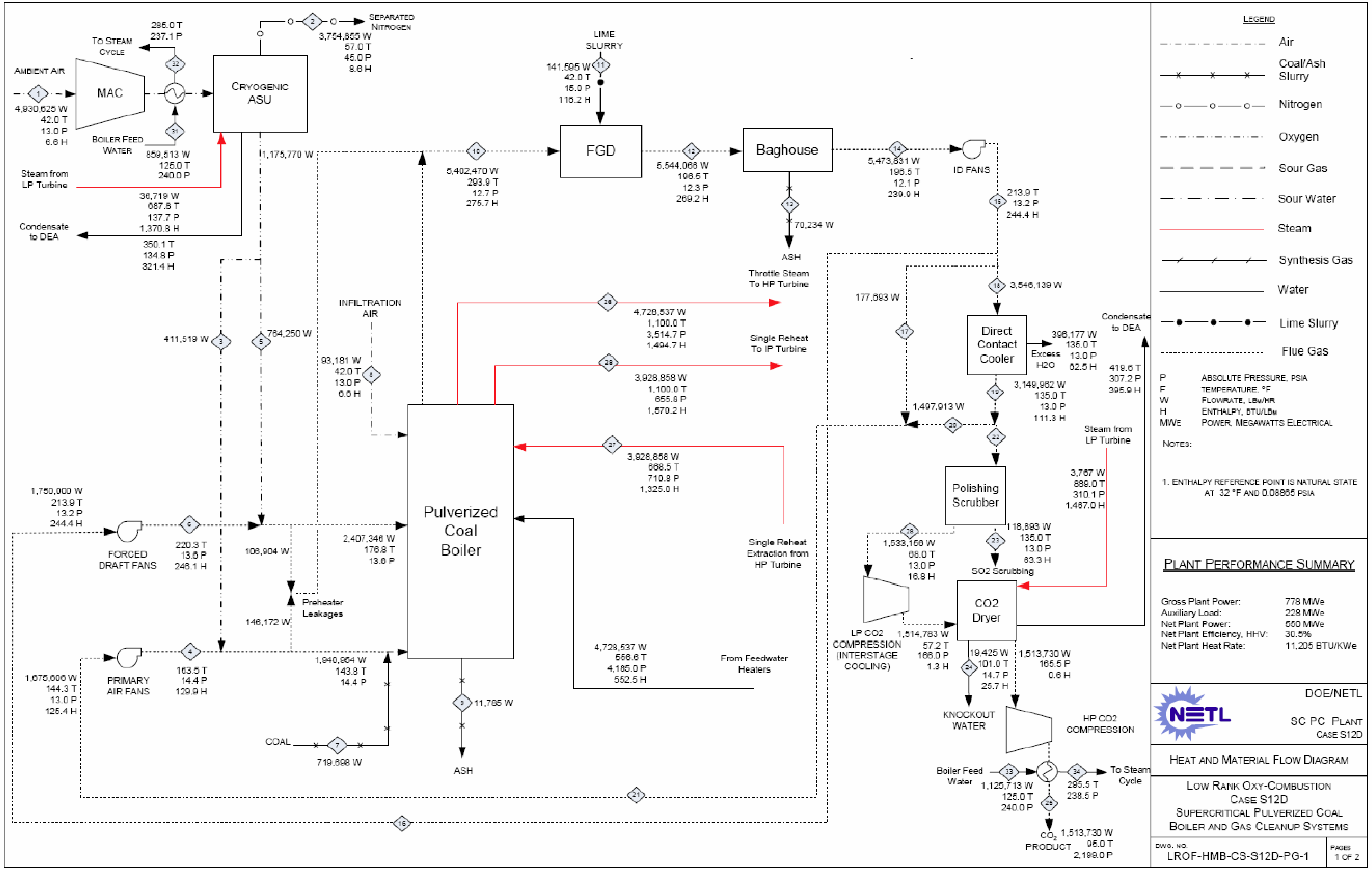
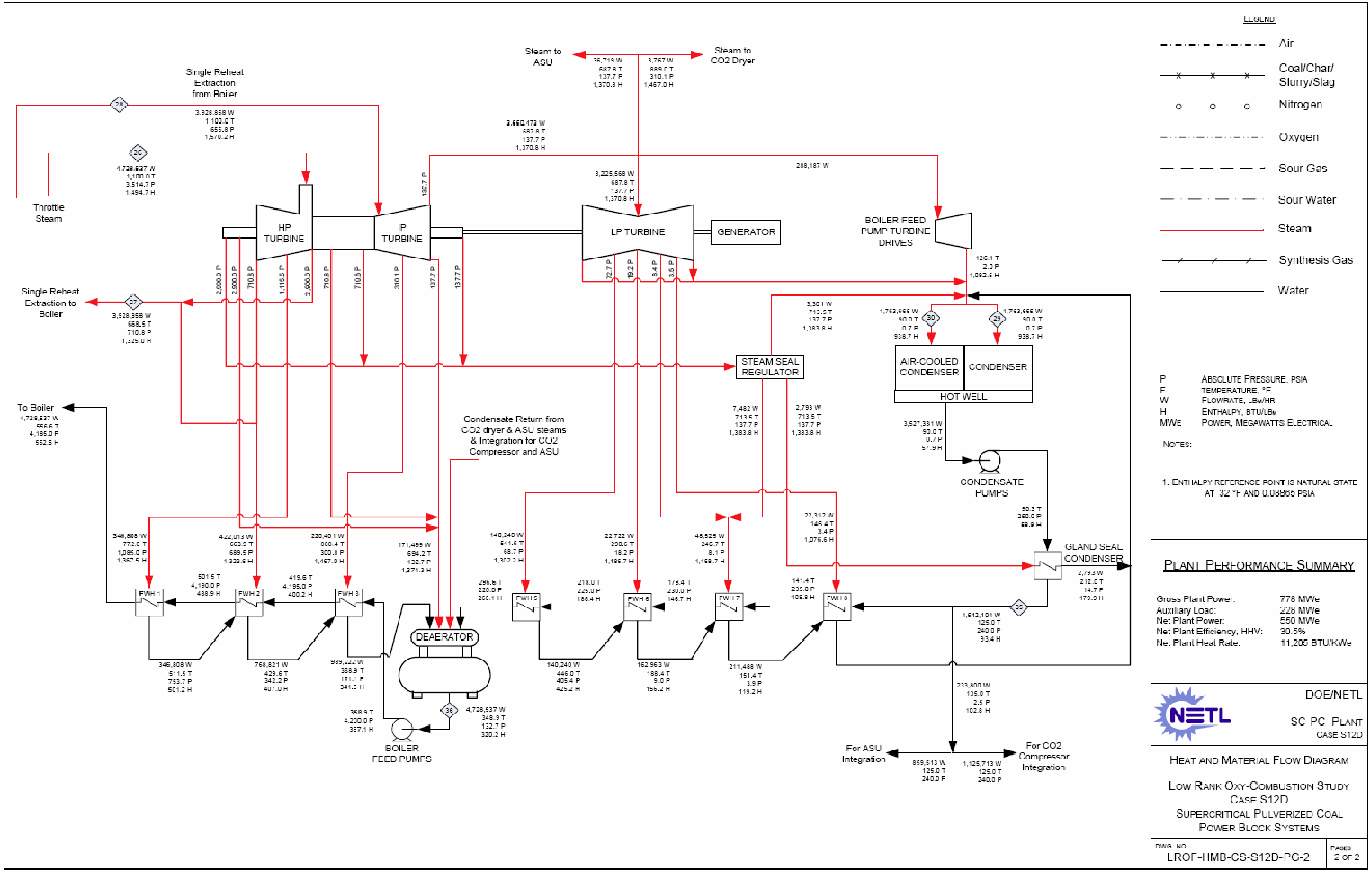


Exhibit 6-15 Cases S12D Power Block System Heat and Mass Balance Diagram



6.3.9 Major Equipment List for Cases S12C and S12D

Major equipment items for these cases are shown in the following tables. The accounts used in the equipment list correspond to the account numbers used in the cost estimates in Section 6.5. 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	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
1	Bottom Trestle Dumper and Receiving Hoppers	N/A	181 tonne (200 ton)	181 tonne (200 ton)	2(0)
2	Feeder	Belt	572 tonne/hr (630 tph)	572 tonne/hr (630 tph)	2(0)
3	Conveyor No. 1	Belt	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1(0)
4	Transfer Tower No. 1	Enclosed	N/A	N/A	1(0)
5	Conveyor No. 2	Belt	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1(0)
6	As-Received Coal Sampling System	Two-stage	N/A	N/A	1(0)
7	Stacker/Reclaimer	Traveling, linear	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1(0)
8	Reclaim Hopper	N/A	64 tonne (70 ton)	64 tonne (70 ton)	2(1)
9	Feeder	Vibratory	263 tonne/hr (290 tph)	272 tonne/hr (300 tph)	2(1)
10	Conveyor No. 3	Belt w/ tripper	526 tonne/hr (580 tph)	535 tonne/hr (590 tph)	1(0)
11	Crusher Tower	N/A	N/A	N/A	1(0)
12	Coal Surge Bin w/ Vent Filter	Dual outlet	263 tonne (290 ton)	272 tonne (300 ton)	2(0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
13	Crusher	Impactor reduction	8 cm x 0 - 3 cm x 0 (3" x 0 - 1-1/4" x 0)	8 cm x 0 - 3 cm x 0 (3" x 0 - 1-1/4" x 0)	2(0)
14	As-Fired Coal Sampling System	Swing hammer	N/A	N/A	1(1)
15	Conveyor No. 4	Belt w/tripper	526 tonne/hr (580 tph)	535 tonne/hr (590 tph)	1(0)
16	Transfer Tower No. 2	Enclosed	N/A	N/A	1(0)
17	Conveyor No. 5	Belt w/ tripper	526 tonne/hr (580 tph)	535 tonne/hr (590 tph)	1(0)
18	Coal Silo w/ Vent Filter and Slide Gates	Field erected	544 tonne (600 ton)	635 tonne (700 ton)	6(0)
19	Lime Truck Unloading System	N/A	#N/A	18 tonne/hr (20 tph)	1(0)
20	Lime Bulk Storage Silo w/Vent Filter	Field erected	#N/A	635 tonne (700 ton)	3(0)
21	Lime Live Storage Transport	Pneumatic	#N/A	8 tonne/hr (9 tph)	1(0)
22	Lime Day Bin	w/ actuator	#N/A	73 tonne (80 ton)	2(0)
23	Activated Carbon Storage Silo and Feeder System with Vent Filter	Shop assembled	#N/A	#N/A	1(0)

ACCOUNT 2 COAL AND SORBENT PREPARATION AND FEED

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
1	Coal Feeder	Gravimetric	54 tonne/hr (60 tph)	64 tonne/hr (70 tph)	6(0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
2	Coal Pulverizer	Ball type or equivalent	54 tonne/hr (60 tph)	64 tonne/hr (70 tph)	6(0)
3	Lime Slaker	N/A	#N/A	8 tonne/hr (9 tph)	1(1)
4	Lime Slurry Tank	Field Erected	#N/A	367,188 liters (97,000 gal)	1(1)
5	Lime Slurry Feed Pumps	Horizontal centrifugal	#N/A	379 lpm @ 9m H_2O (100 gpm @ 30 ft H_2O)	1(1)

ACCOUNT 3 FEEDWATER AND MISCELLANEOUS SYSTEMS AND EQUIPMENT

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
1	Demineralized Water Storage Tank	Vertical, cylindrical, outdoor	1,393,032 liters (368,000 gal)	1,419,529 liters (375,000 gal)	2(0)
2	Condensate Pumps	Vertical canned	29,148 lpm @ 213 m H_2O (7,700 gpm @ 700 ft H_2O)	29,526 lpm @ 213 m H_2O (7,800 gpm @ 700 ft H_2O)	1(1)
3	Deaerator and Storage Tank	Horizontal spray type	2,320,579 kg/hr (5,116,000 lb/hr), 5 min. tank	2,359,134 kg/hr (5,201,000 lb/hr), 5 min. tank	1(0)
4	Boiler Feed Pump/Turbine	Barrel type, multi-stage, centrifugal	38,990 lpm @ 3,475 m H_2O (10,300 gpm @ 11,400 ft H_2O)	39,747 lpm @ 3,475 m H_2O (10,500 gpm @ 11,400 ft H_2O)	1(1)
5	Startup Boiler Feed Pump, Electric Motor Driven	Barrel type, multi-stage, centrifugal	11,735 lpm @ 3,475 m H_2O (3,100 gpm @ 11,400 ft H_2O)	11,735 lpm @ 3,475 m H_2O (3,100 gpm @ 11,400 ft H_2O)	1(0)
6	LP Feedwater Heater 1A/1B	Horizontal U-tube	866,361 kg/hr (1,910,000 lb/hr)	879,969 kg/hr (1,940,000 lb/hr)	2(0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
7	LP Feedwater Heater 2A/2B	Horizontal U-tube	866,361 kg/hr (1,910,000 lb/hr)	879,969 kg/hr (1,940,000 lb/hr)	2(0)
8	LP Feedwater Heater 3A/3B	Horizontal U-tube	866,361 kg/hr (1,910,000 lb/hr)	879,969 kg/hr (1,940,000 lb/hr)	2(0)
9	LP Feedwater Heater 4A/4B	Horizontal U-tube	866,361 kg/hr (1,910,000 lb/hr)	879,969 kg/hr (1,940,000 lb/hr)	2(0)
10	HP Feedwater Heater 6	Horizontal U-tube	2,322,393 kg/hr (5,120,000 lb/hr)	2,358,680 kg/hr (5,200,000 lb/hr)	1(0)
11	HP Feedwater Heater 7	Horizontal U-tube	2,322,393 kg/hr (5,120,000 lb/hr)	2,358,680 kg/hr (5,200,000 lb/hr)	1(0)
12	HP Feedwater heater 8	Horizontal U-tube	2,322,393 kg/hr (5,120,000 lb/hr)	2,358,680 kg/hr (5,200,000 lb/hr)	1(0)
13	Auxiliary Boiler	Shop fabricated, water tube	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)	1(0)
14	Fuel Oil System	No. 2 fuel oil for light off	1,135,624 liter (300,000 gal)	1,135,624 liter (300,000 gal)	1(0)
15	Service Air Compressors	Flooded Screw	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	2(1)
16	Instrument Air Dryers	Duplex, regenerative	28 m^3/min (1,000 scfm)	28 m^3/min (1,000 scfm)	2(1)
17	Closed Cycle Cooling Heat Exchangers	Shell and tube	53 GJ/hr (50 MMBtu/hr) each	53 GJ/hr (50 MMBtu/hr) each	2(0)
18	Closed Cycle Cooling Water Pumps	Horizontal centrifugal	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)	2(1)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
19	Engine-Driven Fire Pump	Vertical turbine, diesel engine	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)	1(1)
20	Fire Service Booster Pump	Two-stage horizontal centrifugal	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)	1(1)
21	Raw Water Pumps	Stainless steel, single suction	5,375 lpm @ 18 m H_2O (1,420 gpm @ 60 ft H_2O)	5,716 lpm @ 18 m H_2O (1,510 gpm @ 60 ft H_2O)	2(1)
22	Ground Water Pumps	Stainless steel, single suction	2,688 lpm @ 268 m H_2O (710 gpm @ 880 ft H_2O)	2,839 lpm @ 268 m H_2O (750 gpm @ 880 ft H_2O)	4(1)
23	Filtered Water Pumps	Stainless steel, single suction	454 lpm @ 49 m H_2O (120 gpm @ 160 ft H_2O)	492 lpm @ 49 m H_2O (130 gpm @ 160 ft H_2O)	2(1)
24	Filtered Water Tank	Vertical, cylindrical	439,108 liter (116,000 gal)	458,035 liter (121,000 gal)	1(0)
25	Makeup Water Demineralizer	Multi-media filter, cartridge filter, RO membrane assembly, electrodeionization unit	946 lpm (250 gpm)	946 lpm (250 gpm)	1(1)
26	Liquid Waste Treatment System	--	10 years, 24-hour storm	10 years, 24-hour storm	1(0)

ACCOUNT 4 BOILER AND ACCESSORIES

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
1	Boiler	Supercritical, drum, wall-fired, low NOx burners, overfire air	2,322,393 kg/hr steam @ 25.5 MPa/602°C/602°C (5,120,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)	2,358,680 kg/hr steam @ 25.5 MPa/602°C/602°C (5,200,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)	1(0)
2	Primary Air Fan	Centrifugal	#N/A	#N/A	2(0)
3	Forced Draft Fan	Centrifugal	#N/A	#N/A	2(0)
4	Induced Draft Fan	Centrifugal	884,959 kg/hr, 18,216 m^3/min @ 85 cm WG (1,951,000 lb/hr, 643,300 acfm @ 33 in. WG)	1,365,767 kg/hr, 24,534 m3/min @ 94 cm WG (3,011,000 lb/hr, 866,400 acfm @ 37 in. WG)	2(0)
5	SCR Reactor Vessel	Space for spare layer	1,769,010 kg/hr (3,900,000 lb/hr)	2,730,626 kg/hr (6,020,000 lb/hr)	2(0)
6	SCR Catalyst	--	--	--	3(0)
7	Dilution Air Blower	Centrifugal	51 m^3/min @ 108 cm WG (1,800 acfm @ 42 in. WG)	51 m^3/min @ 108 cm WG (1,800 acfm @ 42 in. WG)	2(1)
8	Ammonia Storage	Horizontal tank	56,781 liter (15,000 gal)	56,781 liter (15,000 gal)	5(0)
9	Ammonia Feed Pump	Centrifugal	11 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)	11 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)	2(1)
10	ASU Main Air Compressor	Centrifugal, multi-stage	16,509 m^3/min @ 0.3 MPa (583,000 scfm @ 46 psia)	16,820 m^3/min @ 0.3 MPa (594,000 scfm @ 46 psia)	2(0)

ACCOUNT 5 FLUE GAS CLEANUP

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
1	Fabric Filter	Single stage, high-ratio with pulse-jet online cleaning system, air-to-cloth ratio - 3.5 ft/min	#N/A	1,285,481 kg/hr (2,834,000 lb/hr) 99.9% efficiency	2(0)
2	Spray Dryer	Co-current open spray	26,873 m^3/min (949,000 acfm)	23,107 m^3/min (816,000 acfm)	2(0)
3	Atomizer	Rotary	#N/A	227 lpm @ 64 m H_2O (60 gpm @ 210 ft H_2O)	2(1)
4	Spray Dryer Solids Conveying	---	---	---	2(0)
5	Carbon Injectors	---	#N/A	#N/A	1(0)

ACCOUNT 7 DUCTING AND STACK

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
1	Stack	Reinforced concrete with FRP liner	#N/A	#N/A	1 (0)

ACCOUNT 8 STEAM TURBINE GENERATOR

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
1	Steam Turbine	Commercially available	816 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)	819 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)	1(0)
2	Steam Turbine Generator	Hydrogen cooled, static excitation	910 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	910 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	1(0)
3	Surface Condenser	Single pass, divided waterbox including vacuum pumps	1,850 GJ/hr (1,750 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 9°C (48°F), Water temperature rise 11°C (20°F)	1,800 GJ/hr (1,710 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 9°C (48°F), Water temperature rise 11°C (20°F)	1(0)
4	Air-cooled Condenser	---	1,850 GJ/hr (1,750 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 6°C (42°F)	1,800 GJ/hr (1,710 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 6°C (42°F)	1(0)

ACCOUNT 9 COOLING WATER SYSTEM

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
1	Circulating Water Pumps	Vertical, wet pit	492,100 lpm @ 30 m (130,000 gpm @ 100 ft)	522,400 lpm @ 30 m (138,000 gpm @ 100 ft)	2(1)
2	Cooling Tower	Evaporative, mechanical draft, multi-cell	3°C (37°F) wet bulb / 9°C (48°F) CWT / 20°C (68°F) HWT / 2743 GJ/hr (2600 MMBtu/hr) heat duty	3°C (37°F) wet bulb / 9°C (48°F) CWT / 20°C (68°F) HWT / 2901 GJ/hr (2750 MMBtu/hr) heat duty	1(0)

ACCOUNT 10 ASH/SPENT SORBENT RECOVERY AND HANDLING

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
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	--	5.4 tonne/hr (6 tph)	5.4 tonne/hr (6 tph)	1 (1)
4	Pyrites Hopper (part of pulverizer scope of supply included with boiler)	--	--	--	6 (0)
5	Hydroejectors	--	--	--	
6	Economizer /Pyrites Transfer Tank	--	--	--	4(0)
7	Ash Sluice Pumps	Vertical, wet pit	227 lpm @ 17 m H_2O (60 gpm @ 56 ft H_2O)	227 lpm @ 17 m H_2O (60 gpm @ 56 ft H_2O)	4(0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
8	Ash Seal Water Pumps	Vertical, wet pit	7,571 lpm @ 9 m H_2O (2000 gpm @ 28 ft H_2O)	7,571 lpm @ 9 m H_2O (2000 gpm @ 28 ft H_2O)	2(0)
9	Hydrobins	--	227 lpm (60 gpm)	227 lpm (60 gpm)	1(1)
10	Baghouse Hopper (part of baghouse scope of supply)	--	--	--	6(0)
11	Air Heater Hopper (part of boiler scope of supply)	--	--	--	12(0)
12	Air Blower	--	21 m^3/min @ 0.2 MPa (750 scfm @ 24 psi)	32 m^3/min @ 0.2 MPa (1130 scfm @ 24 psi)	1(0)
13	Fly Ash Silo	Reinforced concrete	1,360 tonne (1,500 ton)	2,090 tonne (2,300 ton)	1(1)
14	Slide Gate Valves	--	--	--	1(1)
15	Unloader	--	--	--	1(1)
16	Telescoping Unloading Chute	--	127 tonne/hr (140 tph)	200 tonne/hr (220 tph)	24(0)
17	Recycle Waste Storage Silo	Reinforced concrete	#N/A	272 tonne (300 ton)	10(0)
18	Recycle Waste Conveyor	--	#N/A	36 tonne/hr (40 tph)	1(1)
19	Recycle Slurry Mixer	--	#N/A	946 lpm (250 gpm)	2(0)
20	Recycle Waste Slurry Tank	--	#N/A	56,780 liters (15,000 gal)	2(0)
21	Recycle Waste Pump	--	#N/A	946 lpm (250 gpm)	1(0)

ACCOUNT 11 ACCESSORY ELECTRIC PLANT

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
1	STG Transformer	Oil-filled	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	1(0)
2	Auxiliary Transformer	Oil-filled	24 kV/4.16 kV, 247 MVA, 3-ph, 60 Hz	24 kV/4.16 kV, 250 MVA, 3-ph, 60 Hz	1(1)
3	Low Voltage Transformer	Dry ventilated	4.16 kV/480 V, 37 MVA, 3-ph, 60 Hz	4.16 kV/480 V, 37 MVA, 3-ph, 60 Hz	1(1)
4	STG Isolated Phase Bus Duct and Tap Bus	Aluminum, self-cooled	24 kV, 3-ph, 60 Hz	24 kV, 3-ph, 60 Hz	1(0)
5	Medium Voltage Switchgear	Metal clad	4.16 kV, 3-ph, 60 Hz	4.16 kV, 3-ph, 60 Hz	1(1)
6	Low Voltage Switchgear	Metal enclosed	480 V, 3-ph, 60 Hz	480 V, 3-ph, 60 Hz	1(1)
7	Emergency Diesel Generator	Sized for emergency shutdown	750 kW, 480 V, 3-ph, 60 Hz	750 kW, 480 V, 3-ph, 60 Hz	1(0)

ACCOUNT 12 INSTRUMENTATION AND CONTROL

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
1	DCS - Main Control	Monitor/keyboard; Operator printer (laser color); Engineering printer (laser B&W)	Operator stations/printers and engineering stations/printers	Operator stations/printers and engineering stations/printers	1(0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12C	Case S12D	
2	DCS - Processor	Microprocessor with redundant input/output	N/A	N/A	1(0)
3	DCS - Data Highway	Fiber optic	Fully redundant, 25% spare	Fully redundant, 25% spare	1(0)

6.4 PERFORMANCE RESULTS FOR CASE S12E, S12F, AND L12F

A process block flow diagram for the SC CO_2 capture (with partial condensation CO_2 purification option) Case, S12E, is shown in Exhibit 6-16 and the corresponding stream tables are shown in Exhibit 6-17.

A process block flow diagram for the SC CO_2 capture/cryogenic distillation purification (with dry only CO_2 purification option) cases, S12F and L12F, is shown in Exhibit Exhibit 6-18 and the corresponding stream tables are shown in Exhibit 6-19 and Exhibit 6-20.

Overall performance for cases S12E, S12F, and L12F is summarized in Exhibit 6-21, which includes auxiliary power requirements.

6.4.1 Block Flow Diagram and Stream Table

Exhibit 6-16 Case S12E SC PC Oxycombustion with CO_2 Partial Condensation Block Flow Diagram

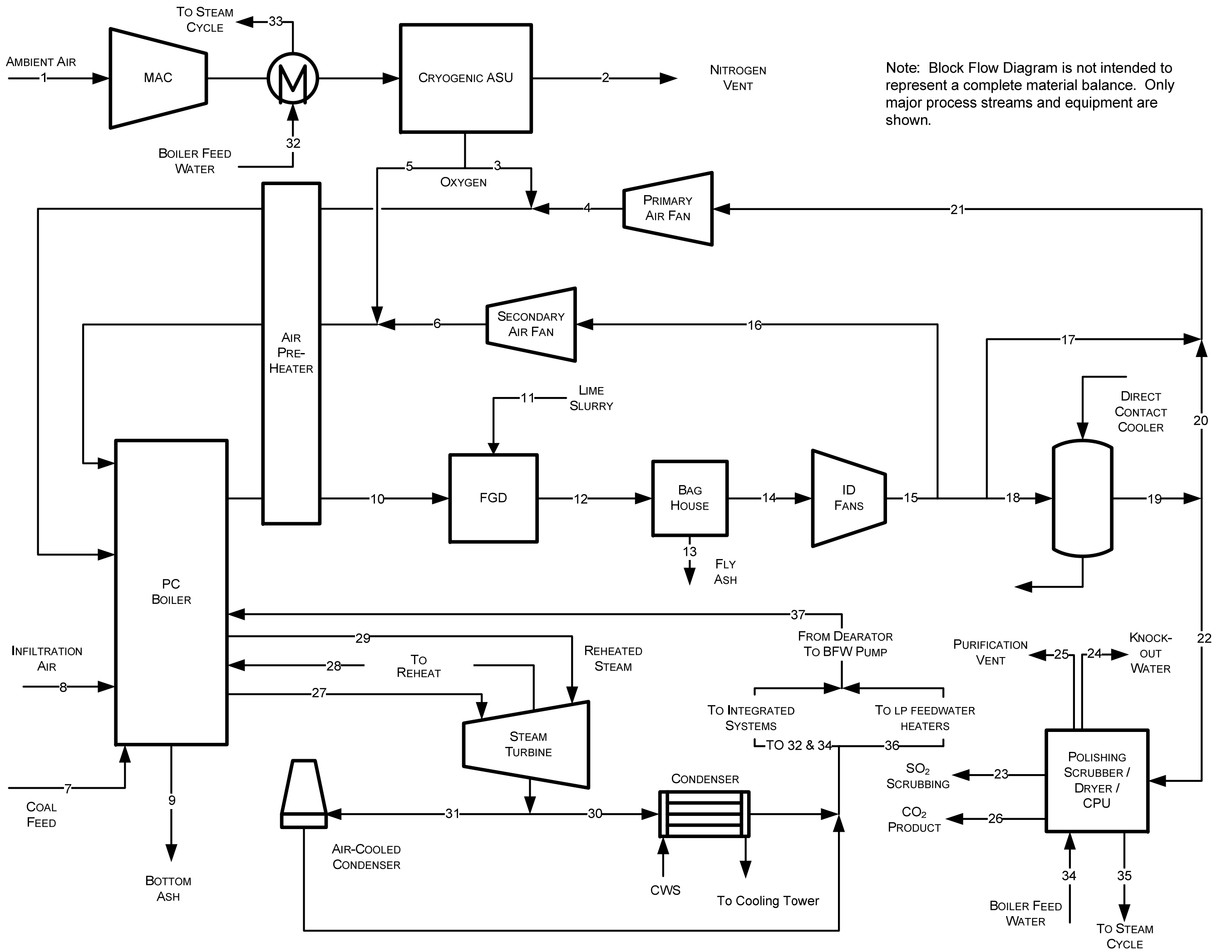


Exhibit 6-17 Case S12E SC PC Oxycombustion with CO_2 Partial Condensation Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20
V-L Mole Fraction																			
Ar	0.0093	0.0025	0.0343	0.0285	0.0343	0.0230	0.0000	0.0093	0.0000	0.0241	0.0000	0.0230	0.0000	0.0230	0.0230	0.0230	0.0230	0.0293	0.0293
CO_2	0.0003	0.0004	0.0000	0.6803	0.0000	0.5496	0.0000	0.0003	0.0000	0.5758	0.0000	0.5496	0.0000	0.5496	0.5496	0.5496	0.5496	0.6994	0.6994
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	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0064	0.0081	0.0000	0.1952	0.0000	0.3499	0.0000	0.0064	0.0000	0.3178	1.0000	0.3499	0.0000	0.3499	0.3499	0.3499	0.3499	0.1726	0.1726
N_2	0.7759	0.9826	0.0162	0.0741	0.0162	0.0598	0.0000	0.7759	0.0000	0.0627	0.0000	0.0598	0.0000	0.0598	0.0598	0.0598	0.0598	0.0762	0.0762
O_2	0.2081	0.0064	0.9495	0.0218	0.9495	0.0176	0.0000	0.2081	0.0000	0.0184	0.0000	0.0176	0.0000	0.0176	0.0176	0.0176	0.0176	0.0224	0.0224
SO_2	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0011	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	73,664	57,904	5,516	19,832	10,244	21,565	0	1,420	0	66,954	3,299	70,147	0	70,147	70,147	21,565	2,529	36,189	17,303
V-L Flowrate (kg/hr)	2,128,535	1,620,959	177,652	741,208	329,924	725,748	0	41,023	0	2,306,461	59,432	2,360,772	0	2,360,772	2,360,772	725,748	85,103	1,372,192	656,106
Solids Flowrate (kg/hr)	0	0	0	0	0	0	316,848	0	5,188	20,754	5,044	30,919	30,919	0	0	0	0	0	0
Temperature (°C)	6	17	14	73	14	105	6	6	149	149	6	91	91	91	101	101	101	57	57
Pressure (MPa, abs)	0.09	0.10	0.14	0.10	0.14	0.09	0.09	0.09	0.09	0.09	0.10	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09
Enthalpy (kJ/kg)[A]	15.26	30.70	12.15	304.73	12.15	578.59	---	15.26	---	650.82	258.23	635.24	---	564.18	574.74	574.74	574.74	257.90	257.90
Density (kg/m^3)	1.1	1.2	1.9	1.3	1.9	1.0	---	1.1	---	0.9	1,012.1	0.9	---	0.9	1.0	1.0	1.0	1.2	1.2
V-L Molecular Weight	28.895	27.994	32.207	37.374	32.207	33.654	---	28.895	---	34.449	18.015	33.654	---	33.654	33.654	33.654	33.654	37.918	37.918
V-L Flowrate (lb_{mol}/hr)	162,402	127,657	12,161	43,722	22,584	47,542	0	3,130	0	147,607	7,273	154,649	0	154,649	154,649	47,542	5,575	79,782	38,147
V-L Flowrate (lb/hr)	4,692,616	3,573,602	391,655	1,634,085	727,359	1,600,000	0	90,440	0	5,084,877	131,024	5,204,612	0	5,204,612	5,204,612	1,600,000	187,619	3,025,165	1,446,466
Solids Flowrate (lb/hr)	0	0	0	0	0	0	698,531	0	11,439	45,754	11,121	68,164	68,164	0	0	0	0	0	0
Temperature (°F)	42	63	57	164	57	220	42	42	300	300	42	197	196	196	214	214	214	135	135
Pressure (psia)	13.0	14.7	20.3	14.4	20.3	13.6	13.0	13.0	12.7	12.7	15.0	12.3	12.1	12.1	13.2	13.2	13.2	13.0	13.0
Enthalpy (Btu/lb)[A]	6.6	13.2	5.2	131.0	5.2	248.7	---	6.6	---	279.8	111.0	273.1	---	242.6	247.1	247.1	247.1	110.9	110.9
Density (lb/ft^3)	0.070	0.073	0.118	0.081	0.118	0.063	---	0.070	---	0.054	63.181	0.059	---	0.058	0.062	0.062	0.062	0.077	0.077

Exhibit 6-17 continued
Case S12E SC PC Oxycombustion with CO_2 Partial Condensation Stream Table

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
V-L Mole Fraction																	
Ar	0.0285	0.0293	0.0003	0.0000	0.1375	0.0079	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.6803	0.6994	0.0067	0.0000	0.3574	0.9771	0.0000	0.0000	0.0000	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	0.0000	0.0000	0.0000	0.0000
H_2O	0.1952	0.1726	0.9923	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.0741	0.0762	0.0000	0.0000	0.3931	0.0109	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0218	0.0224	0.0000	0.0000	0.1120	0.0042	0.0000	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	0.0006	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	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	19,832	18,885	2,817	465	3,318	12,285	115,440	95,894	95,894	42,790	42,790	20,596	20,596	12,296	12,296	53,843	116,595
V-L Flowrate (kg/hr)	741,208	716,086	51,338	8,385	118,853	537,511	2,079,692	1,727,554	1,727,554	770,877	770,877	371,049	371,049	221,510	221,510	969,993	2,100,489
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	63	57	57	40	21	27	593	354	593	32	32	52	141	52	146	52	176
Pressure (MPa, abs)	0.09	0.09	0.09	0.10	0.10	15.31	24.23	4.90	4.52	0.00	0.00	1.65	1.63	1.65	1.64	1.65	0.91
Enthalpy (kJ/kg)[A]	294.28	257.90	147.23	65.22	17.51	-224.59	3,476.62	3,082.04	3,652.22	2,123.06	2,123.06	217.35	591.45	217.35	616.44	217.35	744.69
Density (kg/m^3)	1.2	1.2	60.9	979.4	1.5	602.9	69.2	18.7	11.6	0.0	0.0	988.0	926.1	988.0	920.8	988.0	891.1
V-L Molecular Weight	37.374	37.918	18.227	18.015	35.817	43.754	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	43,722	41,635	6,210	1,026	7,316	27,084	254,503	211,410	211,410	94,336	94,336	45,407	45,407	27,107	27,107	118,703	257,048
V-L Flowrate (lb/hr)	1,634,085	1,578,700	113,180	18,485	262,025	1,185,010	4,584,936	3,808,606	3,808,606	1,699,494	1,699,494	818,023	818,023	488,346	488,346	2,138,467	4,630,785
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	145	135	135	103	70	81	1,100	669	1,100	90	90	125	285	125	296	125	349
Pressure (psia)	13.0	13.0	13.0	14.7	15.0	2,220.0	3,514.7	710.8	655.8	0.7	0.7	240.0	237.1	240.0	238.5	240.0	132.7
Enthalpy (Btu/lb)[A]	126.5	110.9	63.3	28.0	7.5	-96.6	1,494.7	1,325.0	1,570.2	912.8	912.8	93.4	254.3	93.4	265.0	93.4	320.2
Density (lb/ft^3)	0.075	0.077	3.804	61.141	0.094	37.639	4.319	1.165	0.722	0.003	0.003	61.678	57.814	61.678	57.484	61.678	55.627

Exhibit 6-18 Case S12F and L12F SC PC Oxycombustion with CO_2 Cryogenic Distillation Block Flow Diagram

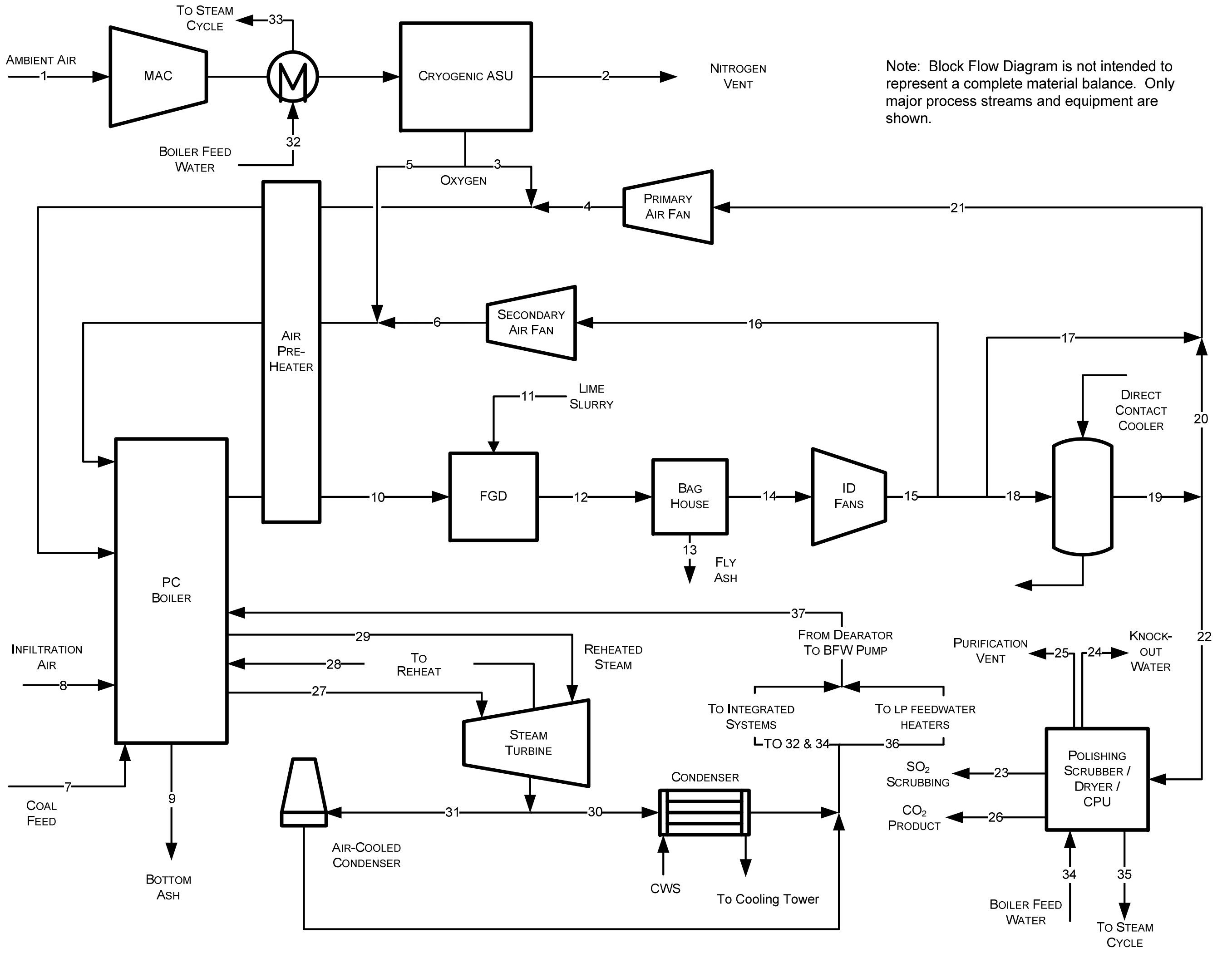


Exhibit 6-19 Case S12F SC PC Oxycombustion with CO_2 Cryogenic Distillation Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
V-L Mole Fraction																				
Ar	0.0093	0.0025	0.0343	0.0285	0.0343	0.0230	0.0000	0.0093	0.0000	0.0241	0.0000	0.0230	0.0000	0.0230	0.0230	0.0230	0.0230	0.0230	0.0293	0.0293
CO_2	0.0003	0.0004	0.0000	0.6803	0.0000	0.5493	0.0000	0.0003	0.0000	0.5755	0.0000	0.5493	0.0000	0.5493	0.5493	0.5493	0.5493	0.5493	0.6995	0.6995
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	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0064	0.0081	0.0000	0.1953	0.0000	0.3502	0.0000	0.0064	0.0000	0.3182	1.0000	0.3502	0.0000	0.3502	0.3502	0.3502	0.3502	0.3502	0.1726	0.1726
N_2	0.7759	0.9826	0.0162	0.0741	0.0162	0.0598	0.0000	0.7759	0.0000	0.0627	0.0000	0.0598	0.0000	0.0598	0.0598	0.0598	0.0598	0.0598	0.0762	0.0762
O_2	0.2081	0.0064	0.9495	0.0217	0.9495	0.0175	0.0000	0.2081	0.0000	0.0184	0.0000	0.0175	0.0000	0.0175	0.0175	0.0175	0.0175	0.0175	0.0223	0.0223
SO_2	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0011	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	74,021	58,185	5,543	19,931	10,294	22,244	0	1,427	0	67,857	3,340	71,091	0	71,091	71,091	22,244	2,544	46,304	36,364	17,388
V-L Flowrate (kg/hr)	2,138,850	1,628,814	178,512	744,891	331,523	748,427	0	41,226	0	2,336,924	60,175	2,391,952	0	2,391,952	2,391,952	748,427	85,581	1,557,944	1,378,880	659,310
Solids Flowrate (kg/hr)	0	0	0	0	0	0	318,415	0	5,214	20,856	5,056	31,059	31,059	0	0	0	0	0	0	0
Temperature (°C)	6	17	14	73	14	105	6	6	149	149	6	91	91	91	101	101	101	101	57	57
Pressure (MPa, abs)	0.09	0.10	0.14	0.10	0.14	0.09	0.09	0.09	0.09	0.09	0.10	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09
Enthalpy (kJ/kg)[A]	15.26	30.70	12.15	304.82	12.15	579.38	---	15.26	---	650.91	254.98	635.33	---	564.81	575.38	575.38	575.38	575.38	257.89	257.89
Density (kg/m^3)	1.1	1.2	1.9	1.3	1.9	1.0	---	1.1	---	0.9	1,012.1	0.9	---	0.9	1.0	1.0	1.0	1.0	1.2	1.2
V-L Molecular Weight	28.895	27.994	32.207	37.373	32.207	33.646	---	28.895	---	34.439	18.015	33.646	---	33.646	33.646	33.646	33.646	33.646	37.919	37.919
V-L Flowrate (lb_{mol}/hr)	163,189	128,276	12,220	43,941	22,693	49,040	0	3,145	0	149,598	7,364	156,729	0	156,729	156,729	49,040	5,608	102,082	80,169	38,333
V-L Flowrate (lb/hr)	4,715,356	3,590,920	393,553	1,642,203	730,883	1,650,000	0	90,888	0	5,152,036	132,663	5,273,352	0	5,273,352	5,273,352	1,650,000	188,673	3,434,679	3,039,910	1,453,529
Solids Flowrate (lb/hr)	0	0	0	0	0	0	701,985	0	11,495	45,980	11,146	68,473	68,473	0	0	0	0	0	0	0
Temperature (°F)	42	63	57	164	57	220	42	42	300	300	42	197	196	196	214	214	214	214	135	135
Pressure (psia)	13.0	14.7	20.3	14.4	20.3	13.6	13.0	13.0	12.7	12.7	15.0	12.3	12.1	12.1	13.2	13.2	13.2	13.2	13.0	13.0
Enthalpy (Btu/lb)[A]	6.6	13.2	5.2	131.0	5.2	249.1	---	6.6	---	279.8	109.6	273.1	---	242.8	247.4	247.4	247.4	247.4	110.9	110.9
Density (lb/ft^3)	0.070	0.073	0.118	0.081	0.118	0.063	---	0.070	---	0.054	63.181	0.059	---	0.058	0.062	0.062	0.062	0.062	0.077	0.077

Exhibit 6-19 continued

Case S12F SC PC Oxycombustion with CO_2 Cryogenic Distillation Stream Table

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
V-L Mole Fraction																	
Ar	0.0285	0.0293	0.0003	0.0000	0.1524	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.6803	0.6995	0.0067	0.0000	0.3328	0.9998	0.0000	0.0000	0.0000	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	0.0000	0.0000	0.0000	0.0000
H_2O	0.1953	0.1726	0.9923	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.0741	0.0762	0.0000	0.0000	0.3982	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0217	0.0223	0.0000	0.0000	0.1166	0.0000	0.0000	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	0.0006	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	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	19,931	18,977	2,830	468	3,629	12,049	115,992	96,355	96,355	42,957	42,957	20,696	20,696	12,297	12,297	54,080	117,152
V-L Flowrate (kg/hr)	744,891	719,570	51,585	8,425	129,279	530,281	2,089,623	1,735,871	1,735,871	773,878	773,878	372,847	372,847	221,541	221,541	974,264	2,110,519
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	63	57	57	40	21	27	593	354	593	32	32	52	141	52	146	52	176
Pressure (MPa, abs)	0.09	0.09	0.09	0.10	0.10	15.31	24.23	4.90	4.52	0.00	0.00	1.65	1.63	1.65	1.64	1.65	0.91
Enthalpy (kJ/kg)[A]	294.37	257.89	147.23	65.26	17.23	-233.12	3,476.62	3,082.03	3,652.22	2,122.97	2,122.97	217.35	591.45	217.35	616.44	217.35	744.69
Density (kg/m^3)	1.2	1.2	61.0	979.4	1.5	685.0	69.2	18.7	11.6	0.0	0.0	988.0	926.1	988.0	920.8	988.0	891.1
V-L Molecular Weight	37.373	37.919	18.226	18.015	35.620	44.009	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	43,941	41,837	6,240	1,031	8,002	26,564	255,718	212,427	212,427	94,703	94,703	45,627	45,627	27,111	27,111	119,226	258,275
V-L Flowrate (lb/hr)	1,642,203	1,586,381	113,726	18,574	285,010	1,169,069	4,606,831	3,826,940	3,826,940	1,706,109	1,706,109	821,987	821,987	488,414	488,414	2,147,884	4,652,899
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	145	135	135	103	70	81	1,100	669	1,100	90	90	125	285	125	296	125	349
Pressure (psia)	13.0	13.0	13.0	14.7	15.0	2,220.0	3,514.7	710.8	655.8	0.7	0.7	240.0	237.1	240.0	238.5	240.0	132.7
Enthalpy (Btu/lb)[A]	126.6	110.9	63.3	28.1	7.4	-100.2	1,494.7	1,325.0	1,570.2	912.7	912.7	93.4	254.3	93.4	265.0	93.4	320.2
Density (lb/ft^3)	0.075	0.077	3.806	61.141	0.094	42.765	4.319	1.165	0.722	0.003	0.003	61.678	57.814	61.678	57.484	61.678	55.627

Exhibit 6-20 Case L12F SC PC Oxycombustion with CO_2 Cryogenic Distillation Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
V-L Mole Fraction																				
Ar	0.0093	0.0025	0.0343	0.0286	0.0343	0.0222	0.0000	0.0093	0.0000	0.0233	0.0000	0.0222	0.0000	0.0222	0.0222	0.0222	0.0222	0.0222	0.0294	0.0294
CO_2	0.0003	0.0004	0.0000	0.6879	0.0000	0.5342	0.0000	0.0003	0.0000	0.5600	0.0000	0.5342	0.0000	0.5342	0.5342	0.5342	0.5342	0.5342	0.7080	0.7080
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	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.0062	0.0078	0.0000	0.1864	0.0000	0.3682	0.0000	0.0062	0.0000	0.3365	1.0000	0.3682	0.0000	0.3682	0.3682	0.3682	0.3682	0.3682	0.1627	0.1627
N_2	0.7761	0.9829	0.0162	0.0747	0.0162	0.0580	0.0000	0.7761	0.0000	0.0608	0.0000	0.0580	0.0000	0.0580	0.0580	0.0580	0.0580	0.0580	0.0769	0.0769
O_2	0.2082	0.0064	0.9495	0.0223	0.9495	0.0173	0.0000	0.2082	0.0000	0.0181	0.0000	0.0173	0.0000	0.0173	0.0173	0.0173	0.0173	0.0173	0.0229	0.0229
SO_2	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0013	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	77,362	60,807	5,794	27,829	10,761	9,010	0	1,490	0	67,778	3,389	71,046	0	71,046	71,046	9,010	3,212	58,825	44,389	24,617
V-L Flowrate (kg/hr)	2,235,580	1,702,398	186,614	1,046,028	346,568	299,253	0	43,066	0	2,304,658	61,051	2,359,806	0	2,359,806	2,359,806	299,253	106,676	1,953,876	1,693,812	939,356
Solids Flowrate (kg/hr)	0	0	0	0	0	0	425,050	0	8,384	33,538	5,819	45,261	45,261	0	0	0	0	0	0	0
Temperature (°C)	4	17	14	72	14	104	4	4	149	149	4	91	91	91	100	100	100	100	57	57
Pressure (MPa, abs)	0.10	0.10	0.14	0.10	0.14	0.10	0.10	0.10	0.09	0.09	0.10	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10
Enthalpy (kJ/kg)[A]	13.75	30.21	12.15	291.21	12.15	610.13	---	13.75	---	731.38	292.49	714.67	---	596.26	606.31	606.31	606.31	606.31	244.53	244.53
Density (kg/m^3)	1.2	1.2	1.9	1.4	1.9	1.1	---	1.2	---	0.9	1,013.1	1.0	---	1.0	1.0	1.0	1.0	1.0	1.3	1.3
V-L Molecular Weight	28.898	27.997	32.207	37.588	32.207	33.215	---	28.898	---	34.003	18.015	33.215	---	33.215	33.215	33.215	33.215	33.215	38.158	38.158
V-L Flowrate (lb_{mol}/hr)	170,554	134,057	12,774	61,352	23,723	19,863	0	3,286	0	149,425	7,471	156,629	0	156,629	156,629	19,863	7,081	129,686	97,861	54,272
V-L Flowrate (lb/hr)	4,928,610	3,753,145	411,413	2,306,098	764,052	659,741	0	94,945	0	5,080,902	134,595	5,202,481	0	5,202,481	5,202,481	659,741	235,181	4,307,559	3,734,215	2,070,925
Solids Flowrate (lb/hr)	0	0	0	0	0	0	937,075	0	18,484	73,938	12,829	99,782	99,782	0	0	0	0	0	0	0
Temperature (°F)	40	63	57	162	57	219	40	40	300	300	40	197	196	196	213	213	213	213	135	135
Pressure (psia)	13.8	14.7	20.3	15.2	20.3	14.4	13.8	13.8	13.5	13.5	15.0	13.1	12.9	12.9	14.0	14.0	14.0	14.0	13.8	13.8
Enthalpy (Btu/lb)[A]	5.9	13.0	5.2	125.2	5.2	262.3	---	5.9	---	314.4	125.7	307.3	---	256.3	260.7	260.7	260.7	260.7	105.1	105.1
Density (lb/ft^3)	0.074	0.073	0.118	0.086	0.118	0.066	---	0.074	---	0.056	63.247	0.062	---	0.061	0.065	0.065	0.065	0.065	0.083	0.083

Exhibit 6-20 continued
Case L12F SC PC Oxycombustion with CO_2 Cryogenic Distillation Stream Table

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
V-L Mole Fraction																	
Ar	0.0286	0.0294	0.0003	0.0000	0.1511	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.6879	0.7080	0.0072	0.0000	0.3330	0.9998	0.0000	0.0000	0.0000	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	0.0000	0.0000	0.0000	0.0000
H_2O	0.1864	0.1627	0.9916	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.0747	0.0769	0.0000	0.0000	0.3973	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0223	0.0229	0.0000	0.0000	0.1186	0.0000	0.0000	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	0.0008	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	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	27,829	19,772	2,781	459	3,825	12,707	116,598	96,863	96,863	43,165	43,165	18,201	18,201	12,275	12,275	57,021	117,764
V-L Flowrate (kg/hr)	1,046,032	754,456	50,745	8,273	136,229	559,208	2,100,542	1,745,014	1,745,014	777,632	777,632	327,893	327,893	221,130	221,130	1,027,246	2,121,547
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	62	57	57	40	21	27	593	354	593	32	32	52	141	52	146	52	176
Pressure (MPa, abs)	0.10	0.10	0.10	0.10	0.10	15.31	24.23	4.90	4.52	0.00	0.00	1.65	1.63	1.65	1.64	1.65	0.91
Enthalpy (kJ/kg)[A]	281.42	244.53	147.09	65.32	17.25	-233.12	3,476.62	3,082.01	3,652.22	2,113.21	2,113.21	217.35	591.45	217.35	616.44	217.35	744.69
Density (kg/m^3)	1.3	1.3	60.4	979.4	1.5	685.0	69.2	18.7	11.6	0.0	0.0	988.0	926.1	988.0	920.8	988.0	891.1
V-L Molecular Weight	37.588	38.158	18.248	18.015	35.616	44.009	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	61,353	43,589	6,131	1,012	8,433	28,013	257,054	213,546	213,546	95,163	95,163	40,126	40,126	27,061	27,061	125,709	259,625
V-L Flowrate (lb/hr)	2,306,106	1,663,290	111,874	18,238	300,335	1,232,843	4,630,901	3,847,097	3,847,097	1,714,385	1,714,385	722,881	722,881	487,508	487,508	2,264,689	4,677,210
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	144	135	135	103	70	81	1,100	669	1,100	90	90	125	285	125	296	125	349
Pressure (psia)	13.8	13.8	13.8	14.7	15.0	2,220.0	3,514.7	710.8	655.8	0.7	0.7	240.0	237.1	240.0	238.5	240.0	132.7
Enthalpy (Btu/lb)[A]	121.0	105.1	63.2	28.1	7.4	-100.2	1,494.7	1,325.0	1,570.2	908.5	908.5	93.4	254.3	93.4	265.0	93.4	320.2
Density (lb/ft^3)	0.080	0.083	3.769	61.140	0.094	42.765	4.319	1.165	0.722	0.003	0.003	61.678	57.814	61.678	57.484	61.678	55.627

6.4.2 Plant Power Summary

Exhibit 6-21 Cases S12E, S12F, and L12F Plant Power Summary

100 Percent Load

Plant Output				
	Case S12E	**Case S12F**	**Case L12F**	
Steam Turbine Power	745,000	748,300	751,000	kW_e
Total	**745,000**	**748,300**	**751,000**	kW_e
Auxiliary Load				
Coal Handling and Conveying	570	570	690	kW_e
Pulverizers	4,750	4,770	6,370	kW_e
Sorbent Handling & Reagent Preparation	180	180	180	kW_e
Ash Handling	1,070	1,070	1,580	kW_e
Primary Air Fans	2,230	2,240	2,950	kW_e
Forced Draft Fans	820	880	330	kW_e
Induced Draft Fans	7,180	7,280	6,830	kW_e
Main Air Compressor	93,250	93,710	92,040	kW_e
ASU Auxiliaries	1,000	1,000	1,000	kW_e
Baghouse	150	150	220	kW_e
Spray Dryer FGD	2,890	2,910	3,330	kW_e
CPU	62,100	64,740	67,140	kW_e
Miscellaneous Balance of Plant[a,b]	2,000	2,000	2,000	kW_e
Steam Turbine Auxiliaries	400	400	400	kW_e
Condensate Pumps	990	990	1,000	kW_e
Circulating Water Pumps	3,270	3,280	3,300	kW_e
Ground Water Pumps	320	320	330	kW_e
Cooling Tower Fans	2,100	2,110	1,980	kW_e
Air Cooled Condenser Fans	6,880	6,910	6,480	kW_e
Transformer Losses	2,760	2,780	2,800	kW_e
Total	194,910	198,290	200,950	kW_e
Plant Performance				
Net Auxiliary Load	194,910	198,290	200,950	kW_e
Net Plant Power	550,090	550,010	550,050	kW_e
Net Exported Power Efficiency (HHV)	31.4%	31.2%	30.3%	
Net Plant Heat Rate (HHV)	11,474 (10,875)	11,532 (10,930)	11,893 (11,273)	kJ/kWhr (Btu/kWhr)
Coal Feed Flowrate	316,848 (698,531)	318,415 (701,985)	425,050 (937,075)	kg/hr (lb/hr)
Thermal Input[c,d]	1,753,215	1,761,883	1,817,225	kW_{th}
Condenser Duty	3,063 (2,903)	3,075 (2,914)	3,075 (2,914)	GJ/hr (MMBtu/hr)
Raw Water Withdrawal	13.5 (3,574)	13.6 (3,589)	13.6 (3,592)	m^3/min (gpm)

[a] Boiler feed pumps are turbine driven
[b] Includes plant control systems, lighting, HVAC, and miscellaneous low voltage loads
[c] HHV of as received Rosebud PRB coal is 19,920 kJ/kg (8,564 Btu/lb)
[d] HHV of as received ND Lignite coal is 15,391 kJ/kg (6,617 Btu/lb)

6.4.3 Energy Balance

An overall energy balance for the plant is shown in Exhibit 6-22.

Exhibit 6-22
Cases S12E, S12F, and L12F Overall Energy Balance

	HHV			Sensible + Latent			Power			Total		
	S12E	S12F	L12F	S12E	S12F	L12F	S12E	S12F	L12F	S12E	S12F	L12F
Heat In, GJ/hr (MMBtu/hr)												
Coal	6,312 (5,982)	6,343 (6,012)	6,542 (6,201)	3.2 (3.1)	3.3 (3.1)	3.8 (3.6)				6,315 (5,985)	6,346 (6,015)	6,546 (6,204)
Combustion Air				33.1 (31.4)	33.3 (31.5)	31.3 (29.7)				33.1 (31.4)	33.3 (31.5)	31.3 (29.7)
Raw Water Makeup				18.9 (17.9)	18.9 (17.9)	15.2 (14.4)				18.9 (17.9)	18.9 (17.9)	15.2 (14.4)
Lime				0.02 (0.02)	0.02 (0.02)	0.02 (0.02)				0.02 (0.02)	0.02 (0.02)	0.02 (0.02)
Auxiliary Power							702 (665)	714 (677)	723 (686)	702 (665)	714 (677)	723 (686)
Totals	**6,312 (5,992)**	**6,343 (6,012)**	**6,542 (6,201)**	**55.2 (52.3)**	**55.5 (52.6)**	**50.3 (47.7)**	**702 (665)**	**714 (677)**	**723 (686)**	**7,068 (6,700)**	**7,112 (6,741)**	**7,316 (6,934)**
Heat Out, GJ/hr (MMBtu/hr)												
Boiler Loss				56.1 (53.2)	56.4 (53.5)	56.7 (53.7)				51.6 (53.2)	56.4 (53.5)	56.7 (53.7)
Air Heater Loss				5.3 (5.0)	5.4 (5.1)	5.4 (5.1)				5.3 (5.0)	5.4 (5.1)	5.4 (5.1)
CO_2 Cooling Duty				227.7 (215.8)	227.4 (215.5)	239.2 (226.8)				227.7 (215.8)	227.4 (215.5)	239.2 (226.8)
DCC Cooling				389.2	392.4	609.7				389.2	392.4	609.7

	HHV			Sensible + Latent			Power			Total		
	S12E	S12F	L12F	S12E	S12F	L12F	S12E	S12F	L12F	S12E	S12F	L12F
Duty				(368.9)	(371.9)	(577.8)				(368.9)	(371.9)	(577.9)
SO_2 Polishing Scrubber Cooling Duty				151.2 (143.3)	151.9 (143.9)	150.5 (142.6)				151.2 (143.3)	151.9 (143.9)	150.5 (142.6)
ASU Cold Box Pre-Cooling				178.0 (168.7)	178.8 (169.5)	186.0 (176.3)				178.0 (168.7)	178.8 (169.5)	186.0 (176.3)
Bottom Ash				0.6 (0.6)	0.6 (0.6)	1.0 (0.9)				0.6 (0.6)	0.6 (0.6)	1.0 (0.9)
Fly Ash + FGD Ash				2.3 (2.2)	2.3 (2.2)	3.3 (3.1)				2.3 (2.2)	2.3 (2.2)	3.3 (3.1)
Knockout Water				27.0 (25.6)	27.2 (25.8)	39.0 (37.0)				27.0 (25.6)	27.2 (25.8)	39.0 (37.0)
CPU Vent				2 (2)	2 (2)	2 (2)				2 (2)	2 (2)	2 (2)
ASU Vent Stream				50 (47)	50 (47)	51 (49)				50 (47)	50 (47)	51 (49)
Condenser				3,063 (2,903)	3,075 (2,914)	3,075 (2,914)				3,063 (2,903)	3,075 (2,914)	3,075 (2,914)
CO_2				-121 (-114)	-124 (-117)	-130 (-124)				-121 (-114)	-124 (-117)	-130 (-124)
Cooling Tower Blowdown				15.7 (14.9)	15.8 (14.9)	15.3 (14.5)				15.7 (14.9)	15.8 (14.9)	15.3 (14.5)
Process Losses[a]				270.7 (256.6)	287.9 (272.9)	239.1 (226.6)				270.7 (256.2)	287.9 (272.9)	239.1 (226.6
ST Generator/Exhaust Losses							68 (65)	69 (65)	69 (65)	68 (65)	69 (65)	69 (65)

	HHV			Sensible + Latent			Power			Total		
	S12E	S12F	L12F	S12E	S12F	L12F	S12E	S12F	L12F	S12E	S12F	L12F
Power							2,682 (2,542)	2,694 (2,553)	2,704 (2,563)	2,682 (2,542)	2,694 (2,553)	2,704 (2,563)
Totals				**4,318 (4,093)**	**4,350 (4,123)**	**4,543 (4,306)**	**2,750 (2,607)**	**2,763 (2,318)**	**2,704 (2,628)**	**7,068 (6,700)**	**7,112 (6,741)**	**7,316 (6,934)**

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

6.4.4 Water Balance

An overall water balance for the plant is shown in Exhibit 6-23. Raw water 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 is re-used as internal recycle. The difference between demand and recycle is raw water withdrawal. The difference between water withdrawal and process water discharge is defined as water consumption, and can be represented by the portion of the raw water withdrawn that is evaporated, transpired, or incorporated into products or otherwise not returned to the water source from which it was withdrawn. Water consumption represents the net impact of the plant process on the water source balance.

Exhibit 6-23
Cases S12E, S12F, and L12F Water Balance

Water Use	Water Demand, m^3/min (gpm)			Internal Recycle, m^3/min (gpm)			Raw Water Withdrawl, m^3/min (gpm)		
	S12E	S12F	L12F	S12E	S12F	L12F	S12E	S12F	L12F
FGD Makeup	0.99 (262)	1.00 (265)	1.02 (269)	0.0 (0)	0.0 (0)	0.0 (0)	0.99 (262)	0.97 (256)	1.02 (269)
BFW Makeup	0.35 (92)	0.35 (92)	0.35 (93)	0.0 (0)	0.0 (0)	0.0 (0)	0.35 (92)	0.35 (93)	0.35 (93)
Cooling Tower Makeup	12.54 (3,312)	12.58 (3,324)	12.58 (3,323)	0.35 (92)	0.35 (92)	0.35 (93)	12.19 (3,220)	16.18 (4274)	12.23 (3,231)
Total	**13.9 (3,665)**	**13.9 (3,681)**	**13.9 (3,685)**	**0.35 (92)**	**0.35 (92)**	**0.35 (93)**	**13.5 (3,574)**	**17.5 (4,623)**	**13.6 (3,592)**

Exhibit 6-23 (Continued)

Water Use	ProcessWater Discharge, m^3/min (gpm)			Raw Water Consumption, m^3/min (gpm)		
	S12E	S12F	L12F	S12E	S12F	L12F
FGD Makeup	0.00 (0.00)	0.00 (0)	0.00 (0.00)	0.96 (255)	0.97 (256)	0.99 (260.83)
BFW Makeup	0.00 (0.00)	0.00 (0)	0.00 (0.00)	0.35 (92)	0.35 (93)	0.36 (93.80)
Cooling Tower Makeup	4.59 (1213.77)	4.61 (1217)	4.93 (1302.59)	12.41 (3278)	11.57 (3057)	12.16 (3213.57)
Total	**4.59 (1213.77)**	**4.61 (1217)**	**4.93 (1302.59)**	**13.72 (3625)**	**12.89 (3406)**	**13.51 (3568.20)**

6.4.5 Carbon Balance

The carbon balances for the three oxycombustion PC cases with CO_2 purification are shown in Exhibit 6-24. The carbon input to the plant consists of carbon in the air entering the ASU and the infiltration air entering the boiler in addition to carbon in the coal. The carbon entering the ASU is removed before entering the boiler island. Carbon leaves the plant as CO_2 product or is vented to the atmosphere. The percent of total carbon sequestered is defined as the amount of carbon product produced (as sequestration-ready CO_2) divided by the carbon in the coal feedstock, expressed as a percentage.

% Captured = Carbon in Product for Sequestration / Carbon in the Coal

or

317,847/349,741*100 = 90.9% (S12E)

318,996/351,471*100 = 90.8% (S12F)

336,398/370,648*100 = 90.8% (L12F)

Exhibit 6-24
Cases S12E, S12F, and L12F Carbon Balance

Carbon In, kg/hr (lb/hr)				Carbon Out, kg/hr (lb/hr)			
	S12E	**S12F**	**L12F**		**S12E**	**S12F**	**L12F**
Coal	158,640 (349,741)	159,424 (351,471)	168,123 (370,648)	**ASU Vent**	290 (640)	292 (643)	305 (672)
Air (CO_2)	296 (652)	297 (655)	311 (685)	**CPU Vent**	14,243 (31,401)	14,506 (31,980)	15,297 (33,725)
				CO_2 Product	144,173 (317,847)	144,694 (318,996)	152,587 (336,398)
				SO_2 Scrubber	228 (502)	229 (504)	241 (532)
				DCC Discharge	1 (3)	1 (3)	2 (5)
				Convergence Tolerance[a]	0 (1)	0 (-1)	1 (1)
Total	158,936 (350,393)	159,722 (352,126)	168,434 (371,333)	**Total**	158,936 (350,393)	159,722 (352,126)	168,434 (371,333)

[a] By difference

6.4.6 Sulfur Balance

Exhibit 6-25 shows the sulfur balances for the three oxycombustion PC cases with CO_2 purification. Sulfur input comes solely from the sulfur in the coal. Sulfur output is the sulfur combined with lime in the ash, sulfur discharge from the DCC and polishing scrubber, and the sulfur sequestered in the CO_2 product stream. The total sulfur capture is represented by the following fraction:

(Sulfur in Ash + Sulfur co-sequestered + Sulfur in waste discharge streams)/Sulfur in the coal)

or

(4,954 + 128 + 0)/5,081*100 = 100% (S12E)

(4,979 + 127 + 0)/5,107*100 = 100% (S12F)

(5,711 + 158 + 0)/5,870*100 = 100% (L12F)

Exhibit 6-25
Cases S12E, S12F, and L12F Sulfur Balance

Sulfur In, kg/hr (lb/hr)				Sulfur Out, kg/hr (lb/hr)			
	S12E	**S12F**	**L12F**		**S12E**	**S12F**	**L12F**
Coal	2,305 (5,081)	2,316 (5,107)	2,663 (5,870)	**Ash**	2,247 (4,954)	2,259 (4,979)	2,591 (5,711)
				SO_2 Scrubber	58 (128)	58 (127)	72 (158)
				CPU Vent	0 (0)	0 (0)	0 (0)
				CO_2 Product	0 (0)	0 (0)	0 (0)
				DCC Discharge	0 (0)	0 (0)	0(0)
				Convergence Tolerance[a]	0 (0)	0 (0)	0 (0)
Total	2,305 (5,081)	2,316 (5,107)	2,663 (5,870)	**Total**	2,305 (5,081)	2,316 (5,107)	2,663 (5,870)

[a] by difference

6.4.7 Air Emissions

Estimated air emissions for cases S12E, S12F, and L12F are shown in Exhibit 6-26. All particulates are assumed to be removed from the process stream after the baghouse by either the direct contact cooler or the SO_2 polishing scrubber, with no particulate matter being vented to the atmosphere. Mercury was assumed to be absorbed in the desiccant dryer, removed with the condensed water in CO_2 compression train, and co-sequestered with the CO_2 product stream. Eighty percent of the NO_x generated in the boiler is assumed to be vented from the CPU, with the remaining NO_x, in the form of NO_2, co-sequestered. SO_2 emissions are controlled using the lime spray dryer FGD and the SO_2 polishing scrubber. Any remaining SO_2 was assumed to be co-sequestered.

Exhibit 6-26
Cases S12E, S12F, and L12F Estimated Air Emissions

	kg/GJ ($lb/10^6$ Btu)			Tonne/year (ton/year) 85% capacity factor			kg/MWh (lb/MWh)		
	S12E	S12F	L12F	S12E	S12F	L12F	S12E	S12F	L12F
SO_2	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0 (0)	0 (0)	0 (0)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
NO_X	0.024 (0.056)	0.024 (0.056)	0.024 (0.056)	1,131 (1,247)	1,137 (1,253)	1,173 (1,293)	0.204 (0.450)	0.204 (0.450)	0.210 (0.462)
Particulates	0.000 (0.000)	0.0000 (0.000)	0.000 (0.000)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Hg	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
CO_2	8.3 (19.2)	8.4 (19.5)	8.6 (19.9)	388,596 (428,353)	395,767 (436,258)	4217,357 (460,057)	70 (154)	71 (157)	75 (165)
CO_2[a]							97 (215)	99 (219)	105 (231)

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

6.4.8 Heat and Mass Balance Diagrams

Heat and mass balance diagrams are shown for the following subsystems in Exhibit 6-27 through Exhibit 6-32:

- Boiler and gas cleanup system
- Power block system

Exhibit 6-27 Case S12E Boiler and Gas Cleanup System Heat and Mass Balance Diagram

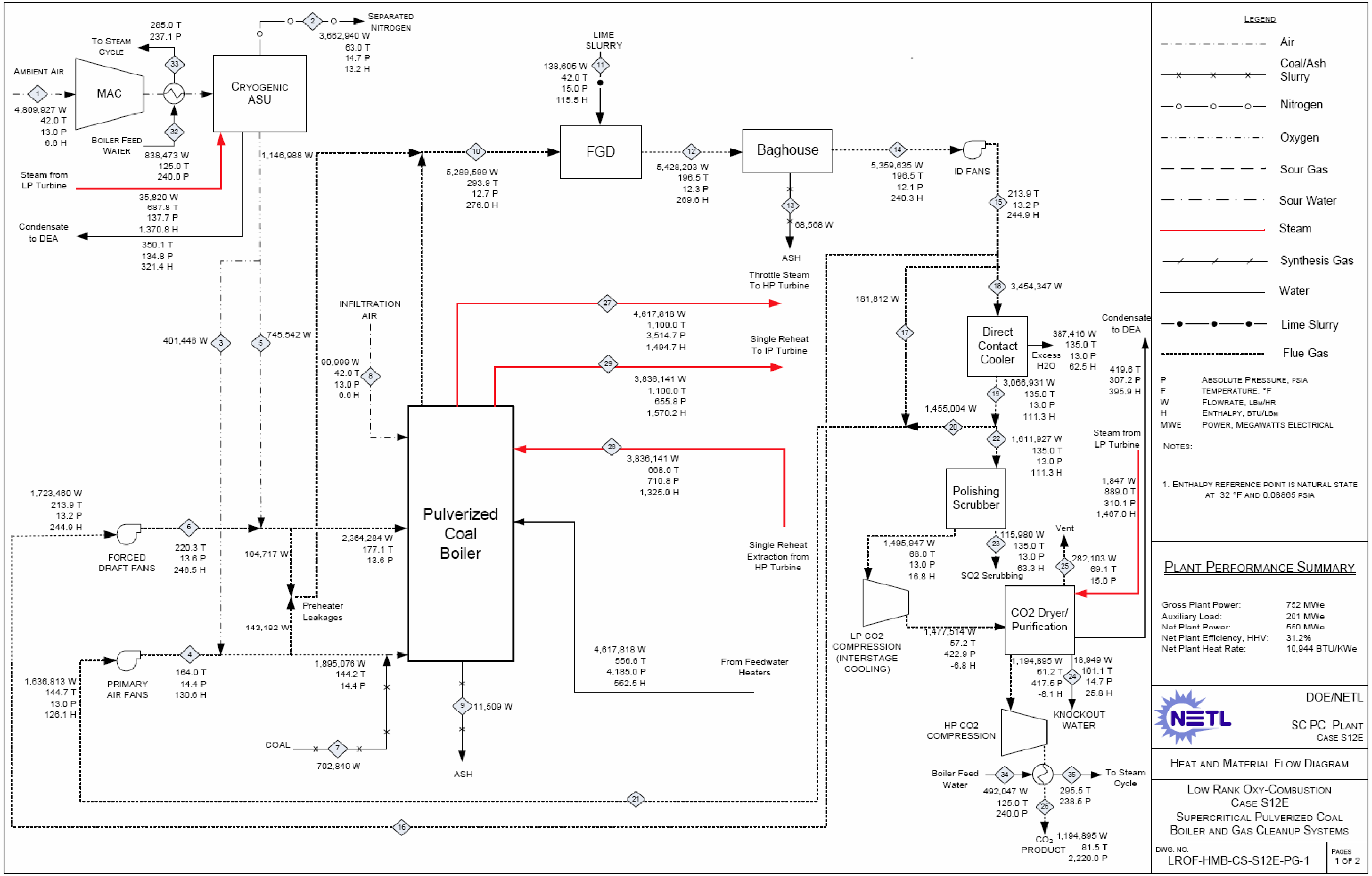


Exhibit 6-28 Case S12E Power Block System Heat and Mass Balance Diagram

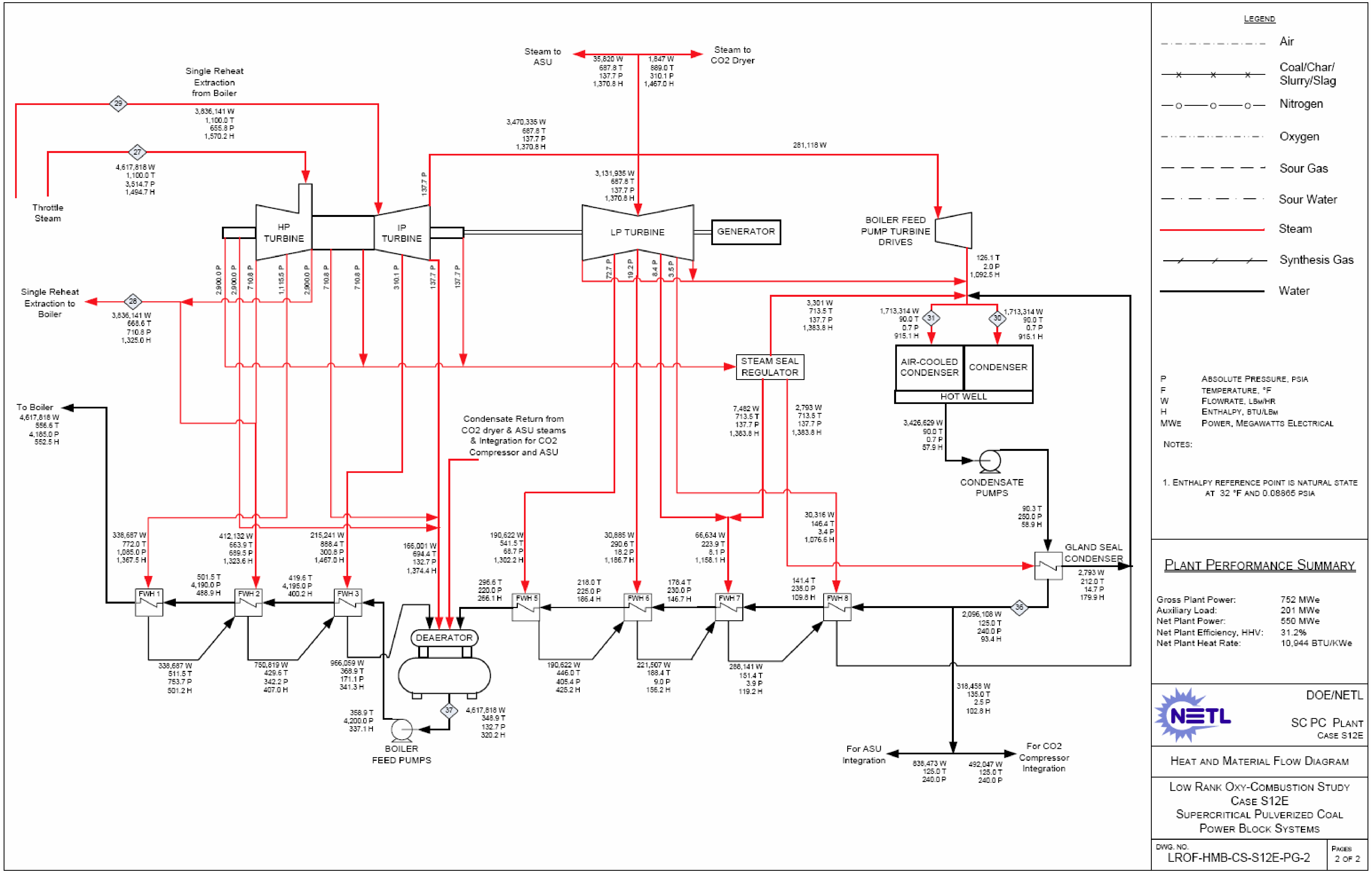


Exhibit 6-29 Case S12F Boiler and Gas Cleanup System Heat and Mass Balance Diagram

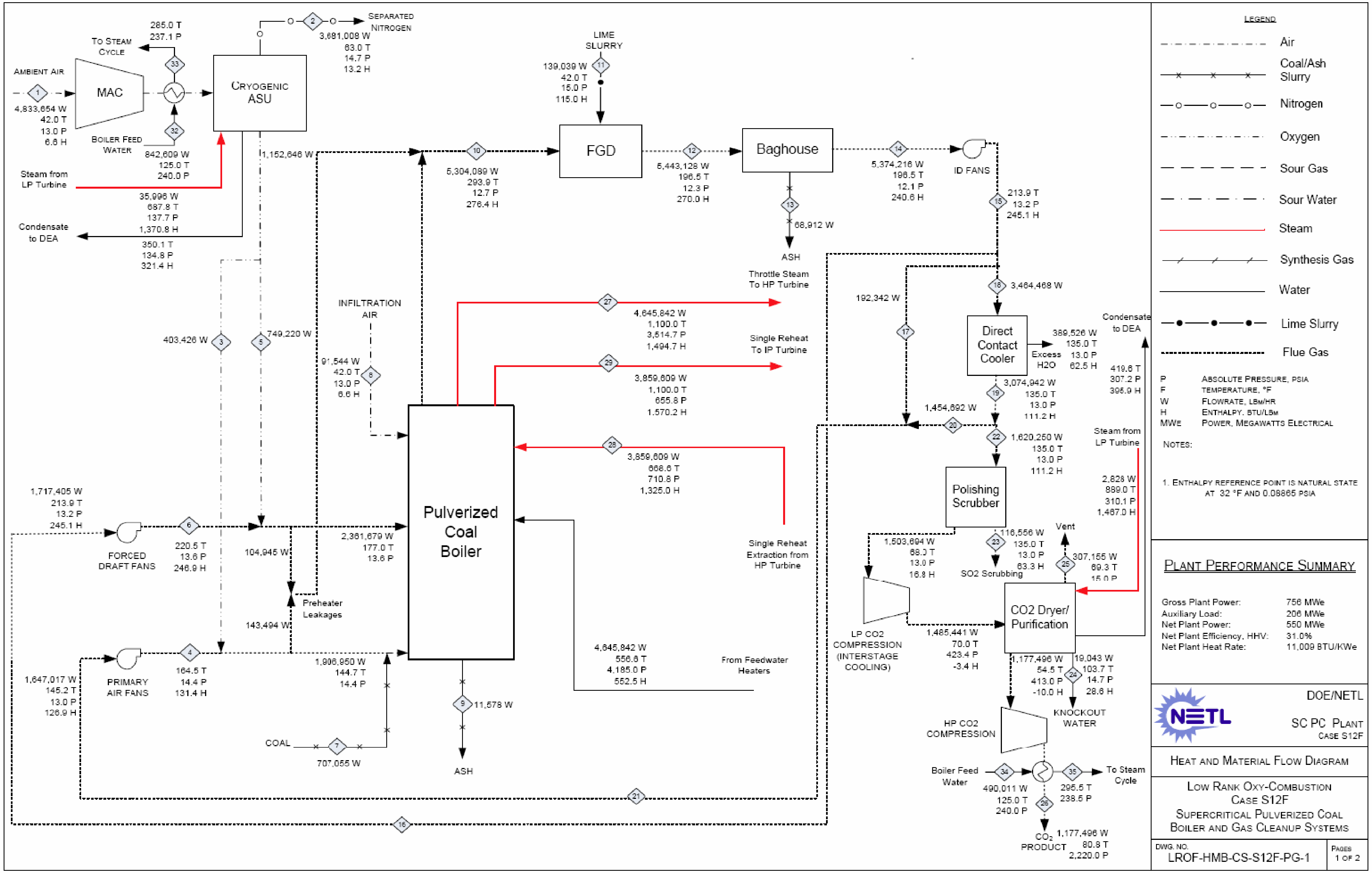


Exhibit 6-30 Case S12F Power Block System Heat and Mass Balance Diagram

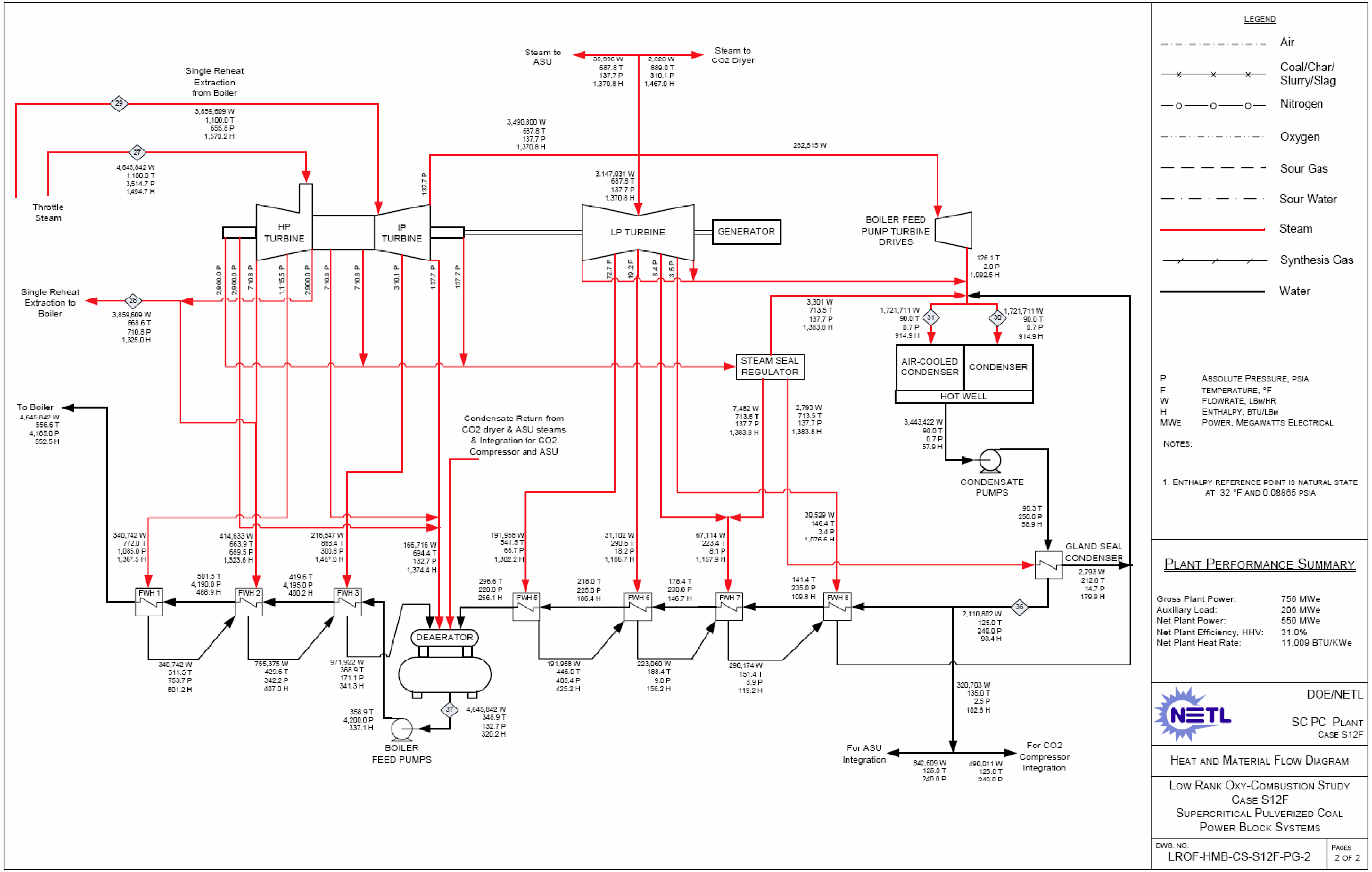


Exhibit 6-31 Case L12F Boiler and Gas Cleanup System Heat and Mass Balance Diagram

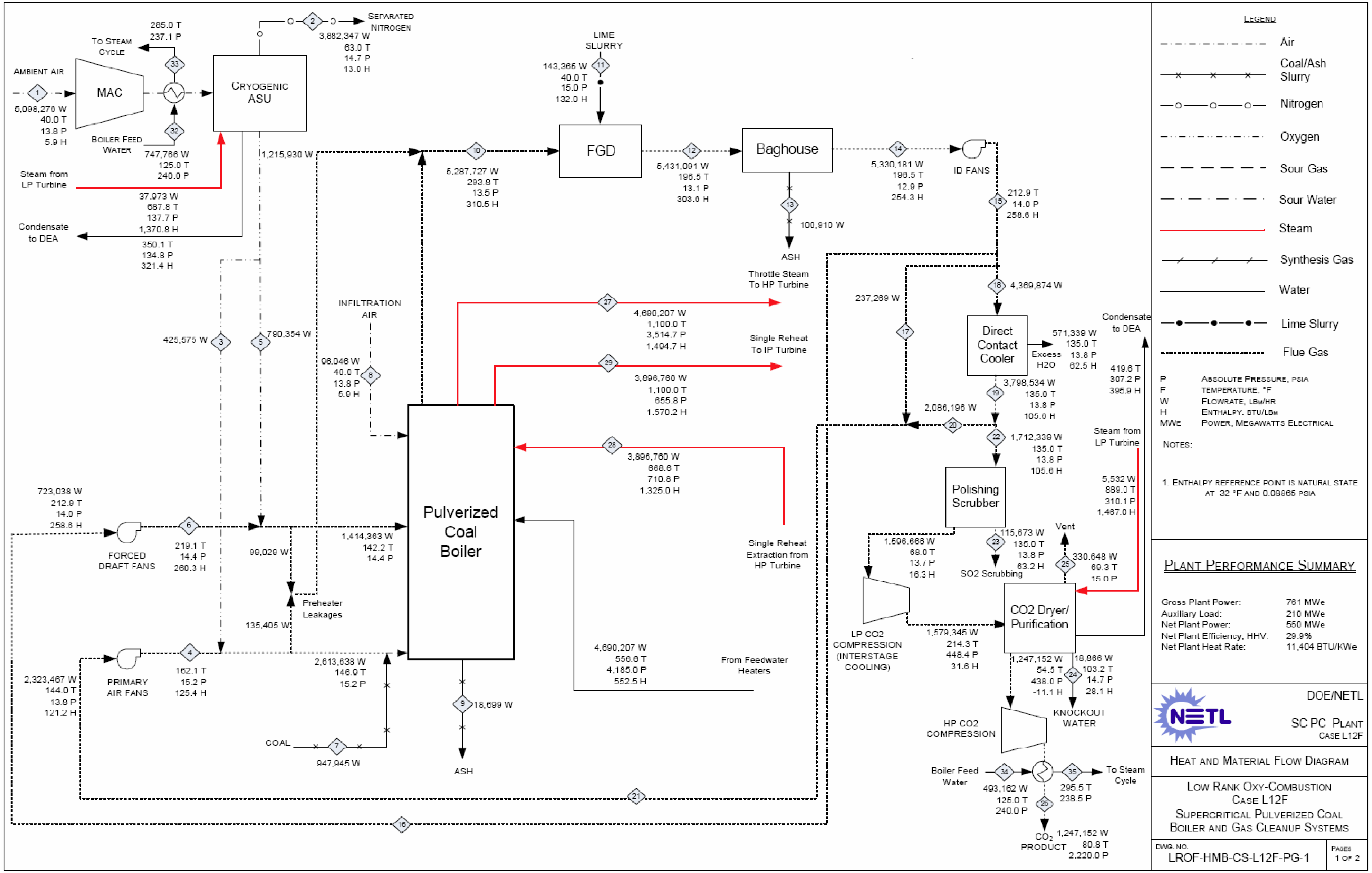
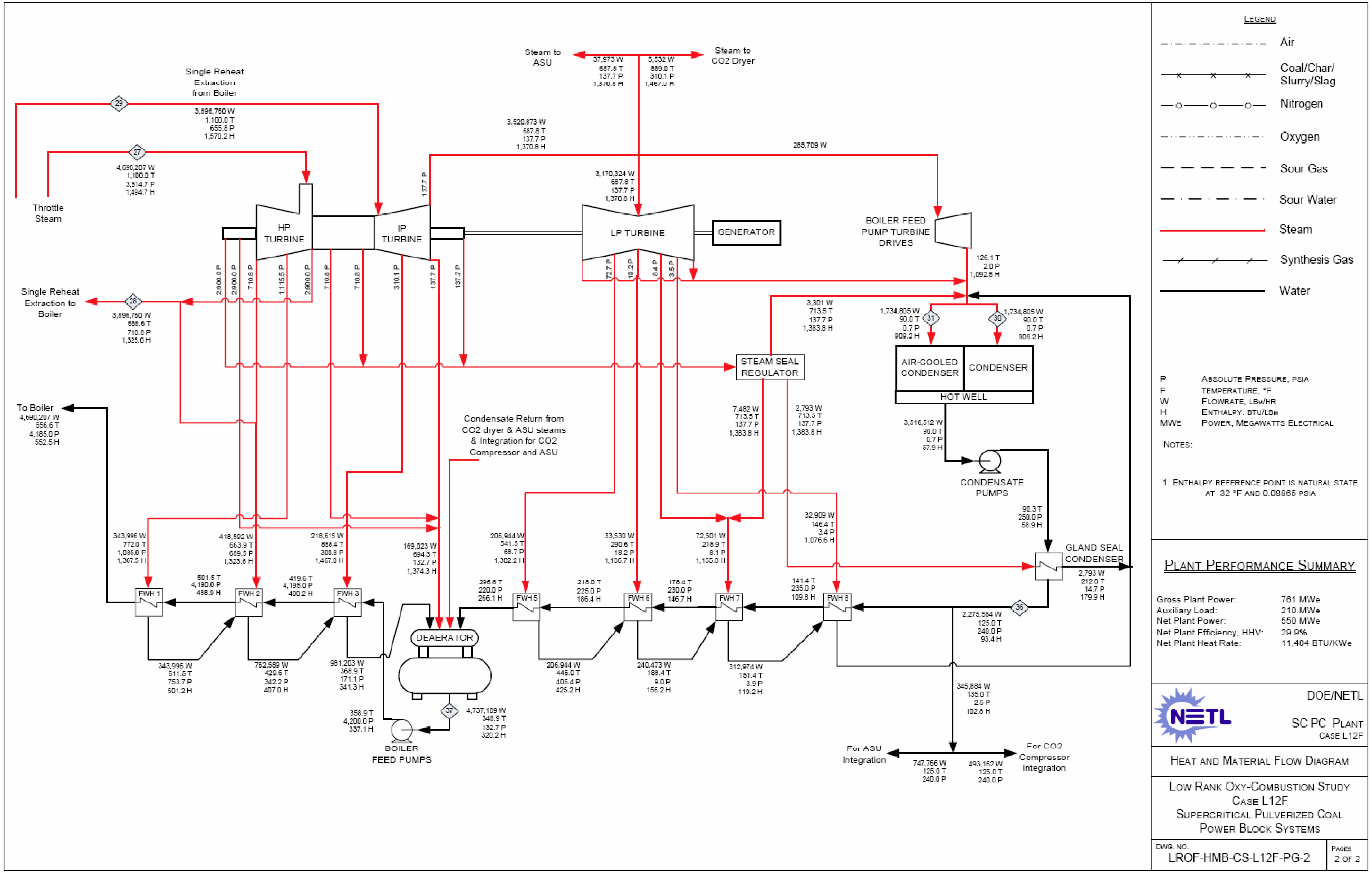


Exhibit 6-32 Case L12F Power Block System Heat and Mass Balance Diagram



6.4.9 Major Equipment List for Cases S12E, S12F, and L12F

Major equipment items for these cases are shown in the following tables. The accounts used in the equipment list correspond to the account numbers used in the cost estimates in Section 6.5. 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	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
1	Bottom Trestle Dumper and Receiving Hoppers	N/A	181 tonne (200 ton)	181 tonne (200 ton)	2(0)
2	Feeder	Belt	572 tonne/hr (630 tph)	572 tonne/hr (630 tph)	2(0)
3	Conveyor No. 1	Belt	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1(0)
4	Transfer Tower No. 1	Enclosed	N/A	N/A	1(0)
5	Conveyor No. 2	Belt	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1(0)
6	As-Received Coal Sampling System	Two-stage	N/A	N/A	1(0)
7	Stacker/Reclaimer	Traveling, linear	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1(0)
8	Reclaim Hopper	N/A	64 tonne (70 ton)	91 tonne (100 ton)	2(1)
9	Feeder	Vibratory	263 tonne/hr (290 tph)	354 tonne/hr (390 tph)	2(1)
10	Conveyor No. 3	Belt w/ tripper	526 tonne/hr (580 tph)	708 tonne/hr (780 tph)	1(0)
11	Crusher Tower	N/A	N/A	N/A	2(0)
12	Coal Surge Bin w/ Vent Filter	Dual outlet	263 tonne (290 ton)	354 tonne (390 ton)	2(0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
13	Crusher	Impactor reduction	8 cm x 0 - 3 cm x 0 (3" x 0 - 1-1/4" x 0)	8 cm x 0 - 3 cm x 0 (3" x 0 - 1-1/4" x 0)	1(0)
14	As-Fired Coal Sampling System	Swing hammer	N/A	N/A	1(0)
15	Conveyor No. 4	Belt w/tripper	526 tonne/hr (580 tph)	708 tonne/hr (780 tph)	1(0)
16	Transfer Tower No. 2	Enclosed	N/A	N/A	1(0)
17	Conveyor No. 5	Belt w/ tripper	526 tonne/hr (580 tph)	708 tonne/hr (780 tph)	1(0)
18	Coal Silo w/ Vent Filter and Slide Gates	Field erected	544 tonne (600 ton)	816 tonne (900 ton)	2(1)
19	Lime Truck Unloading System	N/A	18 tonne/hr (20 tph)	27 tonne/hr (30 tph)	2(1)
20	Lime Bulk Storage Silo w/Vent Filter	Field erected	635 tonne (700 ton)	726 tonne (800 ton)	1(0)
21	Lime Live Storage Transport	Pneumatic	8 tonne/hr (9 tph)	10 tonne/hr (11 tph)	1(0)
22	Lime Day Bin	w/ actuator	64 tonne (70 ton)	82 tonne (90 ton)	2(0)
23	Activated Carbon Storage Silo and Feeder System with Vent Filter	Shop assembled	#N/A	#N/A	2(0)

ACCOUNT 2 COAL AND SORBENT PREPARATION AND FEED

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
1	Coal Feeder	Gravimetric	54 tonne/hr (60 tph)	82 tonne/hr (90 tph)	6(0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
2	Coal Pulverizer	Ball type or equivalent	54 tonne/hr (60 tph)	82 tonne/hr (90 tph)	6(0)
3	Lime Slaker	N/A	7 tonne/hr (8 tph)	9 tonne/hr (10 tph)	1(1)
4	Lime Slurry Tank	Field Erected	355,831 liters (94,000 gal)	412,613 liters (109,000 gal)	1(1)
5	Lime Slurry Feed Pumps	Horizontal centrifugal	379 lpm @ 9m H_2O (100 gpm @ 30 ft H_2O)	416 lpm @ 9m H_2O (110 gpm @ 30 ft H_2O)	1(1)

ACCOUNT 3 FEEDWATER AND MISCELLANEOUS SYSTEMS AND EQUIPMENT

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
1	Demineralized Water Storage Tank	Vertical, cylindrical, outdoor	1,385,461 liters (366,000 gal)	1,404,388 liters (371,000 gal)	2(0)
2	Condensate Pumps	Vertical canned	28,769 lpm @ 213 m H_2O (7,600 gpm @ 700 ft H_2O)	29,526 lpm @ 213 m H_2O (7,800 gpm @ 700 ft H_2O)	1(1)
3	Deaerator and Storage Tank	Horizontal spray type	2,304,249 kg/hr (5,080,000 lb/hr), 5 min. tank	2,340,083 kg/hr (5,159,000 lb/hr), 5 min. tank	1(0)
4	Boiler Feed Pump/Turbine	Barrel type, multi-stage, centrifugal	38,611 lpm @ 3,475 m H_2O (10,200 gpm @ 11,400 ft H_2O)	39,368 lpm @ 3,475 m H_2O (10,400 gpm @ 11,400 ft H_2O)	1(1)
5	Startup Boiler Feed Pump, Electric Motor Driven	Barrel type, multi-stage, centrifugal	11,356 lpm @ 3,475 m H_2O (3,000 gpm @ 11,400 ft H_2O)	11,735 lpm @ 3,475 m H_2O (3,100 gpm @ 11,400 ft H_2O)	1(0)
6	LP Feedwater Heater 1A/1B	Horizontal U-tube	852,754 kg/hr (1,880,000 lb/hr)	875,433 kg/hr (1,930,000 lb/hr)	2(0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
7	LP Feedwater Heater 2A/2B	Horizontal U-tube	852,754 kg/hr (1,880,000 lb/hr)	875,433 kg/hr (1,930,000 lb/hr)	2(0)
8	LP Feedwater Heater 3A/3B	Horizontal U-tube	852,754 kg/hr (1,880,000 lb/hr)	875,433 kg/hr (1,930,000 lb/hr)	2(0)
9	LP Feedwater Heater 4A/4B	Horizontal U-tube	852,754 kg/hr (1,880,000 lb/hr)	875,433 kg/hr (1,930,000 lb/hr)	2(0)
10	HP Feedwater Heater 6	Horizontal U-tube	2,304,249 kg/hr (5,080,000 lb/hr)	2,340,537 kg/hr (5,160,000 lb/hr)	1(0)
11	HP Feedwater Heater 7	Horizontal U-tube	2,304,249 kg/hr (5,080,000 lb/hr)	2,340,537 kg/hr (5,160,000 lb/hr)	1(0)
12	HP Feedwater heater 8	Horizontal U-tube	2,304,249 kg/hr (5,080,000 lb/hr)	2,340,537 kg/hr (5,160,000 lb/hr)	1(0)
13	Auxiliary Boiler	Shop fabricated, water tube	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)	1(0)
14	Fuel Oil System	No. 2 fuel oil for light off	1,135,624 liter (300,000 gal)	1,135,624 liter (300,000 gal)	1(0)
15	Service Air Compressors	Flooded Screw	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	2(1)
16	Instrument Air Dryers	Duplex, regenerative	28 m^3/min (1,000 scfm)	28 m^3/min (1,000 scfm)	2(1)
17	Closed Cycle Cooling Heat Exchangers	Shell and tube	53 GJ/hr (50 MMBtu/hr) each	53 GJ/hr (50 MMBtu/hr) each	2(0)
18	Closed Cycle Cooling Water Pumps	Horizontal centrifugal	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)	2(1)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
19	Engine-Driven Fire Pump	Vertical turbine, diesel engine	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)	1(1)
20	Fire Service Booster Pump	Two-stage horizontal centrifugal	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)	1(1)
21	Raw Water Pumps	Stainless steel, single suction	5,754 lpm @ 18 m H_2O (1,520 gpm @ 60 ft H_2O)	6,170 lpm @ 18 m H_2O (1,630 gpm @ 60 ft H_2O)	2(1)
22	Ground Water Pumps	Stainless steel, single suction	2,877 lpm @ 268 m H_2O (760 gpm @ 880 ft H_2O)	3,066 lpm @ 268 m H_2O (810 gpm @ 880 ft H_2O)	4(1)
23	Filtered Water Pumps	Stainless steel, single suction	454 lpm @ 49 m H_2O (120 gpm @ 160 ft H_2O)	454 lpm @ 49 m H_2O (120 gpm @ 160 ft H_2O)	2(1)
24	Filtered Water Tank	Vertical, cylindrical	439,108 liter (116,000 gal)	439,108 liter (116,000 gal)	1(0)
25	Makeup Water Demineralizer	Multi-media filter, cartridge filter, RO membrane assembly, electrodeionization unit	908 lpm (240 gpm)	946 lpm (250 gpm)	1(1)
26	Liquid Waste Treatment System	--	10 years, 24-hour storm	10 years, 24-hour storm	1(0)

ACCOUNT 4 BOILER AND ACCESSORIES

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
1	Boiler	Supercritical, drum, wall-fired, low NOx burners, overfire air	2,304,249 kg/hr steam @ 25.5 MPa/602°C/602°C (5,080,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)	2,340,537 kg/hr steam @ 25.5 MPa/602°C/602°C (5,160,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)	1(0)
2	Primary Air Fan	Centrifugal	#N/A	#N/A	2(0)
3	Forced Draft Fan	Centrifugal	#N/A	#N/A	2(0)
4	Induced Draft Fan	Centrifugal	#N/A	#N/A	2(0)
5	SCR Reactor Vessel	Space for spare layer	2,676,195 kg/hr (5,900,000 lb/hr)	2,658,051 kg/hr (5,860,000 lb/hr)	2(0)
6	SCR Catalyst	--	--	--	3(0)
7	Dilution Air Blower	Centrifugal	51 m^3/min @ 108 cm WG (1,800 acfm @ 42 in. WG)	54 m^3/min @ 108 cm WG (1,900 acfm @ 42 in. WG)	2(1)
8	Ammonia Storage	Horizontal tank	56,781 liter (15,000 gal)	56,781 liter (15,000 gal)	5(0)
9	Ammonia Feed Pump	Centrifugal	11 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)	11 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)	2(1)
10	ASU Main Air Compressor	Centrifugal, multi-stage	16,395 m^3/min @ 0.3 MPa (579,000 scfm @ 46 psia)	17,387 m^3/min @ 0.3 MPa (614,000 scfm @ 46 psia)	2(0)

ACCOUNT 5 FLUE GAS CLEANUP

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
1	Fabric Filter	Single stage, high-ratio with pulse-jet online cleaning system, air-to-cloth ratio - 3.5 ft/min	#N/A	#N/A	2(0)
2	Spray Dryer	Co-current open spray	25,202 m^3/min (890,000 acfm)	23,871 m^3/min (843,000 acfm)	2(0)
3	Atomizer	Rotary	189 lpm @ 64 m H_2O (50 gpm @ 210 ft H_2O)	227 lpm @ 64 m H_2O (60 gpm @ 210 ft H_2O)	2(1)
4	Spray Dryer Solids Conveying	---	---	---	2(0)
5	Carbon Injectors	---	#N/A	#N/A	1(0)

ACCOUNT 7 DUCTING AND STACK

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
1	Stack	Reinforced concrete with FRP liner	#N/A	#N/A	1 (0)

ACCOUNT 8 STEAM TURBINE GENERATOR

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
1	Steam Turbine	Commercially available	791 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)	801 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)	1(0)
2	Steam Turbine Generator	Hydrogen cooled, static excitation	880 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	890 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	1(0)
3	Surface Condenser	Single pass, divided waterbox including vacuum pumps	1,710 GJ/hr (1,620 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 9°C (48°F), Water temperature rise 11°C (20°F)	1,710 GJ/hr (1,620 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 8°C (47°F), Water temperature rise 11°C (20°F)	1(0)
4	Air-cooled Condenser	---	1,710 GJ/hr (1,620 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 6°C (42°F)	1,710 GJ/hr (1,620 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 4°C (40°F)	1(0)

ACCOUNT 9 COOLING WATER SYSTEM

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
1	Circulating Water Pumps	Vertical, wet pit	526,200 lpm @ 30 m (139,000 gpm @ 100 ft)	564,000 lpm @ 30 m (149,000 gpm @ 100 ft)	2(1)
2	Cooling Tower	Evaporative, mechanical draft, multi-cell	3°C (37°F) wet bulb / 9°C (48°F) CWT / 20°C (68°F) HWT / 2933 GJ/hr (2780 MMBtu/hr) heat duty	2°C (36°F) wet bulb / 8°C (47°F) CWT / 19°C (67°F) HWT / 3155 GJ/hr (2990 MMBtu/hr) heat duty	1(0)

ACCOUNT 10 ASH/SPENT SORBENT RECOVERY AND HANDLING

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
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	--	5.4 tonne/hr (6 tph)	9.1 tonne/hr (10 tph)	1(1)
4	Pyrites Hopper (part of pulverizer scope of supply included with boiler)	--	--	--	6(0)
5	Hydroejectors	--	--	--	12()

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
6	Economizer /Pyrites Transfer Tank	--	--	--	1(0)
7	Ash Sluice Pumps	Vertical, wet pit	227 lpm @ 17 m H_2O (60 gpm @ 56 ft H_2O)	379 lpm @ 17 m H_2O (100 gpm @ 56 ft H_2O)	1(1)
8	Ash Seal Water Pumps	Vertical, wet pit	7,571 lpm @ 9 m H_2O (2000 gpm @ 28 ft H_2O)	7,571 lpm @ 9 m H_2O (2000 gpm @ 28 ft H_2O)	1(1)
9	Hydrobins	--	227 lpm (60 gpm)	379 lpm (100 gpm)	1(1)
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	--	31 m^3/min @ 0.2 MPa (1100 scfm @ 24 psi)	46 m^3/min @ 0.2 MPa (1630 scfm @ 24 psi)	1(1)
13	Fly Ash Silo	Reinforced concrete	2,090 tonne (2,300 ton)	2,990 tonne (3,300 ton)	2(0)
14	Slide Gate Valves	--	--	--	2(0)
15	Unloader	--	--	--	1(0)
16	Telescoping Unloading Chute	--	191 tonne/hr (210 tph)	281 tonne/hr (310 tph)	1(0)
17	Recycle Waste Storage Silo	Reinforced concrete	272 tonne (300 ton)	272 tonne (300 ton)	2(0)
18	Recycle Waste Conveyor	--	36 tonne/hr (40 tph)	36 tonne/hr (40 tph)	1(0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
19	Recycle Slurry Mixer	--	908 lpm (240 gpm)	871 lpm (230 gpm)	1(1)
20	Recycle Waste Slurry Tank	--	53,000 liters (14,000 gal)	53,000 liters (14,000 gal)	1(0)
21	Recycle Waste Pump	--	908 lpm (240 gpm)	871 lpm (230 gpm)	1(1)

ACCOUNT 11 ACCESSORY ELECTRIC PLANT

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
1	STG Transformer	Oil-filled	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	1(0)
2	Auxiliary Transformer	Oil-filled	24 kV/4.16 kV, 221 MVA, 3-ph, 60 Hz	24 kV/4.16 kV, 250 MVA, 3-ph, 60 Hz	1(1)
3	Low Voltage Transformer	Dry ventilated	4.16 kV/480 V, 33 MVA, 3-ph, 60 Hz	4.16 kV/480 V, 37 MVA, 3-ph, 60 Hz	1(1)
4	STG Isolated Phase Bus Duct and Tap Bus	Aluminum, self-cooled	24 kV, 3-ph, 60 Hz	24 kV, 3-ph, 60 Hz	1(0)
5	Medium Voltage Switchgear	Metal clad	4.16 kV, 3-ph, 60 Hz	4.16 kV, 3-ph, 60 Hz	1(1)
6	Low Voltage Switchgear	Metal enclosed	480 V, 3-ph, 60 Hz	480 V, 3-ph, 60 Hz	1(1)
7	Emergency Diesel Generator	Sized for emergency shutdown	750 kW, 480 V, 3-ph, 60 Hz	750 kW, 480 V, 3-ph, 60 Hz	1(0)

ACCOUNT 12 INSTRUMENTATION AND CONTROL

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12E	Case S12F & Case L12F	
1	DCS - Main Control	Monitor/keyboard; Operator printer (laser color); Engineering printer (laser B&W)	Operator stations/printers and engineering stations/printers	Operator stations/printers and engineering stations/printers	1(0)
2	DCS - Processor	Microprocessor with redundant input/output	N/A	N/A	1(0)
3	DCS - Data Highway	Fiber optic	Fully redundant, 25% spare	Fully redundant, 25% spare	1(0)

6.5 ECONOMIC ANALYSIS FOR SUPERCRITICAL OXYCOMBUSTION CASES

Capital and operating costs for the five SC oxycombustion cases are presented in Section 6.5.1. A cost and performance summary table for all five cases is given in Section 6.5.2 and additional cost detail sheets for all cases are shown in Exhibit 6-33 through Exhibit 6-36.

6.5.1 Cost Results for Cases S12C, S12D, S12E, S12F, and L12F

Capital and operating cost estimating methodology is explained in Section 2.7. The capital and operating costs for these cases are shown in the following exhibits:

The total plant cost summary organized by cost account, detailed breakdown of capital costs, and initial and annual O&M costs for case S12C is shown in Exhibit 6-33 and Exhibit 6-34 respectively.

The detailed breakdown for case S12D is shown in Exhibit 6-35 through 6-38. The detailed breakdown for case S12E is shown in Exhibit 6-37 through 6-41. The detailed breakdown for case S12F is shown in Exhibit 6-39 through 6-44. The detailed breakdown for case L12F is shown in Exhibit 6-41 through 6-47.

Exhibit 6-33 Case S12C Total Plant Costs

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12C - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.02 MW, net   Capital Charge Factor 0.175   Capacity Factor 0.85

Cost Base: June 2007
Prepared: 16-Mar-10
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
	SUBTOTAL 1.	**$18,014**	**$5,756**	**$10,000**	**$0**	**$33,770**		**$3,036**		**$0**		**$5,521**	**$42,327**	**$77**
2	COAL PREP & FEED SYSTEMS													
	SUBTOTAL 2.	**$9,860**	**$784**	**$2,746**	**$0**	**$13,390**		**$1,177**		**$0**		**$2,185**	**$16,752**	**$30**
3	FEEDWATER & MISC. BOP SYSTEMS													
	SUBTOTAL 3.	**$44,801**	**$0**	**$21,199**	**$0**	**$66,001**		**$6,000**		**$0**		**$11,353**	**$83,354**	**$152**
4	PC BOILER & ACCESSORIES													
	SUBTOTAL 4.	**$390,355**	**$0**	**$245,667**	**$0**	**$636,022**		**$32,295**		**$49,827**		**$71,814**	**$789,959**	**$1,436**
5A	FLUE GAS CLEANUP													
	SUBTOTAL 5A.	**$37,106**	**$0**	**$16,793**	**$0**	**$53,899**		**$2,938**		**$0**		**$5,684**	**$62,521**	**$114**
5B	CO2 REMOVAL & COMPRESSION													
	SUBTOTAL 5B.	**$56,475**	**$0**	**$40,896**	**$0**	**$97,371**		**$9,312**		**$0**		**$21,337**	**$128,020**	**$233**
6	COMBUSTION TURBINE/ACCESSORIES													
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
	SUBTOTAL 7.	**$11,294**	**$0**	**$7,203**	**$0**	**$18,498**		**$1,626**		**$0**		**$2,938**	**$23,062**	**$42**
8	STEAM TURBINE GENERATOR													
	SUBTOTAL 8.	**$93,917**	**$1,359**	**$26,689**	**$0**	**$121,965**		**$11,255**		**$0**		**$15,704**	**$148,924**	**$271**
9	COOLING WATER SYSTEM													
	SUBTOTAL 9.	**$10,974**	**$7,134**	**$12,111**	**$0**	**$30,219**		**$2,841**		**$0**		**$4,641**	**$37,701**	**$69**
10	ASH/SPENT SORBENT HANDLING SYS													
	SUBTOTAL 10.	**$5,446**	**$173**	**$7,282**	**$0**	**$12,901**		**$1,240**		**$0**		**$1,455**	**$15,597**	**$28**
11	ACCESSORY ELECTRIC PLANT													
	SUBTOTAL 11.	**$16,944**	**$14,313**	**$39,944**	**$0**	**$71,200**		**$6,479**		**$0**		**$10,236**	**$87,915**	**$160**
12	INSTRUMENTATION & CONTROL													
	SUBTOTAL 12.	**$10,841**	**$0**	**$10,994**	**$0**	**$21,835**		**$1,980**		**$1,092**		**$3,059**	**$27,966**	**$51**
13	IMPROVEMENTS TO SITE													
	SUBTOTAL 13.	**$3,275**	**$1,882**	**$6,600**	**$0**	**$11,757**		**$1,160**		**$0**		**$2,583**	**$15,500**	**$28**
14	BUILDINGS & STRUCTURES													
	SUBTOTAL 14.	**$0**	**$25,163**	**$23,739**	**$0**	**$48,902**		**$4,410**		**$0**		**$7,997**	**$61,310**	**$111**
	Total Cost	**$709,303**	**$56,565**	**$471,861**	**$0**	**$1,237,730**		**$85,750**		**$50,919**		**$166,507**	**$1,540,907**	**$2,802**

Capital Cost Estimate Details

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12C - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.02 MW, net   Capital Charge Factor 0.175   Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
1.1	Coal Receive & Unload	4,730	0	2,161	0	6,891	8.9%	616	0%	0	15.0%	1,126	8,633	16
1.2	Coal Stackout & Reclaim	6,113	0	1,385	0	7,498	8.7%	656	0%	0	15.0%	1,223	9,378	17
1.3	Coal Conveyors & Yd Crus	5,684	0	1,370	0	7,054	8.8%	618	0%	0	15.0%	1,151	8,823	16
1.4	Other Coal Handling	1,487	0	317	0	1,804	8.7%	158	0%	0	15.0%	294	2,256	4
1.5	Sorbent Receive & Unload	0	0	0	0	0	8.8%	0	0%	0	15.0%	0	0	0
1.6	Sorbent Stackout & Reclaim	0	0	0	0	0	8.7%	0	0%	0	15.0%	0	0	0
1.7	Sorbent Conveyors	0	0	0	0	0	8.6%	0	0%	0	15.0%	0	0	0
1.8	Other Sorbent Handling	0	0	0	0	0	8.8%	0	0%	0	15.0%	0	0	0
1.9	Coal & Sorbent Hnd.Foundations	0	5,756	4,767	0	10,523	9.4%	988	0%	0	15.0%	1,727	13,238	24
	SUBTOTAL 1.	**$18,014**	**$5,756**	**$10,000**	**$0**	**$33,770**		**$3,036**		**$0**		**$5,521**	**$42,327**	**$77**
2	COAL PREP & FEED SYSTEMS													
2.1	Coal Crushing & Drying	2,769	0	540	0	3,309	8.7%	288	0%	0	15.0%	540	4,137	8
2.2	Coal Conveyor to Storage	7,091	0	1,548	0	8,638	8.7%	755	0%	0	15.0%	1,409	10,802	20
2.3	Coal Injection System	0	0	0	0	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	0.0%	0	0	0
2.5	Sorbent Prep Equipment	0	0	0	0	0	0.0%	0	0%	0	15.0%	0	0	0
2.6	Sorbent Storage & Feed	0	0	0	0	0	0.0%	0	0%	0	15.0%	0	0	0
2.7	Sorbent Injection System	0	0	0	0	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	0.0%	0	0	0
2.9	Coal & Sorbent Feed Foundation	0	784	658	0	1,442	9.3%	134	0%	0	15.0%	236	1,813	3
	SUBTOTAL 2.	**$9,860**	**$784**	**$2,746**	**$0**	**$13,390**		**$1,177**		**$0**		**$2,185**	**$16,752**	**$30**
3	FEEDWATER & MISC. BOP SYSTEMS													
3.1	Feedwater System	21,745	0	7,024	0	28,770	8.7%	2,514	0%	0	15.0%	4,693	35,976	65
3.2	Water Makeup & Pretreating	3,919	0	1,261	0	5,180	9.5%	490	0%	0	20.0%	1,134	6,804	12
3.3	Other Feedwater Subsystems	6,657	0	2,813	0	9,471	9.0%	848	0%	0	15.0%	1,548	11,867	22
3.4	Service Water Systems	768	0	418	0	1,186	9.4%	112	0%	0	20.0%	260	1,557	3
3.5	Other Boiler Plant Systems	8,580	0	8,471	0	17,050	9.5%	1,620	0%	0	15.0%	2,800	21,470	39
3.6	FO Supply Sys & Nat Gas	270	0	337	0	607	9.4%	57	0%	0	15.0%	100	763	1
3.7	Waste Treatment Equipment	0	0	0	0	0	9.7%	0	0%	0	20.0%	0	0	0
3.8	Misc. Power Plant Equipment	2,863	0	874	0	3,737	9.6%	359	0%	0	20.0%	819	4,916	9
	SUBTOTAL 3.	**$44,801**	**$0**	**$21,199**	**$0**	**$66,001**		**$6,000**		**$0**		**$11,353**	**$83,354**	**$152**
4	PC BOILER & ACCESSORIES													
4.1	PC (Oxycombustion) Boiler	223,244	0	108,940	0	332,183	9.7%	32,295	15%	49,827	10.0%	41,431	455,737	829
4.2	ASU/Oxidant Compression	167,111	0	136,728	0	303,839	0.0%	0	0%	0	10.0%	30,384	334,223	608
4.3	Open	0	0	0	0	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	0.0%	0	0	0
4.5	Primary Air System	w/4.1	0	w/4.1	0	0	0.0%	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	0.0%	0	0	0
4.7	Major Component Rigging	0	w/4.1	w/4.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
4.8	PC Foundations	0	w/14.1	w/14.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 4.	**$390,355**	**$0**	**$245,667**	**$0**	**$636,022**		**$32,295**		**$49,827**		**$71,814**	**$789,959**	**$1,436**
5A	FLUE GAS CLEANUP						*							
5.1	Absorber Vessels & Accessories	0	0	0	0	0	9.5%	0	0%	0	10.0%	0	0	0
5.2	Other FGD	0	0	0	0	0	9.6%	0	0%	0	10.0%	0	0	0
5.3	Bag House & Accessories	15,555	0	7,714	0	23,269	0.0%	0	0%	0	10.0%	2,327	25,596	47
5.4	Other Particulate Removal Materials	21,551	0	9,079	0	30,630	9.6%	2,938	0%	0	10.0%	3,357	36,925	67
5.5	Gypsum Dewatering System	N/A	N/A	N/A	N/A	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	0.0%	0	0	0
5.7	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.8	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.9	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 5A.	**$37,106**	**$0**	**$16,793**	**$0**	**$53,899**		**$2,938**		**$0**		**$5,684**	**$62,521**	**$114**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12C - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.02 MW, net
Capital Charge Factor 0.175 Capacity Factor 0.85
Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
5B	CO2 REMOVAL & COMPRESSION													
5B.1	CO2 Condensing Heat Exchanger	0	0	0	0	0	10%	0	0%	0	15.0%	0	0	0
5B.2	CO2 Compression & Drying	56,475	0	40,896	0	97,371	10%	9,312	0%	0	20.0%	21,337	128,020	233
5B.3	CO2 Pipeline											0	0	0
5B.4	CO2 Storage											0	0	0
5B.5	CO2 Monitoring											0	0	0
	SUBTOTAL 5B.	**$56,475**	**$0**	**$40,896**	**$0**	**$97,371**		**$9,312**		**$0**		**$21,337**	**$128,020**	**$233**
6	COMBUSTION TURBINE/ACCESSORIES													
6.1	Combustion Turbine Generator	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.2	Combustion Turbine Accessories	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.3	Compressed Air Piping	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.4	Combustion Turbine Foundations	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
7.1	Flue Gas Recycle Heat Exhchanger	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
7.2	SCR System	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
7.3	Ductwork	10,363	0	6,658	0	17,021	9%	1,484	0%	0	15.0%	2,776	21,281	39
7.4	Stack	932	0	545	0	1,477	10%	142	0%	0	10.0%	162	1,781	3
7.9	HRSG, Duct & Stack Foundations	0	0	0	0	0	9%	0	0%	0	20.0%	0	0	0
	SUBTOTAL 7.	**$11,294**	**$0**	**$7,203**	**$0**	**$18,498**		**$1,626**		**$0**		**$2,938**	**$23,062**	**$42**
8	STEAM TURBINE GENERATOR													
8.1	Steam TG & Accessories	63,895	0	8,486	0	72,381	9.6%	6,937	0%	0	10.0%	7,932	87,250	159
8.2	Turbine Plant Auxiliaries	433	0	928	0	1,361	9.8%	133	0%	0	10.0%	149	1,644	3
8.3a	Condenser & Auxiliaries	4,892	0	2,951	0	7,844	9.6%	755	0%	0	10.0%	860	9,459	17
8.3b	Air Cooled Condenser													
8.4	Steam Piping	24,696	0	12,177	0	36,873	8.4%	3,098	0%	0	15.0%	5,996	45,966	84
8.9	TG Foundations	0	1,359	2,147	0	3,506	9.5%	332	0%	0	20.0%	768	4,606	8
	SUBTOTAL 8.	**$93,917**	**$1,359**	**$26,689**	**$0**	**$121,965**		**$11,255**		**$0**		**$15,704**	**$148,924**	**$271**
9	COOLING WATER SYSTEM													
9.1	Cooling Towers	7,526	0	2,344	0	9,870	9.6%	944	0%	0	10.0%	1,081	11,895	22
9.2	Circulating Water Pumps	1,998	0	190	0	2,189	8.5%	185	0%	0	10.0%	237	2,611	5
9.3	Circ. Water System Auxiliaries	565	0	75	0	640	9.5%	61	0%	0	10.0%	70	771	1
9.4	Circ. Water Piping	0	4,476	4,338	0	8,815	9.4%	825	0%	0	15.0%	1,446	11,086	20
9.5	Make-up Water System	438	0	586	0	1,024	9.6%	98	0%	0	15.0%	168	1,291	2
9.6	Component Cooling Water System	447	0	355	0	802	9.5%	76	0%	0	15.0%	132	1,010	2
9.9	Circ. Water System Foundations	0	2,658	4,223	0	6,880	9.5%	651	0%	0	20.0%	1,506	9,038	16
	SUBTOTAL 9.	**$10,974**	**$7,134**	**$12,111**	**$0**	**$30,219**		**$2,841**		**$0**		**$4,641**	**$37,701**	**$69**
10	ASH/SPENT SORBENT HANDLING SYS													
10.1	Ash Coolers	N/A	0	N/A	0	0	0%	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%	0	0	0
10.3	HGCU Ash Letdown	N/A	0	N/A	0	0	0%	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%	0	0	0
10.5	Other Ash Recovery Equipment	N/A	0	N/A	0	0	0%	0	0%	0	0.0%	0	0	0
10.6	Ash Storage Silos	729	0	2,245	0	2,974	10%	292	0%	0	10.0%	327	3,593	7
10.7	Ash Transport & Feed Equipment	4,717	0	4,832	0	9,550	10%	913	0%	0	10.0%	1,046	11,509	21
10.8	Misc. Ash Handling Equipment	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
10.9	Ash/Spent Sorbent Foundation	0	173	204	0	377	9%	35	0%	0	20.0%	82	495	1
	SUBTOTAL 10.	**$5,446**	**$173**	**$7,282**	**$0**	**$12,901**		**$1,240**		**$0**		**$1,455**	**$15,597**	**$28**

Department:	NETL Office of Systems Analysis and Planning
Project:	Oxy-Fuel Combustion Systems Analysis
Case:	Case S12C - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size:	550.02 MW, net; Capital Charge Factor 0.175; Capacity Factor 0.85
Cost Base:	June 2007
Prepared:	16-Mar-10
	x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT													
11.1	Generator Equipment	1,910	0	310	0	2,220	9.3%	206	0%	0	7.5%	182	2,607	5
11.2	Station Service Equipment	6,693	0	2,199	0	8,893	9.3%	831	0%	0	7.5%	729	10,453	19
11.3	Switchgear & Motor Control	7,695	0	1,308	0	9,003	9.3%	834	0%	0	10.0%	984	10,821	20
11.4	Conduit & Cable Tray	0	4,824	16,682	0	21,506	9.7%	2,082	0%	0	15.0%	3,538	27,126	49
11.5	Wire & Cable	0	9,104	17,574	0	26,677	8.4%	2,248	0%	0	15.0%	4,339	33,264	60
11.6	Protective Equipment	270	0	918	0	1,188	9.8%	116	0%	0	10.0%	130	1,435	3
11.7	Standby Equipment	372	0	8	0	381	9.2%	35	0%	0	10.0%	42	457	1
11.8	Main Power Transformers	3	0	0	0	4	7.6%	0	0%	0	10.0%	0	4	0
11.9	Electrical Foundations	0	385	944	0	1,329	9.6%	127	0%	0	20.0%	291	1,748	3
	SUBTOTAL 11.	**$16,944**	**$14,313**	**$39,944**	**$0**	**$71,200**		**$6,479**		**$0**		**$10,236**	**$87,915**	**$160**
12	INSTRUMENTATION & CONTROL													
12.1	PC Control Equipment	w/12.7	0	w/12.7	0	0	0%	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%	0	0	0
12.3	Steam Turbine Control	w/8.1	0	w/8.1	0	0	0%	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%	0	0	0
12.5	Signal Processing Equipment	W/12.7	0	w/12.7	0	0	0%	0	0%	0	0.0%	0	0	0
12.6	Control Boards, Panels & Racks	558	0	334	0	893	9%	84	5%	45	15.0%	153	1,175	2
12.7	Computer Accessories	5,635	0	985	0	6,620	9%	614	5%	331	10.0%	757	8,322	15
12.8	Instrument Wiring & Tubing	3,055	0	6,061	0	9,116	9%	777	5%	456	15.0%	1,552	11,902	22
12.9	Other I & C Equipment	1,592	0	3,613	0	5,206	10%	505	5%	260	10.0%	597	6,568	12
	SUBTOTAL 12.	**$10,841**	**$0**	**$10,994**	**$0**	**$21,835**		**$1,980**		**$1,092**		**$3,059**	**$27,966**	**$51**
13	IMPROVEMENTS TO SITE													
13.1	Site Preparation	0	55	1,101	0	1,156	9.9%	115	0%	0	20.0%	254	1,525	3
13.2	Site Improvements	0	1,827	2,269	0	4,097	9.9%	404	0%	0	20.0%	900	5,401	10
13.3	Site Facilities	3,275	0	3,229	0	6,504	9.9%	641	0%	0	20.0%	1,429	8,574	16
	SUBTOTAL 13.	**$3,275**	**$1,882**	**$6,600**	**$0**	**$11,757**		**$1,160**		**$0**		**$2,583**	**$15,500**	**$28**
14	BUILDINGS & STRUCTURES													
14.1	Boiler Building	0	9,682	8,514	0	18,196	9.0%	1,635	0%	0	15.0%	2,975	22,806	41
14.2	Turbine Building	0	12,722	11,857	0	24,579	9.0%	2,215	0%	0	15.0%	4,019	30,813	56
14.3	Administration Building	0	635	672	0	1,307	9.1%	119	0%	0	15.0%	214	1,640	3
14.4	Circulation Water Pumphouse	0	228	181	0	409	8.9%	37	0%	0	15.0%	67	513	1
14.5	Water Treatment Buildings	0	514	423	0	937	9.0%	84	0%	0	15.0%	153	1,175	2
14.6	Machine Shop	0	425	286	0	710	8.9%	63	0%	0	15.0%	116	889	2
14.7	Warehouse	0	288	289	0	577	9.0%	52	0%	0	15.0%	94	723	1
14.8	Other Buildings & Structures	0	235	200	0	436	9.0%	39	0%	0	15.0%	71	546	1
14.9	Waste Treating Building & Str.	0	434	1,317	0	1,751	9.5%	166	0%	0	15.0%	288	2,205	4
	SUBTOTAL 14.	**$0**	**$25,163**	**$23,739**	**$0**	**$48,902**		**$4,410**		**$0**		**$7,997**	**$61,310**	**$111**
	Total Cost	**$709,303**	**$56,565**	**$471,861**	**$0**	**$1,237,730**		**$85,750**		**$50,919**		**$166,507**	**$1,540,907**	**$2,802**

Exhibit 6-34 Case S12C Initial and Annual O&M Expenses

INITIAL & ANNUAL O&M EXPENSES

Case:	Case S12C - Oxyfuel Supercritical PC w/ CO2 Capture		
Plant Size (MWe):	550.02	**Heat Rate (Btu/kWh):**	11,029
Primary/Secondary Fuel:	Montana Rosebud PRB Coal	**Fuel Cost ($/MM Btu):**	0.76
Design/Construction	4 years	**Book Life (yrs):**	20
TPC (Plant Cost) Year:	Jan 2007	**TPI Year:**	2015
Capacity Factor (%):	85	**CO_2 Captured (TPD):**	15593

OPERATING & MAINTENANCE LABOR

Operating Labor

Operating Labor Rate (base):	$33.00	$/hour
Operating Labor Burden:	30.00	% of base
Labor Overhead Charge:	25.00	% of labor

Operating Labor Requirements per Shift:	**units/mod.**	**Total Plant**
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 Operating Jobs	14.0	14.0

	$	**$/kW-net**
Annual Operating Labor Cost (calc'd)	5,261,256	9.57
Maintenance Labor Cost (calc'd)	10,910,757	19.84
Administrative & Support Labor (calc'd)	4,043,003	7.35
	20,215,017	**36.75**

VARIABLE OPERATING COSTS

	$	**$/kWh-net**
Maintenance Material Costs (calc'd)	**$16,366,136**	**0.00400**

Consumables	**Consumption Initial**	**Consumption /Day**	**Unit Cost**	**Initial Cost**	**$**	**$/kWh-net**
Water (/1000 gallons)	0	6,968	1.03	$0	$2,226,809	0.00054
Chemicals						
MU & WT Chem. (lb)	236,121	33,732	0.16	$38,913	$1,724,670	0.00042
Limestone (ton)	938	134	20.60	$19,328	$856,640	0.00021
Carbon (Hg Removal) (lb)	0	0	1.00	$0	$0	0.00000
MEA Solvent (ton)	1,104	0	2142.40	$2,366,256	$0	0.00000
Caustic Soda, NaOH (ton)	0	0	412.96	$0	$0	0.00000
Sulfuric acid, H_2SO_4 (ton)	0	0	132.15	$0	$0	0.00000
Corrosion Inhibitor	0	0	0.00	$0	$0	0.00000
Activated C, MEA (lb)	0	0	1.00	$0	$0	0.00000
Ammonia, 28% soln (ton)	0	0	123.60	$0	$0	0.00000
Subtotal Chemicals				**$2,424,496**	**$2,581,310**	**0.00063**
Other						
Supplemental Fuel (MMBtu)	0	0	6.75	$0	$0	0.00000
SCR Catalyst Replacement (m^3)	w/equip.	0.0000	5500.00	$0	$0	0.00000
Emission Penalties	0	0	0.00	$0	$0	0.00000
Subtotal Other				**$0**	**$0**	**0.00000**
Waste Disposal						
Spent Mercury Catalyst (lb)	0	0	0.31	$0	$0	0.00000
Flyash (ton)	0	823	15.45	$0	$3,944,065	0.00096
Bottom Ash (ton)	0	138	15.45	$0	$662,016	0.00016
Subtotal Solid Waste Disposal				**$0**	**$4,606,081**	**0.00112**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	0.00000
Sulfur (tons)	0	0	0.00	$0	$0	0.00000
Subtotal By-Products				**$0**	**$0**	**0.00000**
TOTAL VARIABLE OPERATING COSTS					**$25,780,336**	**0.00629**
Coal FUEL (tons)	**254,992**	**8,500**	**12.96**	**$3,304,699**	**$34,176,100**	**0.00834**
NATURAL GAS FUEL (Mscf)	**0**	**0**	**6.93**	**$0**	**$0**	**0.00000**

Exhibit 6-35 Case S12D Total Plant Costs

Department:	NETL Office of Systems Analysis and Planning	**Cost Base:**	June 2007
Project:	Oxy-Fuel Combustion Systems Analysis	**Prepared:**	16-Mar-10
Case:	Case S12D - Oxyfuel Supercritical PC w/ CO2 Capture		**x $1, 000**
Plant Size:	550.07 MW, net Capital Charge Factor 0.175 Capacity Factor 0.85		

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
	SUBTOTAL 1.	**$19,776**	**$5,994**	**$13,081**	**$0**	**$38,851**		**$3,492**		**$0**		**$6,351**	**$48,694**	**$89**
2	COAL PREP & FEED SYSTEMS													
	SUBTOTAL 2.	**$9,964**	**$801**	**$2,782**	**$0**	**$13,547**		**$1,191**		**$0**		**$2,211**	**$16,948**	**$31**
3	FEEDWATER & MISC. BOP SYSTEMS													
	SUBTOTAL 3.	**$45,678**	**$0**	**$21,581**	**$0**	**$67,259**		**$6,089**		**$0**		**$11,589**	**$84,937**	**$154**
4	PC BOILER & ACCESSORIES													
	SUBTOTAL 4.	**$394,718**	**$0**	**$248,380**	**$0**	**$643,098**		**$62,291**		**$50,406**		**$75,580**	**$831,375**	**$1,511**
5A	FLUE GAS CLEANUP													
	SUBTOTAL 5A.	**$96,060**	**$0**	**$21,790**	**$0**	**$117,850**		**$11,205**		**$0**		**$12,906**	**$141,961**	**$258**
5B	CO2 REMOVAL & COMPRESSION													
	SUBTOTAL 5B.	**$57,183**	**$0**	**$44,464**	**$0**	**$101,648**		**$10,165**		**$0**		**$22,174**	**$133,987**	**$244**
6	COMBUSTION TURBINE/ACCESSORIES													
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
	SUBTOTAL 7.	**$16,433**	**$0**	**$10,210**	**$0**	**$26,643**		**$2,406**		**$0**		**$3,830**	**$32,880**	**$60**
8	STEAM TURBINE GENERATOR													
	SUBTOTAL 8.	**$94,359**	**$1,363**	**$26,846**	**$0**	**$122,568**		**$11,267**		**$0**		**$15,792**	**$149,627**	**$272**
9	COOLING WATER SYSTEM													
	SUBTOTAL 9.	**$11,015**	**$7,383**	**$12,445**	**$0**	**$30,843**		**$2,874**		**$0**		**$4,755**	**$38,471**	**$70**
10	ASH/SPENT SORBENT HANDLING SYS													
	SUBTOTAL 10.	**$6,597**	**$210**	**$8,820**	**$0**	**$15,626**		**$1,487**		**$0**		**$1,761**	**$18,875**	**$34**
11	ACCESSORY ELECTRIC PLANT													
	SUBTOTAL 11.	**$16,479**	**$14,066**	**$39,145**	**$0**	**$69,690**		**$6,315**		**$0**		**$10,004**	**$86,009**	**$156**
12	INSTRUMENTATION & CONTROL													
	SUBTOTAL 12.	**$10,812**	**$0**	**$10,963**	**$0**	**$21,775**		**$1,994**		**$1,089**		**$3,053**	**$27,911**	**$51**
13	IMPROVEMENTS TO SITE													
	SUBTOTAL 13.	**$3,333**	**$1,916**	**$6,718**	**$0**	**$11,967**		**$1,175**		**$0**		**$2,628**	**$15,771**	**$29**
14	BUILDINGS & STRUCTURES													
	SUBTOTAL 14.	**$0**	**$25,576**	**$24,129**	**$0**	**$49,705**		**$4,478**		**$0**		**$8,127**	**$62,310**	**$113**
	Total Cost	**$782,406**	**$57,310**	**$491,354**	**$0**	**$1,331,070**		**$126,429**		**$51,495**		**$180,761**	**$1,689,754**	**$3,072**

Capital Cost Estimate Details

Department:	NETL Office of Systems Analysis and Planning
Project:	Oxy-Fuel Combustion Systems Analysis
Case:	Case S12D - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size:	550.07 MW, net
Capital Charge Factor	0.175
Capacity Factor	0.85
Cost Base:	Jan 2007
Prepared:	19-Sep-09
	x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
1.1	Coal Receive & Unload	4,777	0	2,182	0	6,959	8.9%	621	0%	0	15.0%	1,137	8,718	16
1.2	Coal Stackout & Reclaim	6,174	0	1,399	0	7,573	8.8%	663	0%	0	15.0%	1,235	9,471	17
1.3	Coal Conveyors & Yd Crus	5,740	0	1,384	0	7,124	8.8%	625	0%	0	15.0%	1,162	8,911	16
1.4	Other Coal Handling	1,502	0	320	0	1,822	8.7%	159	0%	0	15.0%	297	2,279	4
1.5	Sorbent Receive & Unload	60	0	18	0	78	8.8%	7	0%	0	15.0%	13	98	0
1.6	Sorbent Stackout & Reclaim	968	0	177	0	1,146	8.7%	100	0%	0	15.0%	187	1,433	3
1.7	Sorbent Conveyors	346	75	85	0	505	8.7%	44	0%	0	15.0%	82	631	1
1.8	Other Sorbent Handling	209	49	109	0	367	8.8%	32	0%	0	15.0%	60	459	1
1.9	Coal & Sorbent Hnd.Foundations	0	5,870	7,406	0	13,276	9.3%	1,241	0%	0	15.0%	2,178	16,694	30
	SUBTOTAL 1.	**$19,776**	**$5,994**	**$13,081**	**$0**	**$38,851**		**$3,492**		**$0**		**$6,351**	**$48,694**	**$89**
2	COAL PREP & FEED SYSTEMS													
2.1	Coal Crushing & Drying	2,799	0	545	0	3,344	8.7%	292	0%	0	15.0%	545	4,181	8
2.2	Prepared Coal Storage & Feed	7,166	0	1,564	0	8,730	8.7%	763	0%	0	15.0%	1,424	10,917	20
2.3	Slurry Prep & Feed	0	0	0	0	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	0.0%	0	0	0
2.5	Sorbent Prep Equipment	0	0	0	0	0	8.7%	0	0%	0	15.0%	0	0	0
2.6	Sorbent Storage & Feed	0	0	0	0	0	8.9%	0	0%	0	15.0%	0	0	0
2.7	Sorbent Injection System	0	0	0	0	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	0.0%	0	0	0
2.9	Coal & Sorbent Feed Foundation	0	801	672	0	1,473	9.2%	136	0%	0	15.0%	241	1,850	3
	SUBTOTAL 2.	**$9,964**	**$801**	**$2,782**	**$0**	**$13,547**		**$1,191**		**$0**		**$2,211**	**$16,948**	**$31**
3	FEEDWATER & MISC. BOP SYSTEMS													
3.1	Feedwater System	21,984	0	7,101	0	29,085	8.8%	2,547	0%	0	15.0%	4,745	36,376	66
3.2	Water Makeup & Pretreating	4,288	0	1,380	0	5,668	9.4%	531	0%	0	20.0%	1,240	7,439	14
3.3	Other Feedwater Subsystems	6,730	0	2,844	0	9,575	8.9%	853	0%	0	15.0%	1,564	11,992	22
3.4	Service Water Systems	841	0	457	0	1,298	9.3%	120	0%	0	20.0%	284	1,702	3
3.5	Other Boiler Plant Systems	8,692	0	8,582	0	17,274	9.4%	1,620	0%	0	15.0%	2,834	21,728	40
3.6	FO Supply Sys & Nat Gas	271	0	338	0	609	9.3%	57	0%	0	15.0%	100	765	1
3.7	Waste Treatment Equipment	0	0	0	0	0	9.7%	0	0%	0	20.0%	0	0	0
3.8	Misc. Power Plant Equipment	2,873	0	878	0	3,751	9.6%	360	0%	0	20.0%	822	4,934	9
	SUBTOTAL 3.	**$45,678**	**$0**	**$21,581**	**$0**	**$67,259**		**$6,089**		**$0**		**$11,589**	**$84,937**	**$154**
4	PC BOILER & ACCESSORIES													
4.1	PC (Oxycombustion) Boiler	225,836	0	110,205	0	336,041	9.7%	32,549	15%	50,406	10.0%	41,900	460,896	838
4.2	ASU/Oxidant Compression	168,881	0	138,176	0	307,057	9.7%	29,742	0%	0	10.0%	33,680	370,479	674
4.3	Open	0	0	0	0	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	0.0%	0	0	0
4.5	Primary Air System	w/4.1	0	w/4.1	0	0	0.0%	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	0.0%	0	0	0
4.7	Major Component Rigging	0	w/4.1	w/4.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
4.8	PC Foundations	0	w/14.1	w/14.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 4.	**$394,718**	**$0**	**$248,380**	**$0**	**$643,098**		**$62,291**		**$50,406**		**$75,580**	**$831,375**	**$1,511**
5A	FLUE GAS CLEANUP						*							
5.1	Absorber Vessels & Accessories	73,711	0	12,399	0	86,110	9.5%	8,150	0%	0	10.0%	9,426	103,686	188
5.2	Other FGD	1,176	0	471	0	1,647	9.6%	159	0%	0	10.0%	181	1,986	4
5.3	Bag House & Accessories	w/5.1	0	w/5.1	0	0	9.6%	0	0%	0	10.0%	0	0	0
5.4	Other Particulate Removal Materials	21,173	0	8,920	0	30,094	9.6%	2,897	0%	0	10.0%	3,299	36,290	66
5.5	Gypsum Dewatering System	N/A	N/A	N/A	N/A	0	9.4%	0	0%	0	10.0%	0	0	0
5.6	Mercury Removal System	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.7	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.8	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.9	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 5A.	**$96,060**	**$0**	**$21,790**	**$0**	**$117,850**		**$11,205**		**$0**		**$12,906**	**$141,961**	**$258**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12D - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.07 MW, net — Capital Charge Factor 0.175 — Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
5B	CO2 REMOVAL & COMPRESSION													
5B.1	CO2 Condensing Heat Exchanger	3,160	0	264	0	3,424	10%	342	0%	0	15.0%	565	4,332	8
5B.2	CO2 Compression & Drying	54,023	0	44,201	0	98,224	10%	9,822	0%	0	20.0%	21,609	129,655	236
5B.3	CO2 Pipeline											0	0	0
5B.4	CO2 Storage											0	0	0
5B.5	CO2 Monitoring											0	0	0
	SUBTOTAL 5B.	**$57,183**	**$0**	**$44,464**	**$0**	**$101,648**		**$10,165**		**$0**		**$22,174**	**$133,987**	**$244**
6	COMBUSTION TURBINE/ACCESSORIES													
6.1	Combustion Turbine Generator	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.2	Combustion Turbine Accessories	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.3	Compressed Air Piping	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.4	Combustion Turbine Foundations	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
7.1	Flue Gas Recycle Heat Exhchanger	0	0	0	0	0	10%	0	0%	0	15.0%	0	0	0
7.2	SCR System	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
7.3	Ductwork	10,364	0	6,659	0	17,023	9%	1,487	0%	0	15.0%	2,777	21,287	39
7.4	Stack	6,069	0	3,551	0	9,620	10%	919	0%	0	10.0%	1,054	11,593	21
7.9	HRSG, Duct & Stack Foundations	0	0	0	0	0	9%	0	0%	0	20.0%	0	0	0
	SUBTOTAL 7.	**$16,433**	**$0**	**$10,210**	**$0**	**$26,643**		**$2,406**		**$0**		**$3,830**	**$32,880**	**$60**
8	STEAM TURBINE GENERATOR													
8.1	Steam TG & Accessories	64,070	0	8,509	0	72,579	9.6%	6,949	0%	0	10.0%	7,953	87,481	159
8.2	Turbine Plant Auxiliaries	434	0	931	0	1,365	9.7%	132	0%	0	10.0%	150	1,647	3
8.3a	Condenser & Auxiliaries	4,839	0	2,919	0	7,758	9.5%	737	0%	0	10.0%	850	9,345	17
8.3b	Air Cooled Condenser													
8.4	Steam Piping	25,016	0	12,334	0	37,350	8.3%	3,117	0%	0	15.0%	6,070	46,537	85
8.9	TG Foundations	0	1,363	2,153	0	3,516	9.4%	331	0%	0	20.0%	769	4,617	8
	SUBTOTAL 8.	**$94,359**	**$1,363**	**$26,846**	**$0**	**$122,568**		**$11,267**		**$0**		**$15,792**	**$149,627**	**$272**
9	COOLING WATER SYSTEM													
9.1	Cooling Towers	7,415	0	2,309	0	9,724	9.5%	923	0%	0	10.0%	1,065	11,711	21
9.2	Circulating Water Pumps	2,080	0	198	0	2,278	8.6%	195	0%	0	10.0%	247	2,720	5
9.3	Circ. Water System Auxiliaries	584	0	78	0	662	9.4%	62	0%	0	10.0%	72	797	1
9.4	Circ. Water Piping	0	4,633	4,490	0	9,123	9.2%	840	0%	0	15.0%	1,494	11,458	21
9.5	Make-up Water System	473	0	632	0	1,106	9.5%	105	0%	0	15.0%	182	1,392	3
9.6	Component Cooling Water System	462	0	368	0	830	9.4%	78	0%	0	15.0%	136	1,044	2
9.9	Circ. Water System Foundations	0	2,750	4,369	0	7,120	9.4%	670	0%	0	20.0%	1,558	9,348	17
	SUBTOTAL 9.	**$11,015**	**$7,383**	**$12,445**	**$0**	**$30,843**		**$2,874**		**$0**		**$4,755**	**$38,471**	**$70**
10	ASH/SPENT SORBENT HANDLING SYS													
10.1	Ash Coolers	N/A	0	N/A	0	0	0%	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%	0	0	0
10.3	HGCU Ash Letdown	N/A	0	N/A	0	0	0%	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%	0	0	0
10.5	Other Ash Recovery Equipment	N/A	0	N/A	0	0	0%	0	0%	0	0.0%	0	0	0
10.6	Ash Storage Silos	883	0	2,720	0	3,602	10%	351	0%	0	10.0%	395	4,349	8
10.7	Ash Transport & Feed Equipment	5,714	0	5,853	0	11,567	9%	1,094	0%	0	10.0%	1,266	13,927	25
10.8	Misc. Ash Handling Equipment	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
10.9	Ash/Spent Sorbent Foundation	0	210	247	0	457	9%	43	0%	0	20.0%	100	599	1
	SUBTOTAL 10.	**$6,597**	**$210**	**$8,820**	**$0**	**$15,626**		**$1,487**		**$0**		**$1,761**	**$18,875**	**$34**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12D - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.07 MW, net   Capital Charge Factor 0.175   Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 29-Sep-10
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT													
11.1	Generator Equipment	387	0	63	0	449	9.3%	42	0%	0	7.5%	37	528	1
11.2	Station Service Equipment	6,734	0	2,213	0	8,947	9.6%	856	0%	0	7.5%	735	10,538	19
11.3	Switchgear & Motor Control	7,742	0	1,316	0	9,058	9.3%	839	0%	0	10.0%	990	10,886	20
11.4	Conduit & Cable Tray	0	4,854	16,783	0	21,637	9.6%	2,071	0%	0	15.0%	3,556	27,264	50
11.5	Wire & Cable	0	9,159	17,681	0	26,840	8.4%	2,261	0%	0	15.0%	4,365	33,466	61
11.6	Protective Equipment	270	0	920	0	1,190	9.8%	116	0%	0	10.0%	131	1,437	3
11.7	Standby Equipment	400	0	9	0	409	9.5%	39	0%	0	10.0%	45	492	1
11.8	Main Power Transformers	946	0	29	0	975	7.6%	74	0%	0	10.0%	105	1,154	2
11.9	Electrical Foundations	0	54	132	0	185	9.5%	18	0%	0	20.0%	41	243	0
	SUBTOTAL 11.	**$16,479**	**$14,066**	**$39,145**	**$0**	**$69,690**		**$6,315**		**$0**		**$10,004**	**$86,009**	**$156**
12	INSTRUMENTATION & CONTROL													
12.1	PC Control Equipment	w/12.7	0	w/12.7	0	0	0%	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%	0	0	0
12.3	Steam Turbine Control	w/8.1	0	w/8.1	0	0	0%	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%	0	0	0
12.5	Signal Processing Equipment	W/12.7	0	w/12.7	0	0	0%	0	0%	0	0.0%	0	0	0
12.6	Control Boards, Panels & Racks	557	0	333	0	890	9.6%	86	0%	0	15.0%	146	1,122	2
12.7	Computer Accessories	5,620	0	982	0	6,602	9.5%	629	0%	0	10.0%	723	7,954	14
12.8	Instrument Wiring & Tubing	3,047	0	6,044	0	9,091	8.5%	774	0%	0	15.0%	1,480	11,346	21
12.9	Other I & C Equipment	1,588	0	3,603	0	5,191	9.7%	506	0%	0	10.0%	570	6,267	11
	SUBTOTAL 12.	**$10,812**	**$0**	**$10,963**	**$0**	**$21,775**		**$1,994**		**$0**		**$2,919**	**$26,689**	**$49**
13	IMPROVEMENTS TO SITE													
13.1	Site Preparation	0	56	1,120	0	1,177	9.9%	116	0%	0	20.0%	258	1,551	3
13.2	Site Improvements	0	1,860	2,310	0	4,170	9.8%	409	0%	0	20.0%	916	5,496	10
13.3	Site Facilities	3,333	0	3,287	0	6,620	9.8%	650	0%	0	20.0%	1,454	8,724	16
	SUBTOTAL 13.	**$3,333**	**$1,916**	**$6,718**	**$0**	**$11,967**		**$1,175**		**$0**		**$2,628**	**$15,771**	**$29**
14	BUILDINGS & STRUCTURES													
14.1	Boiler Building	0	9,801	8,619	0	18,421	9.0%	1,654	0%	0	15.0%	3,011	23,086	42
14.2	Turbine Building	0	12,906	12,028	0	24,934	9.0%	2,245	0%	0	15.0%	4,077	31,255	57
14.3	Administration Building	0	645	682	0	1,328	9.1%	120	0%	0	15.0%	217	1,665	3
14.4	Circulation Water Pumphouse	0	211	168	0	379	8.9%	34	0%	0	15.0%	62	475	1
14.5	Water Treatment Buildings	0	606	499	0	1,105	9.0%	99	0%	0	15.0%	181	1,384	3
14.6	Machine Shop	0	432	290	0	722	8.9%	64	0%	0	15.0%	118	904	2
14.7	Warehouse	0	293	293	0	586	9.0%	53	0%	0	15.0%	96	735	1
14.8	Other Buildings & Structures	0	239	204	0	443	9.0%	40	0%	0	15.0%	72	555	1
14.9	Waste Treating Building & Str.	0	443	1,345	0	1,788	9.4%	169	0%	0	15.0%	294	2,251	4
	SUBTOTAL 14.	**$0**	**$25,576**	**$24,129**	**$0**	**$49,705**		**$4,478**		**$0**		**$8,127**	**$62,310**	**$113**
	Total Cost	**$782,406**	**$57,310**	**$491,354**	**$0**	**$1,331,070**		**$126,429**		**$50,406**		**$180,627**	**$1,688,532**	**$3,070**

Exhibit 6-36 Case S12D Initial and Annual O&M Expenses

INITIAL & ANNUAL O&M EXPENSES			
Case: Case S12D - Oxyfuel Supercritical PC w/ CO2 Capture			
Plant Size (MWe):	550.07	**Heat Rate (Btu/kWh):**	11,205
Primary/Secondary Fuel:	Montana Rosebud PRB Coal	**Fuel Cost ($/MM Btu):**	0.76
Design/Construction	4 years	**Book Life (yrs):**	20
TPC (Plant Cost) Year:	Jan 2007	**TPI Year:**	2015
Capacity Factor (%):	85	**CO_2 Captured (TPD):**	15822

OPERATING & MAINTENANCE LABOR

Operating Labor

Operating Labor Rate (base):	$33.00	$/hour
Operating Labor Burden:	30.00	% of base
Labor Overhead Charge:	25.00	% of labor

Operating Labor Requirements per Shift:	**units/mod.**	**Total Plant**
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 Operating Jobs	14.0	14.0

	$	**$/kW-net**
Annual Operating Labor Cost (calc'd)	5,261,256	9.56
Maintenance Labor Cost (calc'd)	11,733,562	21.33
Administrative & Support Labor (calc'd)	4,248,705	7.72
	21,243,523	**38.62**

VARIABLE OPERATING COSTS

	$	**$/kWh-net**
Maintenance Material Costs (calc'd)	**$17,600,344**	**0.00430**

Consumables	**Consumption Initial**	**/Day**	**Unit Cost**	**Initial Cost**	**$**	**$/kWh-net**
Water (/1000 gallons)	0	6,968	1.03	$0	$2,226,809	0.00054
Chemicals						
MU & WT Chem. (lb)	236,121	33,732	0.16	$38,913	$1,724,670	0.00042
Limestone (ton)	938	134	20.60	$19,328	$856,640	0.00021
Carbon (Hg Removal) (lb)	0	0	1.00	$0	$0	0.00000
MEA Solvent (ton)	1,121	0	2142.40	$2,400,899	$0	0.00000
Caustic Soda, NaOH (ton)	0	0	412.96	$0	$0	0.00000
Sulfuric acid, H_2SO_4 (ton)	0	0	132.15	$0	$0	0.00000
Corrosion Inhibitor	0	0	0.00	$0	$0	0.00000
Activated C, MEA (lb)	0	0	1.00	$0	$0	0.00000
Ammonia, 28% soln (ton)	0	0	123.60	$0	$0	0.00000
Subtotal Chemicals				**$2,459,140**	**$2,581,310**	**0.00063**
Other						
Supplemental Fuel (MMBtu)	0	0	6.75	$0	$0	0.00000
SCR Catalyst Replacement (m^3)	w/equip.	0.0000	5500.00	$0	$0	0.00000
Emission Penalties	0	0	0.00	$0	$0	0.00000
Subtotal Other				**$0**	**$0**	**0.00000**
Waste Disposal						
Spent Mercury Catalyst (lb)	0	0	0.31	$0	$0	0.00000
Flyash (ton)	0	823	15.45	$0	$3,944,065	0.00096
Bottom Ash (ton)	0	138	15.45	$0	$662,016	0.00016
Subtotal Solid Waste Disposal				**$0**	**$4,606,081**	**0.00112**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	0.00000
Sulfur (tons)	0	0	0.00	$0	$0	0.00000
Subtotal By-Products				**$0**	**$0**	**0.00000**
TOTAL VARIABLE OPERATING COSTS					**$27,014,544**	**0.00660**
Coal FUEL (tons)	**259,091**	**8,636**	**12.96**	**$3,357,825**	**$34,725,502**	**0.00848**
NATURAL GAS FUEL (Mscf)	**0**	**0**	**6.93**	**$0**	**$0**	**0.00000**

Exhibit 6-37 Case S12E Total Plant Costs

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12E - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.02 MW, net   Capital Charge Factor 0.175   Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
	SUBTOTAL 1.	**$19,484**	**$5,907**	**$12,889**	**$0**	**$38,280**		**$3,441**		**$0**		**$6,258**	**$47,979**	**$87**
2	COAL PREP & FEED SYSTEMS													
	SUBTOTAL 2.	**$9,810**	**$0**	**$2,077**	**$0**	**$11,887**		**$1,039**		**$0**		**$1,939**	**$14,865**	**$27**
3	FEEDWATER & MISC. BOP SYSTEMS													
	SUBTOTAL 3.	**$45,253**	**$0**	**$21,352**	**$0**	**$66,605**		**$6,032**		**$0**		**$11,501**	**$84,137**	**$153**
4	PC BOILER & ACCESSORIES													
	SUBTOTAL 4.	**$388,516**	**$0**	**$244,531**	**$0**	**$633,048**		**$61,317**		**$49,578**		**$74,394**	**$818,338**	**$1,488**
5A	FLUE GAS CLEANUP						*							
	SUBTOTAL 5A.	**$94,971**	**$0**	**$21,559**	**$0**	**$116,530**		**$11,080**		**$0**		**$12,761**	**$140,370**	**$255**
5B	CO2 REMOVAL & COMPRESSION													
	SUBTOTAL 5B.	**$46,599**	**$0**	**$35,216**	**$0**	**$81,815**		**$8,182**		**$0**		**$17,763**	**$107,760**	**$196**
6	COMBUSTION TURBINE/ACCESSORIES													
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
	SUBTOTAL 7.	**$57,923**	**$890**	**$12,406**	**$0**	**$71,219**		**$6,884**		**$0**		**$11,677**	**$89,780**	**$163**
8	STEAM TURBINE GENERATOR													
	SUBTOTAL 8.	**$93,008**	**$1,322**	**$26,672**	**$0**	**$121,001**		**$11,121**		**$0**		**$15,587**	**$147,710**	**$269**
9	COOLING WATER SYSTEM													
	SUBTOTAL 9.	**$10,766**	**$7,432**	**$12,428**	**$0**	**$30,626**		**$2,853**		**$0**		**$4,740**	**$38,219**	**$69**
10	ASH/SPENT SORBENT HANDLING SYS													
	SUBTOTAL 10.	**$6,510**	**$207**	**$8,704**	**$0**	**$15,421**		**$1,468**		**$0**		**$1,738**	**$18,626**	**$34**
11	ACCESSORY ELECTRIC PLANT													
	SUBTOTAL 11.	**$15,713**	**$13,337**	**$37,167**	**$0**	**$66,218**		**$6,000**		**$0**		**$9,500**	**$81,718**	**$149**
12	INSTRUMENTATION & CONTROL													
	SUBTOTAL 12.	**$10,642**	**$0**	**$10,792**	**$0**	**$21,434**		**$1,963**		**$0**		**$2,873**	**$26,270**	**$48**
13	IMPROVEMENTS TO SITE													
	SUBTOTAL 13.	**$3,336**	**$1,918**	**$6,723**	**$0**	**$11,976**		**$1,176**		**$0**		**$2,630**	**$15,782**	**$29**
14	BUILDINGS & STRUCTURES													
	SUBTOTAL 14.	**$0**	**$25,590**	**$24,142**	**$0**	**$49,732**		**$4,480**		**$0**		**$8,132**	**$62,344**	**$113**
	Total Cost	**$802,531**	**$56,603**	**$476,657**	**$0**	**$1,335,790**		**$127,035**		**$49,578**		**$181,495**	**$1,693,899**	**$3,080**

Capital Cost Estimate Details

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12E - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.02 MW, net   Capital Charge Factor 0.175   Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
1.1	Coal Receive & Unload	4,708	0	2,150	0	6,858	8.9%	612	0%	0	15.0%	1,121	8,591	16
1.2	Coal Stackout & Reclaim	6,084	0	1,378	0	7,463	8.8%	653	0%	0	15.0%	1,217	9,333	17
1.3	Coal Conveyors & Yd Crus	5,657	0	1,364	0	7,021	8.8%	615	0%	0	15.0%	1,145	8,782	16
1.4	Other Coal Handling	1,480	0	316	0	1,796	8.7%	157	0%	0	15.0%	293	2,245	4
1.5	Sorbent Receive & Unload	59	0	18	0	77	8.8%	7	0%	0	15.0%	13	96	0
1.6	Sorbent Stackout & Reclaim	952	0	174	0	1,126	8.7%	98	0%	0	15.0%	184	1,408	3
1.7	Sorbent Conveyors	340	73	83	0	496	8.7%	43	0%	0	15.0%	81	620	1
1.8	Other Sorbent Handling	205	48	108	0	361	8.8%	32	0%	0	15.0%	59	452	1
1.9	Coal & Sorbent Hnd.Foundations	0	5,785	7,298	0	13,083	9.3%	1,223	0%	0	15.0%	2,146	16,452	30
	SUBTOTAL 1.	**$19,484**	**$5,907**	**$12,889**	**$0**	**$38,280**		**$3,441**		**$0**		**$6,258**	**$47,979**	**$87**
2	COAL PREP & FEED SYSTEMS													
2.1	Coal Crushing & Drying	2,755	0	537	0	3,292	8.7%	287	0%	0	15.0%	537	4,116	7
2.2	Prepared Coal Storage & Feed	7,055	0	1,540	0	8,595	8.7%	752	0%	0	15.0%	1,402	10,748	20
2.3	Slurry Prep & Feed	0	0	0	0	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	0.0%	0	0	0
2.5	Sorbent Prep Equipment	0	0	0	0	0	8.7%	0	0%	0	15.0%	0	0	0
2.6	Sorbent Storage & Feed	0	0	0	0	0	8.9%	0	0%	0	15.0%	0	0	0
2.7	Sorbent Injection System	0	0	0	0	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	0.0%	0	0	0
2.9	Coal & Sorbent Feed Foundation	0	0	0	0	0	9.2%	0	0%	0	15.0%	0	0	0
	SUBTOTAL 2.	**$9,810**	**$0**	**$2,077**	**$0**	**$11,887**		**$1,039**		**$0**		**$1,939**	**$14,865**	**$27**
3	FEEDWATER & MISC. BOP SYSTEMS													
3.1	Feedwater System	21,567	0	6,967	0	28,534	8.8%	2,498	0%	0	15.0%	4,655	35,687	65
3.2	Water Makeup & Pretreating	4,516	0	1,454	0	5,969	9.4%	560	0%	0	20.0%	1,306	7,835	14
3.3	Other Feedwater Subsystems	6,603	0	2,790	0	9,393	8.9%	837	0%	0	15.0%	1,535	11,765	21
3.4	Service Water Systems	885	0	482	0	1,367	9.3%	127	0%	0	20.0%	299	1,792	3
3.5	Other Boiler Plant Systems	8,562	0	8,453	0	17,015	9.4%	1,596	0%	0	15.0%	2,792	21,402	39
3.6	FO Supply Sys & Nat Gas	269	0	336	0	604	9.3%	56	0%	0	15.0%	99	760	1
3.7	Waste Treatment Equipment	0	0	0	0	0	9.7%	0	0%	0	20.0%	0	0	0
3.8	Misc. Power Plant Equipment	2,852	0	871	0	3,723	9.6%	357	0%	0	20.0%	816	4,897	9
	SUBTOTAL 3.	**$45,253**	**$0**	**$21,352**	**$0**	**$66,605**		**$6,032**		**$0**		**$11,501**	**$84,137**	**$153**
4	PC BOILER & ACCESSORIES													
4.1	PC (Oxycombustion) Boiler	222,128	0	108,395	0	330,523	9.7%	32,015	15%	49,578	10.0%	41,212	453,328	824
4.2	ASU/Oxidant Compression	166,389	0	136,136	0	302,525	9.7%	29,303	0%	0	10.0%	33,183	365,010	664
4.3	Open	0	0	0	0	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	0.0%	0	0	0
4.5	Primary Air System	w/4.1	0	w/4.1	0	0	0.0%	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	0.0%	0	0	0
4.7	Major Component Rigging	0	w/4.1	w/4.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
4.8	PC Foundations	0	w/14.1	w/14.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 4.	**$388,516**	**$0**	**$244,531**	**$0**	**$633,048**		**$61,317**		**$49,578**		**$74,394**	**$818,338**	**$1,488**
5A	FLUE GAS CLEANUP						*							
5.1	Absorber Vessels & Accessories	72,814	0	12,248	0	85,062	9.5%	8,051	0%	0	10.0%	9,311	102,424	186
5.2	Other FGD	1,161	0	465	0	1,626	9.6%	157	0%	0	10.0%	178	1,961	4
5.3	Bag House & Accessories	w/5.1	0	w/5.1	0	0	9.6%	0	0%	0	10.0%	0	0	0
5.4	Other Particulate Removal Materials	20,996	0	8,846	0	29,842	9.6%	2,873	0%	0	10.0%	3,271	35,986	65
5.5	Gypsum Dewatering System	N/A	N/A	N/A	N/A	0	9.4%	0	0%	0	10.0%	0	0	0
5.6	Mercury Removal System	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.7	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.8	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.9	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 5A.	**$94,971**	**$0**	**$21,559**	**$0**	**$116,530**		**$11,080**		**$0**		**$12,761**	**$140,370**	**$255**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12E - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.02 MW, net   Capital Charge Factor 0.175   Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

		Equipment		Labor		Bare Erected	Eng'g CM H.O. &		Process Cont.		Project Cont.		TOTAL PLANT COST	
Acct No.	**Item/Description**	**Cost**	**Material Cost**	**Direct**	**Indirect**	**Cost $**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**$**	**$/kW**
5B	CO2 REMOVAL & COMPRESSION													
5B.1	CO2 Condensing Heat Exchanger	3,961	0	331	0	4,292	10%	429	0%	0	15.0%	708	5,430	10
5B.2	CO2 Compression & Drying	42,638	0	34,885	0	77,523	10%	7,752	0%	0	20.0%	17,055	102,330	186
5B.3	CO2 Pipeline											0	0	0
5B.4	CO2 Storage											0	0	0
5B.5	CO2 Monitoring											0	0	0
	SUBTOTAL 5B.	**$46,599**	**$0**	**$35,216**	**$0**	**$81,815**		**$8,182**		**$0**		**$17,763**	**$107,760**	**$196**
6	COMBUSTION TURBINE/ACCESSORIES													
6.1	Combustion Turbine Generator	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.2	Combustion Turbine Accessories	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.3	Compressed Air Piping	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.4	Combustion Turbine Foundations	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
7.1	Flue Gas Recycle Heat Exhchanger	46,022	0	3,843	0	49,865	10%	4,986	0%	0	15.0%	8,228	63,079	115
7.2	SCR System	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
7.3	Ductwork	10,259	0	6,591	0	16,851	9%	1,472	0%	0	15.0%	2,748	21,071	38
7.4	Stack	1,641	0	960	0	2,602	10%	249	0%	0	10.0%	285	3,135	6
7.9	HRSG, Duct & Stack Foundations	0	890	1,012	0	1,902	9%	177	0%	0	20.0%	416	2,495	5
	SUBTOTAL 7.	**$57,923**	**$890**	**$12,406**	**$0**	**$71,219**		**$6,884**		**$0**		**$11,677**	**$89,780**	**$163**
8	STEAM TURBINE GENERATOR													
8.1	Steam TG & Accessories	62,592	0	8,313	0	70,905	9.6%	6,789	0%	0	10.0%	7,769	85,463	155
8.2	Turbine Plant Auxiliaries	422	0	905	0	1,327	9.7%	129	0%	0	10.0%	146	1,601	3
8.3a	Condenser & Auxiliaries	5,244	0	3,163	0	8,407	9.5%	799	0%	0	10.0%	921	10,127	18
8.3b	Air Cooled Condenser													
8.4	Steam Piping	24,749	0	12,203	0	36,952	8.3%	3,084	0%	0	15.0%	6,005	46,042	84
8.9	TG Foundations	0	1,322	2,088	0	3,410	9.4%	321	0%	0	20.0%	746	4,477	8
	SUBTOTAL 8.	**$93,008**	**$1,322**	**$26,672**	**$0**	**$121,001**		**$11,121**		**$0**		**$15,587**	**$147,710**	**$269**
9	COOLING WATER SYSTEM													
9.1	Cooling Towers	7,138	0	2,223	0	9,361	9.5%	889	0%	0	10.0%	1,025	11,274	20
9.2	Circulating Water Pumps	2,096	0	200	0	2,296	8.6%	196	0%	0	10.0%	249	2,741	5
9.3	Circ. Water System Auxiliaries	588	0	78	0	667	9.4%	63	0%	0	10.0%	73	803	1
9.4	Circ. Water Piping	0	4,664	4,520	0	9,184	9.2%	846	0%	0	15.0%	1,504	11,534	21
9.5	Make-up Water System	478	0	639	0	1,117	9.5%	106	0%	0	15.0%	183	1,406	3
9.6	Component Cooling Water System	465	0	370	0	836	9.4%	78	0%	0	15.0%	137	1,051	2
9.9	Circ. Water System Foundations	0	2,768	4,398	0	7,167	9.4%	675	0%	0	20.0%	1,568	9,410	17
	SUBTOTAL 9.	**$10,766**	**$7,432**	**$12,428**	**$0**	**$30,626**		**$2,853**		**$0**		**$4,740**	**$38,219**	**$69**
10	ASH/SPENT SORBENT HANDLING SYS													
10.1	Ash Coolers	N/A	0	N/A	0	0	0%	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%	0	0	0
10.3	HGCU Ash Letdown	N/A	0	N/A	0	0	0%	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%	0	0	0
10.5	Other Ash Recovery Equipment	N/A	0	N/A	0	0	0%	0	0%	0	0.0%	0	0	0
10.6	Ash Storage Silos	871	0	2,684	0	3,555	10%	346	0%	0	10.0%	390	4,291	8
10.7	Ash Transport & Feed Equipment	5,639	0	5,776	0	11,415	9%	1,079	0%	0	10.0%	1,249	13,744	25
10.8	Misc. Ash Handling Equipment	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
10.9	Ash/Spent Sorbent Foundation	0	207	244	0	451	9%	42	0%	0	20.0%	99	591	1
	SUBTOTAL 10.	**$6,510**	**$207**	**$8,704**	**$0**	**$15,421**		**$1,468**		**$0**		**$1,738**	**$18,626**	**$34**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12E - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.02 MW, net Capital Charge Factor 0.175 Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT													
11.1	Generator Equipment	379	0	62	0	441	9.3%	41	0%	0	7.5%	36	518	1
11.2	Station Service Equipment	6,384	0	2,098	0	8,482	9.6%	811	0%	0	7.5%	697	9,990	18
11.3	Switchgear & Motor Control	7,340	0	1,248	0	8,587	9.3%	795	0%	0	10.0%	938	10,321	19
11.4	Conduit & Cable Tray	0	4,602	15,911	0	20,513	9.6%	1,963	0%	0	15.0%	3,371	25,848	47
11.5	Wire & Cable	0	8,683	16,762	0	25,445	8.4%	2,144	0%	0	15.0%	4,138	31,728	58
11.6	Protective Equipment	270	0	920	0	1,190	9.8%	116	0%	0	10.0%	131	1,437	3
11.7	Standby Equipment	393	0	9	0	402	9.5%	38	0%	0	10.0%	44	485	1
11.8	Main Power Transformers	946	0	29	0	975	7.6%	74	0%	0	10.0%	105	1,154	2
11.9	Electrical Foundations	0	52	128	0	181	9.5%	17	0%	0	20.0%	40	238	0
	SUBTOTAL 11.	**$15,713**	**$13,337**	**$37,167**	**$0**	**$66,218**		**$6,000**		**$0**		**$9,500**	**$81,718**	**$149**
12	INSTRUMENTATION & CONTROL													
12.1	PC Control Equipment	w/12.7	0	w/12.7	0	0	0%	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%	0	0	0
12.3	Steam Turbine Control	w/8.1	0	w/8.1	0	0	0%	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%	0	0	0
12.5	Signal Processing Equipment	W/12.7	0	w/12.7	0	0	0%	0	0%	0	0.0%	0	0	0
12.6	Control Boards, Panels & Racks	548	0	328	0	876	10%	84	0%	0	15.0%	144	1,104	2
12.7	Computer Accessories	5,532	0	967	0	6,499	10%	619	0%	0	10.0%	712	7,829	14
12.8	Instrument Wiring & Tubing	2,999	0	5,949	0	8,949	9%	762	0%	0	15.0%	1,457	11,168	20
12.9	Other I & C Equipment	1,563	0	3,547	0	5,110	10%	498	0%	0	10.0%	561	6,169	11
	SUBTOTAL 12.	**$10,642**	**$0**	**$10,792**	**$0**	**$21,434**		**$1,963**		**$0**		**$2,873**	**$26,270**	**$48**
13	IMPROVEMENTS TO SITE													
13.1	Site Preparation	0	56	1,121	0	1,177	9.9%	116	0%	0	20.0%	259	1,552	3
13.2	Site Improvements	0	1,861	2,312	0	4,173	9.8%	410	0%	0	20.0%	917	5,500	10
13.3	Site Facilities	3,336	0	3,290	0	6,625	9.8%	650	0%	0	20.0%	1,455	8,731	16
	SUBTOTAL 13.	**$3,336**	**$1,918**	**$6,723**	**$0**	**$11,976**		**$1,176**		**$0**		**$2,630**	**$15,782**	**$29**
14	BUILDINGS & STRUCTURES													
14.1	Boiler Building	0	9,803	8,621	0	18,424	9.0%	1,655	0%	0	15.0%	3,012	23,091	42
14.2	Turbine Building	0	12,909	12,032	0	24,941	9.0%	2,246	0%	0	15.0%	4,078	31,265	57
14.3	Administration Building	0	646	683	0	1,328	9.1%	120	0%	0	15.0%	217	1,666	3
14.4	Circulation Water Pumphouse	0	213	169	0	382	8.9%	34	0%	0	15.0%	62	478	1
14.5	Water Treatment Buildings	0	612	504	0	1,116	9.0%	100	0%	0	15.0%	182	1,398	3
14.6	Machine Shop	0	432	290	0	722	8.9%	64	0%	0	15.0%	118	904	2
14.7	Warehouse	0	293	294	0	586	9.0%	53	0%	0	15.0%	96	735	1
14.8	Other Buildings & Structures	0	239	204	0	443	9.0%	40	0%	0	15.0%	72	555	1
14.9	Waste Treating Building & Str.	0	444	1,346	0	1,790	9.4%	169	0%	0	15.0%	294	2,253	4
	SUBTOTAL 14.	**$0**	**$25,590**	**$24,142**	**$0**	**$49,732**		**$4,480**		**$0**		**$8,132**	**$62,344**	**$113**
	Total Cost	**$802,531**	**$56,603**	**$476,657**	**$0**	**$1,335,790**		**$127,035**		**$49,578**		**$181,495**	**$1,693,899**	**$3,080**

Exhibit 6-38 Case S12E Initial and Annual O&M Expenses

INITIAL & ANNUAL O&M EXPENSES

Case:	Case S12E - Oxyfuel Supercritical PC w/ CO2 Capture		
Plant Size (MWe):	550.02	**Heat Rate (Btu/kWh):**	10,944
Primary/Secondary Fuel:	Montana Rosebud PRB Coal	**Fuel Cost ($/MM Btu):**	0.76
Design/Construction	4 years	**Book Life (yrs):**	20
TPC (Plant Cost) Year:	Jan 2007	**TPI Year:**	2015
Capacity Factor (%):	85	**CO_2 Captured (TPD):**	14062

OPERATING & MAINTENANCE LABOR

Operating Labor

Operating Labor Rate (base):	$33.00 $/hour			
Operating Labor Burden:	30.00 % of base			
Labor Overhead Charge:	25.00 % of labor			
Operating Labor Requirements per Shift:	**units/mod.**	**Total Plant**		
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 Operating Jobs	14.0	14.0		
			$	**$/kW-net**
Annual Operating Labor Cost (calc'd)			5,261,256	9.57
Maintenance Labor Cost (calc'd)			11,775,173	21.41
Administrative & Support Labor (calc'd)			4,259,107	7.74
			21,295,536	**38.72**

VARIABLE OPERATING COSTS

	Consumption Initial	Consumption /Day	Unit Cost	Initial Cost	$	$/kWh-net
Maintenance Material Costs (calc'd)					**$17,662,760**	**0.00431**
Consumables						
Water (/1000 gallons)	0	6,968	1.03	$0	$2,226,809	0.00054
Chemicals						
MU & WT Chem. (lb)	236,121	33,732	0.16	$38,913	$1,724,670	0.00042
Limestone (ton)	938	134	20.60	$19,328	$856,640	0.00021
Carbon (Hg Removal) (lb)	0	0	1.00	$0	$0	0.00000
MEA Solvent (ton)	996	0	2142.40	$2,133,821	$0	0.00000
Caustic Soda, NaOH (ton)	0	0	412.96	$0	$0	0.00000
Sulfuric acid, H_2SO_4 (ton)	0	0	132.15	$0	$0	0.00000
Corrosion Inhibitor	0	0	0.00	$0	$0	0.00000
Activated C, MEA (lb)	0	0	1.00	$0	$0	0.00000
Ammonia, 28% soln (ton)	0	0	123.60	$0	$0	0.00000
Subtotal Chemicals				**$2,192,062**	**$2,581,310**	**0.00063**
Other						
Supplemental Fuel (MMBtu)	0	0	6.75	$0	$0	0.00000
SCR Catalyst Replacement (m^3)	w/equip.	0.0000	5500.00	$0	$0	0.00000
Emission Penalties	0	0	0.00	$0	$0	0.00000
Subtotal Other				**$0**	**$0**	**0.00000**
Waste Disposal						
Spent Mercury Catalyst (lb)	0	0	0.31	$0	$0	0.00000
Flyash (ton)	0	823	15.45	$0	$3,944,065	0.00096
Bottom Ash (ton)	0	138	15.45	$0	$662,016	0.00016
Subtotal Solid Waste Disposal				**$0**	**$4,606,081**	**0.00112**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	0.00000
Sulfur (tons)	0	0	0.00	$0	$0	0.00000
Subtotal By-Products				**$0**	**$0**	**0.00000**
TOTAL VARIABLE OPERATING COSTS					**$27,076,960**	**0.00661**
Coal FUEL (tons)	**253,026**	**8,434**	**12.96**	**$3,279,211**	**$33,912,503**	**0.00828**
NATURAL GAS FUEL (Mscf)	**0**	**0**	**6.93**	**$0**	**$0**	**0.00000**

Exhibit 6-39 Case S12F Total Plant Costs

Department:	NETL Office of Systems Analysis and Planning			**Cost Base:**	Jan 2007
Project:	Oxy-Fuel Combustion Systems Analysis			**Prepared:**	19-Sep-09
Case:	Case S12F - Oxyfuel Supercritical PC w/ CO2 Capture				**x $1, 000**
Plant Size:	550.03 MW, net	Capital Charge Factor 0.175	Capacity Factor 0.85		

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
	SUBTOTAL 1.	**$19,551**	**$5,928**	**$12,935**	**$0**	**$38,414**		**$3,453**		**$0**		**$6,280**	**$48,147**	**$88**
2	COAL PREP & FEED SYSTEMS													
	SUBTOTAL 2.	**$9,849**	**$794**	**$2,751**	**$0**	**$13,394**		**$1,177**		**$0**		**$2,186**	**$16,757**	**$30**
3	FEEDWATER & MISC. BOP SYSTEMS													
	SUBTOTAL 3.	**$45,242**	**$0**	**$21,371**	**$0**	**$66,613**		**$6,032**		**$0**		**$11,489**	**$84,134**	**$153**
4	PC BOILER & ACCESSORIES													
	SUBTOTAL 4.	**$389,945**	**$0**	**$245,391**	**$0**	**$635,336**		**$61,539**		**$49,787**		**$74,666**	**$821,328**	**$1,493**
5A	FLUE GAS CLEANUP						*							
	SUBTOTAL 5A.	**$95,115**	**$0**	**$21,589**	**$0**	**$116,704**		**$11,097**		**$0**		**$12,780**	**$140,581**	**$256**
5B	CO2 REMOVAL & COMPRESSION													
	SUBTOTAL 5B.	**$46,721**	**$0**	**$35,341**	**$0**	**$82,062**		**$8,206**		**$0**		**$17,820**	**$108,088**	**$197**
6	COMBUSTION TURBINE/ACCESSORIES													
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
	SUBTOTAL 7.	**$58,175**	**$891**	**$12,442**	**$0**	**$71,508**		**$6,912**		**$0**		**$11,724**	**$90,145**	**$164**
8	STEAM TURBINE GENERATOR													
	SUBTOTAL 8.	**$93,372**	**$1,327**	**$26,777**	**$0**	**$121,475**		**$11,165**		**$0**		**$15,649**	**$148,289**	**$270**
9	COOLING WATER SYSTEM													
	SUBTOTAL 9.	**$10,780**	**$7,446**	**$12,433**	**$0**	**$30,660**		**$2,856**		**$0**		**$4,745**	**$38,260**	**$70**
10	ASH/SPENT SORBENT HANDLING SYS													
	SUBTOTAL 10.	**$6,528**	**$208**	**$8,728**	**$0**	**$15,464**		**$1,472**		**$0**		**$1,743**	**$18,679**	**$34**
11	ACCESSORY ELECTRIC PLANT													
	SUBTOTAL 11.	**$15,835**	**$13,453**	**$37,482**	**$0**	**$66,771**		**$6,050**		**$0**		**$9,581**	**$82,401**	**$150**
12	INSTRUMENTATION & CONTROL													
	SUBTOTAL 12.	**$10,670**	**$0**	**$10,819**	**$0**	**$21,489**		**$1,968**		**$0**		**$2,881**	**$26,338**	**$48**
13	IMPROVEMENTS TO SITE													
	SUBTOTAL 13.	**$3,339**	**$1,919**	**$6,729**	**$0**	**$11,987**		**$1,177**		**$0**		**$2,633**	**$15,797**	**$29**
14	BUILDINGS & STRUCTURES													
	SUBTOTAL 14.	**$0**	**$25,578**	**$24,130**	**$0**	**$49,708**		**$4,478**		**$0**		**$8,128**	**$62,314**	**$113**
	Total Cost	**$805,121**	**$57,544**	**$478,919**	**$0**	**$1,341,585**		**$127,582**		**$49,787**		**$182,304**	**$1,701,258**	**$3,093**

Capital Cost Estimate Details

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12F - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.03 MW, net — Capital Charge Factor 0.175 — Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
1.1	Coal Receive & Unload	4,725	0	2,158	0	6,884	8.9%	615	0%	0	15.0%	1,125	8,623	16
1.2	Coal Stackout & Reclaim	6,107	0	1,384	0	7,490	8.8%	656	0%	0	15.0%	1,222	9,368	17
1.3	Coal Conveyors & Yd Crus	5,678	0	1,369	0	7,047	8.8%	618	0%	0	15.0%	1,150	8,814	16
1.4	Other Coal Handling	1,485	0	317	0	1,802	8.7%	158	0%	0	15.0%	294	2,254	4
1.5	Sorbent Receive & Unload	59	0	18	0	77	8.8%	7	0%	0	15.0%	13	96	0
1.6	Sorbent Stackout & Reclaim	952	0	174	0	1,127	8.7%	98	0%	0	15.0%	184	1,408	3
1.7	Sorbent Conveyors	340	73	83	0	496	8.7%	43	0%	0	15.0%	81	620	1
1.8	Other Sorbent Handling	205	48	108	0	361	8.8%	32	0%	0	15.0%	59	452	1
1.9	Coal & Sorbent Hnd.Foundations	0	5,806	7,324	0	13,131	9.3%	1,227	0%	0	15.0%	2,154	16,512	30
	SUBTOTAL 1.	**$19,551**	**$5,928**	**$12,935**	**$0**	**$38,414**		**$3,453**		**$0**		**$6,280**	**$48,147**	**$88**
2	COAL PREP & FEED SYSTEMS													
2.1	Coal Crushing & Drying	2,766	0	539	0	3,305	8.7%	288	0%	0	15.0%	539	4,133	8
2.2	Prepared Coal Storage & Feed	7,083	0	1,546	0	8,628	8.7%	755	0%	0	15.0%	1,407	10,791	20
2.3	Slurry Prep & Feed	0	0	0	0	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	0.0%	0	0	0
2.5	Sorbent Prep Equipment	0	0	0	0	0	8.7%	0	0%	0	15.0%	0	0	0
2.6	Sorbent Storage & Feed	0	0	0	0	0	8.9%	0	0%	0	15.0%	0	0	0
2.7	Sorbent Injection System	0	0	0	0	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	0.0%	0	0	0
2.9	Coal & Sorbent Feed Foundation	0	794	666	0	1,460	9.2%	134	0%	0	15.0%	239	1,834	3
	SUBTOTAL 2.	**$9,849**	**$794**	**$2,751**	**$0**	**$13,394**		**$1,177**		**$0**		**$2,186**	**$16,757**	**$30**
3	FEEDWATER & MISC. BOP SYSTEMS													
3.1	Feedwater System	21,657	0	6,996	0	28,653	8.8%	2,509	0%	0	15.0%	4,674	35,836	65
3.2	Water Makeup & Pretreating	4,372	0	1,407	0	5,779	9.4%	542	0%	0	20.0%	1,264	7,584	14
3.3	Other Feedwater Subsystems	6,630	0	2,802	0	9,432	8.9%	841	0%	0	15.0%	1,541	11,814	21
3.4	Service Water Systems	857	0	466	0	1,323	9.3%	123	0%	0	20.0%	289	1,735	3
3.5	Other Boiler Plant Systems	8,601	0	8,491	0	17,092	9.4%	1,603	0%	0	15.0%	2,804	21,499	39
3.6	FO Supply Sys & Nat Gas	269	0	336	0	605	9.3%	56	0%	0	15.0%	99	761	1
3.7	Waste Treatment Equipment	0	0	0	0	0	9.7%	0	0%	0	20.0%	0	0	0
3.8	Misc. Power Plant Equipment	2,856	0	872	0	3,729	9.6%	358	0%	0	20.0%	817	4,904	9
	SUBTOTAL 3.	**$45,242**	**$0**	**$21,371**	**$0**	**$66,613**		**$6,032**		**$0**		**$11,489**	**$84,134**	**$153**
4	PC BOILER & ACCESSORIES													
4.1	PC (Oxycombustion) Boiler	223,064	0	108,852	0	331,916	9.7%	32,150	15%	49,787	10.0%	41,385	455,239	828
4.2	ASU/Oxidant Compression	166,881	0	136,539	0	303,419	9.7%	29,389	0%	0	10.0%	33,281	366,089	666
4.3	Open	0	0	0	0	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	0.0%	0	0	0
4.5	Primary Air System	w/4.1	0	w/4.1	0	0	0.0%	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	0.0%	0	0	0
4.7	Major Component Rigging	0	w/4.1	w/4.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
4.8	PC Foundations	0	w/14.1	w/14.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 4.	**$389,945**	**$0**	**$245,391**	**$0**	**$635,336**		**$61,539**		**$49,787**		**$74,666**	**$821,328**	**$1,493**
5A	FLUE GAS CLEANUP						*							
5.1	Absorber Vessels & Accessories	72,934	0	12,268	0	85,202	9.5%	8,064	0%	0	10.0%	9,327	102,593	187
5.2	Other FGD	1,161	0	465	0	1,626	9.6%	157	0%	0	10.0%	178	1,961	4
5.3	Bag House & Accessories	w/5.1	0	w/5.1	0	0	9.6%	0	0%	0	10.0%	0	0	0
5.4	Other Particulate Removal Materials	21,020	0	8,856	0	29,876	9.6%	2,876	0%	0	10.0%	3,275	36,027	65
5.5	Gypsum Dewatering System	N/A	N/A	N/A	N/A	0	9.4%	0	0%	0	10.0%	0	0	0
5.6	Mercury Removal System	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.7	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.8	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.9	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 5A.	**$95,115**	**$0**	**$21,589**	**$0**	**$116,704**		**$11,097**		**$0**		**$12,780**	**$140,581**	**$256**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12F - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.03 MW, net   Capital Charge Factor 0.175   Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
5B	CO2 REMOVAL & COMPRESSION													
5B.1	CO2 Condensing Heat Exchanger	3,928	0	328	0	4,256	10%	426	0%	0	15.0%	702	5,384	10
5B.2	CO2 Compression & Drying	42,793	0	35,013	0	77,806	10%	7,781	0%	0	20.0%	17,117	102,704	187
5B.3	CO2 Pipeline											0	0	0
5B.4	CO2 Storage											0	0	0
5B.5	CO2 Monitoring											0	0	0
	SUBTOTAL 5B.	**$46,721**	**$0**	**$35,341**	**$0**	**$82,062**		**$8,206**		**$0**		**$17,820**	**$108,088**	**$197**
6	COMBUSTION TURBINE/ACCESSORIES													
6.1	Combustion Turbine Generator	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.2	Combustion Turbine Accessories	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.3	Compressed Air Piping	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.4	Combustion Turbine Foundations	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
7.1	Flue Gas Recycle Heat Exhchanger	46,248	0	3,862	0	50,110	10%	5,011	0%	0	15.0%	8,268	63,389	115
7.2	SCR System	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
7.3	Ductwork	10,283	0	6,606	0	16,889	9%	1,475	0%	0	15.0%	2,755	21,119	38
7.4	Stack	1,644	0	962	0	2,605	10%	249	0%	0	10.0%	285	3,140	6
7.9	HRSG, Duct & Stack Foundations	0	891	1,012	0	1,903	9%	177	0%	0	20.0%	416	2,497	5
	SUBTOTAL 7.	**$58,175**	**$891**	**$12,442**	**$0**	**$71,508**		**$6,912**		**$0**		**$11,724**	**$90,145**	**$164**
8	STEAM TURBINE GENERATOR													
8.1	Steam TG & Accessories	62,833	0	8,345	0	71,178	9.6%	6,815	0%	0	10.0%	7,799	85,792	156
8.2	Turbine Plant Auxiliaries	424	0	908	0	1,332	9.7%	129	0%	0	10.0%	146	1,607	3
8.3a	Condenser & Auxiliaries	5,260	0	3,173	0	8,434	9.5%	801	0%	0	10.0%	924	10,159	18
8.3b	Air Cooled Condenser													
8.4	Steam Piping	24,854	0	12,255	0	37,109	8.3%	3,097	0%	0	15.0%	6,031	46,237	84
8.9	TG Foundations	0	1,327	2,096	0	3,423	9.4%	322	0%	0	20.0%	749	4,494	8
	SUBTOTAL 8.	**$93,372**	**$1,327**	**$26,777**	**$0**	**$121,475**		**$11,165**		**$0**		**$15,649**	**$148,289**	**$270**
9	COOLING WATER SYSTEM													
9.1	Cooling Towers	7,161	0	2,230	0	9,391	9.5%	891	0%	0	10.0%	1,028	11,310	21
9.2	Circulating Water Pumps	2,101	0	200	0	2,301	8.6%	197	0%	0	10.0%	250	2,747	5
9.3	Circ. Water System Auxiliaries	589	0	79	0	668	9.4%	63	0%	0	10.0%	73	804	1
9.4	Circ. Water Piping	0	4,672	4,528	0	9,200	9.2%	848	0%	0	15.0%	1,507	11,555	21
9.5	Make-up Water System	464	0	619	0	1,083	9.5%	103	0%	0	15.0%	178	1,363	2
9.6	Component Cooling Water System	466	0	371	0	837	9.4%	79	0%	0	15.0%	137	1,053	2
9.9	Circ. Water System Foundations	0	2,773	4,406	0	7,180	9.4%	676	0%	0	20.0%	1,571	9,427	17
	SUBTOTAL 9.	**$10,780**	**$7,446**	**$12,433**	**$0**	**$30,660**		**$2,856**		**$0**		**$4,745**	**$38,260**	**$70**
10	ASH/SPENT SORBENT HANDLING SYS													
10.1	Ash Coolers	N/A	0	N/A	0	0	0%	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%	0	0	0
10.3	HGCU Ash Letdown	N/A	0	N/A	0	0	0%	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%	0	0	0
10.5	Other Ash Recovery Equipment	N/A	0	N/A	0	0	0%	0	0%	0	0.0%	0	0	0
10.6	Ash Storage Silos	874	0	2,692	0	3,565	10%	347	0%	0	10.0%	391	4,304	8
10.7	Ash Transport & Feed Equipment	5,655	0	5,792	0	11,447	9%	1,083	0%	0	10.0%	1,253	13,783	25
10.8	Misc. Ash Handling Equipment	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
10.9	Ash/Spent Sorbent Foundation	0	208	244	0	452	9%	42	0%	0	20.0%	99	593	1
	SUBTOTAL 10.	**$6,528**	**$208**	**$8,728**	**$0**	**$15,464**		**$1,472**		**$0**		**$1,743**	**$18,679**	**$34**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
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Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT													
11.1	Generator Equipment	381	0	62	0	442	9.3%	41	0%	0	7.5%	36	520	1
11.2	Station Service Equipment	6,440	0	2,116	0	8,556	9.6%	818	0%	0	7.5%	703	10,077	18
11.3	Switchgear & Motor Control	7,404	0	1,258	0	8,662	9.3%	802	0%	0	10.0%	946	10,411	19
11.4	Conduit & Cable Tray	0	4,642	16,050	0	20,692	9.6%	1,980	0%	0	15.0%	3,401	26,073	47
11.5	Wire & Cable	0	8,759	16,909	0	25,668	8.4%	2,163	0%	0	15.0%	4,175	32,005	58
11.6	Protective Equipment	270	0	920	0	1,190	9.8%	116	0%	0	10.0%	131	1,437	3
11.7	Standby Equipment	394	0	9	0	403	9.5%	38	0%	0	10.0%	44	486	1
11.8	Main Power Transformers	946	0	29	0	975	7.6%	74	0%	0	10.0%	105	1,154	2
11.9	Electrical Foundations	0	53	129	0	182	9.5%	17	0%	0	20.0%	40	239	0
	SUBTOTAL 11.	**$15,835**	**$13,453**	**$37,482**	**$0**	**$66,771**		**$6,050**		**$0**		**$9,581**	**$82,401**	**$150**
12	INSTRUMENTATION & CONTROL													
12.1	PC Control Equipment	w/12.7	0	w/12.7	0	0	0%	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%	0	0	0
12.3	Steam Turbine Control	w/8.1	0	w/8.1	0	0	0%	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%	0	0	0
12.5	Signal Processing Equipment	W/12.7	0	w/12.7	0	0	0%	0	0%	0	0.0%	0	0	0
12.6	Control Boards, Panels & Racks	549	0	329	0	878	10%	84	0%	0	15.0%	144	1,107	2
12.7	Computer Accessories	5,546	0	969	0	6,516	10%	621	0%	0	10.0%	714	7,850	14
12.8	Instrument Wiring & Tubing	3,007	0	5,965	0	8,972	9%	764	0%	0	15.0%	1,460	11,196	20
12.9	Other I & C Equipment	1,567	0	3,556	0	5,123	10%	499	0%	0	10.0%	562	6,185	11
	SUBTOTAL 12.	**$10,670**	**$0**	**$10,819**	**$0**	**$21,489**		**$1,968**		**$0**		**$2,881**	**$26,338**	**$48**
13	IMPROVEMENTS TO SITE													
13.1	Site Preparation	0	56	1,122	0	1,178	9.9%	116	0%	0	20.0%	259	1,554	3
13.2	Site Improvements	0	1,863	2,314	0	4,177	9.8%	410	0%	0	20.0%	917	5,505	10
13.3	Site Facilities	3,339	0	3,293	0	6,631	9.8%	651	0%	0	20.0%	1,456	8,739	16
	SUBTOTAL 13.	**$3,339**	**$1,919**	**$6,729**	**$0**	**$11,987**		**$1,177**		**$0**		**$2,633**	**$15,797**	**$29**
14	BUILDINGS & STRUCTURES													
14.1	Boiler Building	0	9,805	8,623	0	18,428	9.0%	1,655	0%	0	15.0%	3,013	23,096	42
14.2	Turbine Building	0	12,914	12,036	0	24,950	9.0%	2,247	0%	0	15.0%	4,079	31,276	57
14.3	Administration Building	0	646	683	0	1,329	9.1%	120	0%	0	15.0%	217	1,667	3
14.4	Circulation Water Pumphouse	0	213	169	0	382	8.9%	34	0%	0	15.0%	62	479	1
14.5	Water Treatment Buildings	0	594	489	0	1,082	9.0%	97	0%	0	15.0%	177	1,356	2
14.6	Machine Shop	0	432	290	0	722	8.9%	64	0%	0	15.0%	118	904	2
14.7	Warehouse	0	293	294	0	586	9.0%	53	0%	0	15.0%	96	735	1
14.8	Other Buildings & Structures	0	239	204	0	443	9.0%	40	0%	0	15.0%	72	555	1
14.9	Waste Treating Building & Str.	0	442	1,342	0	1,784	9.4%	169	0%	0	15.0%	293	2,246	4
	SUBTOTAL 14.	**$0**	**$25,578**	**$24,130**	**$0**	**$49,708**		**$4,478**		**$0**		**$8,128**	**$62,314**	**$113**
	Total Cost	**$805,121**	**$57,544**	**$478,919**	**$0**	**$1,341,585**		**$127,582**		**$49,787**		**$182,304**	**$1,701,258**	**$3,093**

Exhibit 6-40 Case S12F Initial and Annual O&M Expenses

INITIAL & ANNUAL O&M EXPENSES			
Case:	Case S12F - Oxyfuel Supercritical PC w/ CO2 Capture		
Plant Size (MWe):	550.03	**Heat Rate (Btu/kWh):**	11,009
Primary/Secondary Fuel:	Montana Rosebud PRB Coal	**Fuel Cost ($/MM Btu):**	0.76
Design/Construction	4 years	**Book Life (yrs):**	20
TPC (Plant Cost) Year:	Jan 2007	**TPI Year:**	2015
Capacity Factor (%):	85	**CO_2 Captured (TPD):**	14127

OPERATING & MAINTENANCE LABOR

Operating Labor

Operating Labor Rate (base):	$33.00	$/hour
Operating Labor Burden:	30.00	% of base
Labor Overhead Charge:	25.00	% of labor

Operating Labor Requirements per Shift:	**units/mod.**	**Total Plant**
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 Operating Jobs	14.0	14.0

	$	**$/kW-net**
Annual Operating Labor Cost (calc'd)	5,261,256	9.57
Maintenance Labor Cost (calc'd)	11,826,250	21.50
Administrative & Support Labor (calc'd)	4,271,877	7.77
	21,359,383	**38.83**

VARIABLE OPERATING COSTS

	$	**$/kWh-net**
Maintenance Material Costs (calc'd)	**$17,739,375**	**0.00433**

Consumables	**Consumption Initial**	**Consumption /Day**	**Unit Cost**	**Initial Cost**	**$**	**$/kWh-net**
Water (/1000 gallons)	0	6,968	1.03	$0	$2,226,809	0.00054
Chemicals						
MU & WT Chem. (lb)	236,121	33,732	0.16	$38,913	$1,724,670	0.00042
Limestone (ton)	938	134	20.60	$19,328	$856,640	0.00021
Carbon (Hg Removal) (lb)	0	0	1.00	$0	$0	0.00000
MEA Solvent (ton)	1,001	0	2142.40	$2,143,755	$0	0.00000
Caustic Soda, NaOH (ton)	0	0	412.96	$0	$0	0.00000
Sulfuric acid, H_2SO_4 (ton)	0	0	132.15	$0	$0	0.00000
Corrosion Inhibitor	0	0	0.00	$0	$0	0.00000
Activated C, MEA (lb)	0	0	1.00	$0	$0	0.00000
Ammonia, 28% soln (ton)	0	0	123.60	$0	$0	0.00000
Subtotal Chemicals				**$2,201,996**	**$2,581,310**	**0.00063**
Other						
Supplemental Fuel (MMBtu)	0	0	6.75	$0	$0	0.00000
SCR Catalyst Replacement (m^3)	w/equip.	0.0000	5500.00	$0	$0	0.00000
Emission Penalties	0	0	0.00	$0	$0	0.00000
Subtotal Other				**$0**	**$0**	**0.00000**
Waste Disposal						
Spent Mercury Catalyst (lb)	0	0	0.31	$0	$0	0.00000
Flyash (ton)	0	823	15.45	$0	$3,944,065	0.00096
Bottom Ash (ton)	0	138	15.45	$0	$662,016	0.00016
Subtotal Solid Waste Disposal				**$0**	**$4,606,081**	**0.00112**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	0.00000
Sulfur (tons)	0	0	0.00	$0	$0	0.00000
Subtotal By-Products				**$0**	**$0**	**0.00000**
TOTAL VARIABLE OPERATING COSTS					**$27,153,576**	**0.00663**
Coal FUEL (tons)	**254,540**	**8,485**	**12.96**	**$3,298,836**	**$34,115,465**	**0.00833**
NATURAL GAS FUEL (Mscf)	**0**	**0**	**6.93**	**$0**	**$0**	**0.00000**

Exhibit 6-41 Case L12F Total Plant Costs

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case L12F - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.04 MW, net — Capital Charge Factor 0.175 — Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
	SUBTOTAL 1.	**$23,292**	**$7,088**	**$15,464**	**$0**	**$45,844**		**$4,121**		**$0**		**$7,495**	**$57,461**	**$104**
2	COAL PREP & FEED SYSTEMS													
	SUBTOTAL 2.	**$11,952**	**$956**	**$3,332**	**$0**	**$16,240**		**$1,428**		**$0**		**$2,650**	**$20,318**	**$37**
3	FEEDWATER & MISC. BOP SYSTEMS													
	SUBTOTAL 3.	**$45,924**	**$0**	**$21,659**	**$0**	**$67,583**		**$6,122**		**$0**		**$11,679**	**$85,384**	**$155**
4	PC BOILER & ACCESSORIES													
	SUBTOTAL 4.	**$396,862**	**$0**	**$250,562**	**$0**	**$647,424**		**$62,710**		**$50,118**		**$76,025**	**$836,277**	**$1,520**
5A	FLUE GAS CLEANUP						*							
	SUBTOTAL 5A.	**$92,246**	**$0**	**$21,007**	**$0**	**$113,253**		**$10,769**		**$0**		**$12,402**	**$136,424**	**$248**
5B	CO2 REMOVAL & COMPRESSION													
	SUBTOTAL 5B.	**$47,788**	**$0**	**$36,550**	**$0**	**$84,338**		**$8,434**		**$0**		**$18,348**	**$111,120**	**$202**
6	COMBUSTION TURBINE/ACCESSORIES													
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
	SUBTOTAL 7.	**$59,699**	**$927**	**$13,265**	**$0**	**$73,891**		**$7,125**		**$0**		**$12,122**	**$93,138**	**$169**
8	STEAM TURBINE GENERATOR													
	SUBTOTAL 8.	**$93,826**	**$1,333**	**$26,910**	**$0**	**$122,069**		**$11,219**		**$0**		**$15,729**	**$149,016**	**$271**
9	COOLING WATER SYSTEM													
	SUBTOTAL 9.	**$10,948**	**$7,765**	**$12,868**	**$0**	**$31,582**		**$2,941**		**$0**		**$4,905**	**$39,428**	**$72**
10	ASH/SPENT SORBENT HANDLING SYS													
	SUBTOTAL 10.	**$8,127**	**$258**	**$10,865**	**$0**	**$19,250**		**$1,832**		**$0**		**$2,170**	**$23,253**	**$42**
11	ACCESSORY ELECTRIC PLANT													
	SUBTOTAL 11.	**$15,951**	**$13,591**	**$37,853**	**$0**	**$67,395**		**$6,107**		**$0**		**$9,672**	**$83,174**	**$151**
12	INSTRUMENTATION & CONTROL													
	SUBTOTAL 12.	**$10,702**	**$0**	**$10,852**	**$0**	**$21,554**		**$1,974**		**$0**		**$2,889**	**$26,417**	**$48**
13	IMPROVEMENTS TO SITE													
	SUBTOTAL 13.	**$3,355**	**$1,928**	**$6,761**	**$0**	**$12,043**		**$1,183**		**$0**		**$2,645**	**$15,871**	**$29**
14	BUILDINGS & STRUCTURES													
	SUBTOTAL 14.	**$0**	**$25,649**	**$24,195**	**$0**	**$49,845**		**$4,491**		**$0**		**$8,150**	**$62,486**	**$114**
	Total Cost	**$820,672**	**$59,496**	**$492,145**	**$0**	**$1,372,313**		**$130,455**		**$50,118**		**$186,881**	**$1,739,766**	**$3,163**

Capital Cost Estimate Details

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case L12F - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.04 MW, net — Capital Charge Factor 0.175 — Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
1.1	Coal Receive & Unload	5,668	0	2,588	0	8,256	8.9%	737	0%	0	15.0%	1,349	10,342	19
1.2	Coal Stackout & Reclaim	7,325	0	1,659	0	8,984	8.8%	786	0%	0	15.0%	1,466	11,236	20
1.3	Coal Conveyors & Yd Crus	6,810	0	1,642	0	8,452	8.8%	741	0%	0	15.0%	1,379	10,572	19
1.4	Other Coal Handling	1,782	0	380	0	2,162	8.7%	189	0%	0	15.0%	353	2,703	5
1.5	Sorbent Receive & Unload	65	0	20	0	84	8.8%	7	0%	0	15.0%	14	105	0
1.6	Sorbent Stackout & Reclaim	1,045	0	192	0	1,237	8.7%	108	0%	0	15.0%	202	1,546	3
1.7	Sorbent Conveyors	373	81	92	0	545	8.7%	47	0%	0	15.0%	89	681	1
1.8	Other Sorbent Handling	226	53	118	0	397	8.8%	35	0%	0	15.0%	65	497	1
1.9	Coal & Sorbent Hnd.Foundations	0	6,955	8,773	0	15,728	9.3%	1,470	0%	0	15.0%	2,580	19,778	36
	SUBTOTAL 1.	$23,292	$7,088	$15,464	$0	$45,844		$4,121		$0		$7,495	$57,461	$104
2	COAL PREP & FEED SYSTEMS													
2.1	Coal Crushing & Drying	3,357	0	654	0	4,011	8.7%	350	0%	0	15.0%	654	5,015	9
2.2	Prepared Coal Storage & Feed	8,595	0	1,876	0	10,471	8.7%	916	0%	0	15.0%	1,708	13,095	24
2.3	Slurry Prep & Feed	0	0	0	0	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	0.0%	0	0	0
2.5	Sorbent Prep Equipment	0	0	0	0	0	8.7%	0	0%	0	15.0%	0	0	0
2.6	Sorbent Storage & Feed	0	0	0	0	0	8.9%	0	0%	0	15.0%	0	0	0
2.7	Sorbent Injection System	0	0	0	0	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	0.0%	0	0	0
2.9	Coal & Sorbent Feed Foundation	0	956	802	0	1,758	9.2%	162	0%	0	15.0%	288	2,208	4
	SUBTOTAL 2.	$11,952	$956	$3,332	$0	$16,240		$1,428		$0		$2,650	$20,318	$37
3	FEEDWATER & MISC. BOP SYSTEMS													
3.1	Feedwater System	21,800	0	7,042	0	28,841	8.8%	2,525	0%	0	15.0%	4,705	36,072	66
3.2	Water Makeup & Pretreating	4,537	0	1,460	0	5,997	9.4%	562	0%	0	20.0%	1,312	7,871	14
3.3	Other Feedwater Subsystems	6,674	0	2,820	0	9,494	8.9%	846	0%	0	15.0%	1,551	11,892	22
3.4	Service Water Systems	889	0	484	0	1,373	9.3%	127	0%	0	20.0%	300	1,801	3
3.5	Other Boiler Plant Systems	8,662	0	8,552	0	17,214	9.4%	1,615	0%	0	15.0%	2,824	21,653	39
3.6	FO Supply Sys & Nat Gas	289	0	362	0	651	9.3%	61	0%	0	15.0%	107	819	1
3.7	Waste Treatment Equipment	0	0	0	0	0	9.7%	0	0%	0	20.0%	0	0	0
3.8	Misc. Power Plant Equipment	3,073	0	939	0	4,012	9.6%	385	0%	0	20.0%	879	5,277	10
	SUBTOTAL 3.	$45,924	$0	$21,659	$0	$67,583		$6,122		$0		$11,679	$85,384	$155
4	PC BOILER & ACCESSORIES													
4.1	PC (Oxycombustion) Boiler	224,543	0	109,574	0	334,117	9.7%	32,363	15%	50,118	10.0%	41,660	458,257	833
4.2	ASU/Oxidant Compression	172,319	0	140,988	0	313,307	9.7%	30,347	0%	0	10.0%	34,365	378,020	687
4.3	Open	0	0	0	0	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	0.0%	0	0	0
4.5	Primary Air System	w/4.1	0	w/4.1	0	0	0.0%	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	0.0%	0	0	0
4.7	Major Component Rigging	0	w/4.1	w/4.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
4.8	PC Foundations	0	w/14.1	w/14.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 4.	$396,862	$0	$250,562	$0	$647,424		$62,710		$50,118		$76,025	$836,277	$1,520
5A	FLUE GAS CLEANUP						*							
5.1	Absorber Vessels & Accessories	70,452	0	11,851	0	82,302	9.5%	7,789	0%	0	10.0%	9,009	99,101	180
5.2	Other FGD	1,248	0	500	0	1,748	9.6%	168	0%	0	10.0%	192	2,108	4
5.3	Bag House & Accessories	w/5.1	0	w/5.1	0	0	9.6%	0	0%	0	10.0%	0	0	0
5.4	Other Particulate Removal Materials	20,546	0	8,656	0	29,202	9.6%	2,811	0%	0	10.0%	3,201	35,215	64
5.5	Gypsum Dewatering System	N/A	N/A	N/A	N/A	0	9.4%	0	0%	0	10.0%	0	0	0
5.6	Mercury Removal System	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.7	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.8	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.9	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 5A.	$92,246	$0	$21,007	$0	$113,253		$10,769		$0		$12,402	$136,424	$248

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case L12F - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.04 MW, net Capital Charge Factor 0.175 Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
5B	CO2 REMOVAL & COMPRESSION													
5B.1	CO2 Condensing Heat Exchanger	3,469	0	290	0	3,759	10%	376	0%	0	15.0%	620	4,755	9
5B.2	CO2 Compression & Drying	44,319	0	36,261	0	80,579	10%	8,058	0%	0	20.0%	17,727	106,365	193
5B.3	CO2 Pipeline											0	0	0
5B.4	CO2 Storage											0	0	0
5B.5	CO2 Monitoring											0	0	0
	SUBTOTAL 5B.	**$47,788**	**$0**	**$36,550**	**$0**	**$84,338**		**$8,434**		**$0**		**$18,348**	**$111,120**	**$202**
6	COMBUSTION TURBINE/ACCESSORIES													
6.1	Combustion Turbine Generator	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.2	Combustion Turbine Accessories	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.3	Compressed Air Piping	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.4	Combustion Turbine Foundations	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
7.1	Flue Gas Recycle Heat Exhchanger	46,606	0	3,892	0	50,498	10%	5,050	0%	0	15.0%	8,332	63,880	116
7.2	SCR System	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
7.3	Ductwork	11,495	0	7,385	0	18,880	9%	1,649	0%	0	15.0%	3,079	23,608	43
7.4	Stack	1,598	0	935	0	2,532	10%	242	0%	0	10.0%	277	3,052	6
7.9	HRSG, Duct & Stack Foundations	0	927	1,053	0	1,981	9%	185	0%	0	20.0%	433	2,598	5
	SUBTOTAL 7.	**$59,699**	**$927**	**$13,265**	**$0**	**$73,891**		**$7,125**		**$0**		**$12,122**	**$93,138**	**$169**
8	STEAM TURBINE GENERATOR													
8.1	Steam TG & Accessories	63,120	0	8,383	0	71,502	9.6%	6,846	0%	0	10.0%	7,835	86,183	157
8.2	Turbine Plant Auxiliaries	426	0	912	0	1,338	9.7%	130	0%	0	10.0%	147	1,615	3
8.3a	Condenser & Auxiliaries	5,260	0	3,173	0	8,434	9.5%	801	0%	0	10.0%	924	10,159	18
8.3b	Air Cooled Condenser													
8.4	Steam Piping	25,020	0	12,337	0	37,357	8.3%	3,118	0%	0	15.0%	6,071	46,546	85
8.9	TG Foundations	0	1,333	2,105	0	3,438	9.4%	324	0%	0	20.0%	752	4,514	8
	SUBTOTAL 8.	**$93,826**	**$1,333**	**$26,910**	**$0**	**$122,069**		**$11,219**		**$0**		**$15,729**	**$149,016**	**$271**
9	COOLING WATER SYSTEM													
9.1	Cooling Towers	7,161	0	2,230	0	9,391	9.5%	891	0%	0	10.0%	1,028	11,310	21
9.2	Circulating Water Pumps	2,206	0	210	0	2,417	8.6%	207	0%	0	10.0%	262	2,885	5
9.3	Circ. Water System Auxiliaries	615	0	82	0	697	9.4%	66	0%	0	10.0%	76	839	2
9.4	Circ. Water Piping	0	4,873	4,723	0	9,596	9.2%	884	0%	0	15.0%	1,572	12,052	22
9.5	Make-up Water System	480	0	642	0	1,122	9.5%	106	0%	0	15.0%	184	1,412	3
9.6	Component Cooling Water System	486	0	387	0	873	9.4%	82	0%	0	15.0%	143	1,098	2
9.9	Circ. Water System Foundations	0	2,892	4,595	0	7,487	9.4%	705	0%	0	20.0%	1,638	9,830	18
	SUBTOTAL 9.	**$10,948**	**$7,765**	**$12,868**	**$0**	**$31,582**		**$2,941**		**$0**		**$4,905**	**$39,428**	**$72**
10	ASH/SPENT SORBENT HANDLING SYS													
10.1	Ash Coolers	N/A	0	N/A	0	0	0%	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%	0	0	0
10.3	HGCU Ash Letdown	N/A	0	N/A	0	0	0%	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%	0	0	0
10.5	Other Ash Recovery Equipment	N/A	0	N/A	0	0	0%	0	0%	0	0.0%	0	0	0
10.6	Ash Storage Silos	1,087	0	3,350	0	4,438	10%	432	0%	0	10.0%	487	5,357	10
10.7	Ash Transport & Feed Equipment	7,039	0	7,211	0	14,250	9%	1,348	0%	0	10.0%	1,560	17,157	31
10.8	Misc. Ash Handling Equipment	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
10.9	Ash/Spent Sorbent Foundation	0	258	304	0	563	9%	52	0%	0	20.0%	123	738	1
	SUBTOTAL 10.	**$8,127**	**$258**	**$10,865**	**$0**	**$19,250**		**$1,832**		**$0**		**$2,170**	**$23,253**	**$42**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case L12F - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.04 MW, net   Capital Charge Factor 0.175   Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT													
11.1	Generator Equipment	382	0	62	0	444	9.3%	41	0%	0	7.5%	36	521	1
11.2	Station Service Equipment	6,506	0	2,138	0	8,643	9.6%	827	0%	0	7.5%	710	10,180	19
11.3	Switchgear & Motor Control	7,480	0	1,271	0	8,751	9.3%	810	0%	0	10.0%	956	10,517	19
11.4	Conduit & Cable Tray	0	4,689	16,214	0	20,904	9.6%	2,001	0%	0	15.0%	3,436	26,340	48
11.5	Wire & Cable	0	8,848	17,081	0	25,930	8.4%	2,185	0%	0	15.0%	4,217	32,332	59
11.6	Protective Equipment	270	0	920	0	1,190	9.8%	116	0%	0	10.0%	131	1,437	3
11.7	Standby Equipment	396	0	9	0	405	9.5%	38	0%	0	10.0%	44	487	1
11.8	Main Power Transformers	918	0	29	0	946	7.6%	72	0%	0	10.0%	102	1,120	2
11.9	Electrical Foundations	0	53	130	0	182	9.5%	17	0%	0	20.0%	40	240	0
	SUBTOTAL 11.	**$15,951**	**$13,591**	**$37,853**	**$0**	**$67,395**		**$6,107**		**$0**		**$9,672**	**$83,174**	**$151**
12	INSTRUMENTATION & CONTROL													
12.1	PC Control Equipment	w/12.7	0	w/12.7	0	0	0%	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%	0	0	0
12.3	Steam Turbine Control	w/8.1	0	w/8.1	0	0	0%	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%	0	0	0
12.5	Signal Processing Equipment	W/12.7	0	w/12.7	0	0	0%	0	0%	0	0.0%	0	0	0
12.6	Control Boards, Panels & Racks	551	0	330	0	881	10%	85	0%	0	15.0%	145	1,111	2
12.7	Computer Accessories	5,563	0	972	0	6,535	10%	622	0%	0	10.0%	716	7,873	14
12.8	Instrument Wiring & Tubing	3,016	0	5,983	0	8,999	9%	767	0%	0	15.0%	1,465	11,230	20
12.9	Other I & C Equipment	1,572	0	3,567	0	5,139	10%	500	0%	0	10.0%	564	6,203	11
	SUBTOTAL 12.	**$10,702**	**$0**	**$10,852**	**$0**	**$21,554**		**$1,974**		**$0**		**$2,889**	**$26,417**	**$48**
13	IMPROVEMENTS TO SITE													
13.1	Site Preparation	0	56	1,128	0	1,184	9.9%	117	0%	0	20.0%	260	1,561	3
13.2	Site Improvements	0	1,872	2,325	0	4,197	9.8%	412	0%	0	20.0%	922	5,531	10
13.3	Site Facilities	3,355	0	3,308	0	6,663	9.8%	654	0%	0	20.0%	1,463	8,780	16
	SUBTOTAL 13.	**$3,355**	**$1,928**	**$6,761**	**$0**	**$12,043**		**$1,183**		**$0**		**$2,645**	**$15,871**	**$29**
14	BUILDINGS & STRUCTURES													
14.1	Boiler Building	0	9,817	8,633	0	18,450	9.0%	1,657	0%	0	15.0%	3,016	23,123	42
14.2	Turbine Building	0	12,938	12,059	0	24,997	9.0%	2,251	0%	0	15.0%	4,087	31,335	57
14.3	Administration Building	0	648	685	0	1,332	9.1%	121	0%	0	15.0%	218	1,671	3
14.4	Circulation Water Pumphouse	0	222	176	0	398	8.9%	36	0%	0	15.0%	65	499	1
14.5	Water Treatment Buildings	0	614	506	0	1,120	9.0%	100	0%	0	15.0%	183	1,404	3
14.6	Machine Shop	0	433	291	0	724	8.9%	64	0%	0	15.0%	118	906	2
14.7	Warehouse	0	293	294	0	588	9.0%	53	0%	0	15.0%	96	737	1
14.8	Other Buildings & Structures	0	240	204	0	444	9.0%	40	0%	0	15.0%	73	556	1
14.9	Waste Treating Building & Str.	0	444	1,347	0	1,791	9.4%	169	0%	0	15.0%	294	2,254	4
	SUBTOTAL 14.	**$0**	**$25,649**	**$24,195**	**$0**	**$49,845**		**$4,491**		**$0**		**$8,150**	**$62,486**	**$114**
	Total Cost	**$820,672**	**$59,496**	**$492,145**	**$0**	**$1,372,313**		**$130,455**		**$50,118**		**$186,881**	**$1,739,766**	**$3,163**

Exhibit 6-42 Case L12F Initial and Annual O&M Expenses

INITIAL & ANNUAL O&M EXPENSES						
Case:	Case L12F - Oxyfuel Supercritical PC w/ CO2 Capture					
Plant Size (MWe):	550.04			**Heat Rate (Btu/kWh):**		11,404
Primary/Secondary Fuel:	North Dakota Lignite Coal			**Fuel Cost ($/MM Btu):**		0.90
Design/Construction	4 years			**Book Life (yrs):**		20
TPC (Plant Cost) Year:	Jan 2007			**TPI Year:**		2015
Capacity Factor (%):	85			**CO_2 Captured (TPD):**		14963

OPERATING & MAINTENANCE LABOR

Operating Labor

Operating Labor Rate (base):	$33.00	$/hour
Operating Labor Burden:	30.00	% of base
Labor Overhead Charge:	25.00	% of labor

Operating Labor Requirements per Shift:	**units/mod.**	**Total Plant**
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 Operating Jobs	14.0	14.0

	$	**$/kW-net**
Annual Operating Labor Cost (calc'd)	5,261,256	9.57
Maintenance Labor Cost (calc'd)	12,097,127	21.99
Administrative & Support Labor (calc'd)	4,339,596	7.89
	21,697,979	**39.45**

VARIABLE OPERATING COSTS

	$	**$/kWh-net**
Maintenance Material Costs (calc'd)	**$18,145,691**	**0.00443**

Consumables	**Consumption Initial**	**Consumption /Day**	**Unit Cost**	**Initial Cost**	**$**	**$/kWh-net**
Water (/1000 gallons)	0	6,968	1.03	$0	$2,226,809	0.00054
Chemicals						
MU & WT Chem. (lb)	236,121	33,732	0.16	$38,913	$1,724,670	0.00042
Limestone (ton)	938	134	20.60	$19,328	$856,640	0.00021
Carbon (Hg Removal) (lb)	0	0	1.00	$0	$0	0.00000
MEA Solvent (ton)	1,060	0	2142.40	$2,270,572	$0	0.00000
Caustic Soda, NaOH (ton)	0	0	412.96	$0	$0	0.00000
Sulfuric acid, H_2SO_4 (ton)	0	0	132.15	$0	$0	0.00000
Corrosion Inhibitor	0	0	0.00	$0	$0	0.00000
Activated C, MEA (lb)	0	0	1.00	$0	$0	0.00000
Ammonia, 28% soln (ton)	0	0	123.60	$0	$0	0.00000
Subtotal Chemicals				**$2,328,812**	**$2,581,310**	**0.00063**
Other						
Supplemental Fuel (MMBtu)	0	0	6.75	$0	$0	0.00000
SCR Catalyst Replacement (m^3)	w/equip.	0.0000	5500.00	$0	$0	0.00000
Emission Penalties	0	0	0.00	$0	$0	0.00000
Subtotal Other				**$0**	**$0**	**0.00000**
Waste Disposal						
Spent Mercury Catalyst (lb)	0	0	0.31	$0	$0	0.00000
Flyash (ton)	0	823	15.45	$0	$3,944,065	0.00096
Bottom Ash (ton)	0	138	15.45	$0	$662,016	0.00016
Subtotal Solid Waste Disposal				**$0**	**$4,606,081**	**0.00112**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	0.00000
Sulfur (tons)	0	0	0.00	$0	$0	0.00000
Subtotal By-Products				**$0**	**$0**	**0.00000**
TOTAL VARIABLE OPERATING COSTS					**$27,559,892**	**0.00673**
Coal FUEL (tons)	**341,260**	**11,375**	**11.97**	**$4,084,884**	**$42,244,511**	**0.01031**
NATURAL GAS FUEL (Mscf)	**0**	**0**	**6.93**	**$0**	**$0**	**0.00000**

6.5.2 Cost and Performance Summary for Cryogenic PC Oxycombustion Cases

A summary of plant costs and performance for all of the cryogenic PC oxycombustion cases is shown in Exhibit 6-43, along with the base case (air-fired without capture), S12A.

Exhibit 6-43 Cost and Performance Results for Cryogenic Oxycombustion Cases

Case	S12A	S12C	S12D	S12E	S12F	L12F
Gross Power Output, MW_e	582.7	774.9	778.0	751.5	755.6	760.5
Net Power Output, MW_e	550.0	550.0	550.1	550.0	550.0	550.0
Net Plant Efficiency, % (HHV)	38.7	30.9	30.5	31.2	31.0	29.9
Net Plant Heat Rate, Btu/kWh (HHV)	8,822	11,029	11,205	10,944	11,009	11,404
Total Plant Cost, $x1000	1,018,074	1,543,728	1,688,532	1,693,899	1,701,258	1,739,766
Total Plant Cost, $/kW	1,851	2,807	3,070	3,080	3,093	3,163
CO_2 Capital Cost Penalty[a], $/kW	0.0	955.7	1,218.7	1,228.8	1,242.1	1,312.0
Levelized Cost of Electricity, ¢/kWh (85% Capacity Factor)	5.88	8.85	9.55	9.56	9.60	10.23
Levelized COE CO_2 Penalty[b], ¢/kWh (85% Capacity Factor)	0.00	2.97	3.67	3.67	3.72	4.35
Percent increase in COE[c], (85% Capacity Factor)	0.00%	33.57%	41.45%	41.49%	41.96%	49.09%
Total CO_2 Emitted, lb/MWh_{net}	1,894	0	0	210	215	227
Cost of CO_2 Avoided[d], $/ton	--	31.4	38.8	43.6	44.2	52.2
Total CO_2 Captured, lb/MWh_{net}	0	2,363	2,397	2,130	2,140	2,267
Cost of CO_2 Captured[e], $/ton	--	25.2	30.6	34.5	34.7	38.3

a. CO_2 Capital Cost Penalty = TPC with capture – TPC case S12A air-fired without capture
b. CO_2 LCOE Cost Penalty = LCOE with capture – LCOE case S12A air-fired without capture
c. Relative to Case S12A ("Base Case")
d. CO_2 Cost Avoided = (COE with capture – COE without capture)/(Emissions without capture – Emissions with capture)
e. CO_2 Cost Captured (or Removal) = (COE with capture – COE without capture)/(CO_2 Captured)
Costs do not include CO_2 Transport, Storage, and Monitoring

7. SUPERCRITICAL OXYCOMBUSTION SENSITIVITY STUDY

Two SC PC-fired, Rankine–cycle, oxycombustion power plant designs were evaluated for sensitivity study purpose. (Refer to case description in Exhibit ES-0-1).

Both sensitivity cases use cryogenic ASU to provide oxygen and use PRB coal. The configurations and ambient conditions of these cases are the same as those in Case S12D, except that S12DSen2 features a different type of ASU. The purpose of this sensitivity study is to evaluate the economic impact resulting from the use of a different type of ASU (capital cost and operating cost trade-off). The newer generation ASU, optimized for oxycombustion, is characterized by larger size, lower pressure, and higher oxygen purity (95–98%), as well as other improvements proprietary to Air Liquide. The optimized ASU has a higher energy efficiency, which reduces operating cost; however, it also requires a higher capital cost.

7.1 PLANT CONFIGURATION SUMMARY

All the designs have a nominal net output of 550 MWe. Both USC oxycombustion plants use a single reheat 24.1MPa/593°C/593°C (3,500psig/1,100°F/1,100°F) cycle. Case S12DSen2 differs from Case S12DSen1 in that S12DSen2 adopted the same ASU as the bituminous oxycombustion study [56]. The following is a brief description of these two cases covered in this section:

Case S12DSen1– This is one of the two sensitivity study cases. This sensitivity study case evaluates the effect of ambient temperature and pressure on the performance of an oxycombustion plant. The configuration of the case is the same as case S12D, except this case is assuming ISO ambient conditions.

Case S12DSen2 – This is the second sensitivity case. The purpose of this sensitivity study is to evaluate the performance of different ASU systems and the trade-off between capital cost and operating cost. This case assumes the same configuration and ISO condition as case S12Dsen1, except using a different ASU, adopting the type of ASU used in the bituminous oxycombustion study [56].

Oxycombustion PC plants are assumed to be built on a greenfield site and utilize flue gas recycle for flame temperature control. Major systems for each plant (described in Section 3) include the following:

1. Oxycombustion optimized ASU (Case S12DSen2 only)
2. SC PC Boiler/Steam Generator
3. Dry FGD
4. CPU with Distillation (Specification 3b)
5. Steam Generator

Support facilities include coal handling (receiving, crushing, storing, and drying), limestone handling (including receiving, crushing, storing, and feeding), solid waste disposal, circulating water system with evaporative mechanical draft cooling towers, wastewater treatment, and other ancillary systems equipment necessary for an efficient, highly available, and completely operable facility.

The plant designs are based on using components suitable for a 30-year life, with provision for periodic maintenance and replacement of critical parts. All equipment is based on compliance with the latest applicable codes and standards. The American Society of Mechanical Engineers (ASME), the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers (IEEE), the National Fire Protection Association (NFPA), the Clean Air Act (CAA), state regulations, and the Occupational Safety and Health Administrations (OSHA) codes are all adhered to in the design approach.

7.2 MODEL ASSUMPTIONS FOR SC OXYCOMBUSTION SENSITIVITY CASES

The modeling assumptions used to generate the SC oxycombustion PC case material and energy balances are summarized in Exhibit 7-1. Although the oxygen purity (95 percent) is the same for both cases, different types of ASUs are adopted for this sensitivity study. S12DSen1 uses the optimized ASU with a lower energy consumption, while S12DSen2 uses the conventional ASU with a lower capital cost.

Exhibit 7-1 Modeling Assumptions for Supercritical Oxycombustion Cases

Coal Type	**PRB**	**PRB**
Case	S12DSen1	S12DSen2
Throttle pressure, psig	3,500	3,500
Throttle temperature, ºF	1,100	1,100
Reheat temperature, ºF	1,100	1,100
Condenser pressure, in Hg	1.4	1.4
Cooling water to condenser, ºF	60	60
Cooling water from condenser, ºF	80	80
CO_2 Purifier Vent temperature, °F	48	48
Coal HHV (PRB), Btu/lb	8,564	8,564
FGD efficiency, %	93	93
SOx emissions, lb/MMBtu	0.1	0.1
NOx emissions, lb/MMBtu	0.07	0.07
Baghouse efficiency, %	99.8	99.8
Particulate emissions PM/PM_{10}, lb/MMBtu	0.015	0.015
Mercury removal, %	90	90
ASU Oxygen Purity, %	95	95
CO_2 Capture Efficiency, %[a]	90.9	90.9
Product CO_2 Condition, psia/°F	2220/81	2220/81
Product CO_2 Specification[b]	3b	3b

[a] Percentage of CO_2 in flue gas

[b]Refer Section 3.6.1 for more description of product CO_2 specification.

Material and energy balance information, environmental performance, and a major equipment list for the two oxycombustion cases are summarized in Section 7.3

7.3 PERFORMANCE RESULTS FOR CASES S12DSEN1 AND S12DSEN2

Process block flow diagram for the SC CO_2 capture case (with cryogenic distillation CO_2 purification option), S12DSen1 and S12DSen2, are shown in Exhibit 7-2 and Exhibit 7-4, and the corresponding stream tables are shown in Exhibit 7-3 and Exhibit 7-5**.**

Overall performance for cases S12DSen1 and S12DSen2 is summarized in Exhibit 7-6, which includes auxiliary power requirements.

7.3.1 Block Flow Diagram and Stream Table

Exhibit 7-2 Case S12DSen1 Process Block Flow Diagram

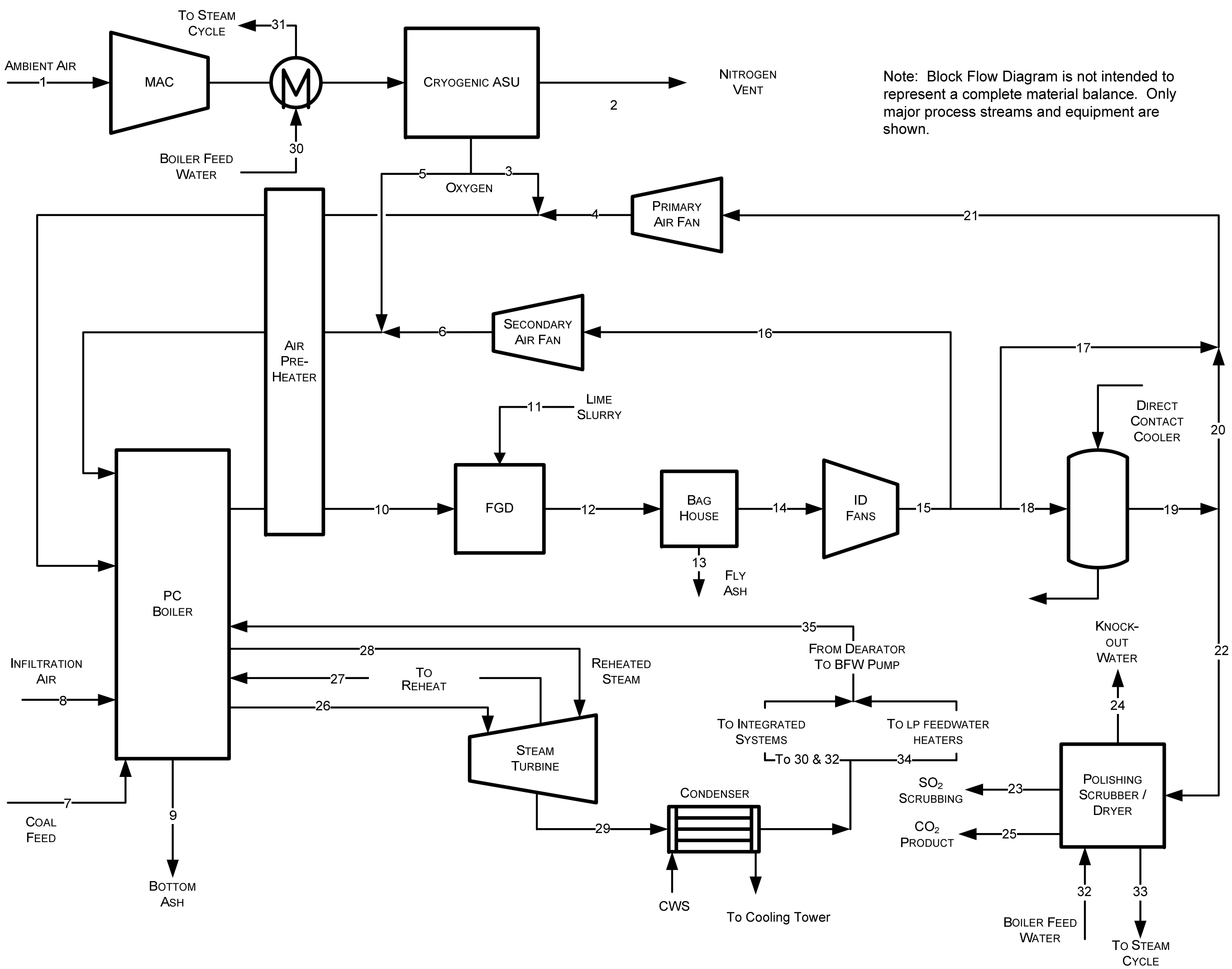

Exhibit 7-3 Case S12DSen1 Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
V-L Mole Fraction																		
Ar	0.0092	0.0025	0.0343	0.0292	0.0343	0.0234	0.0000	0.0092	0.0000	0.0244	0.0000	0.0234	0.0000	0.0234	0.0234	0.0234	0.0234	0.0234
CO_2	0.0003	0.0004	0.0000	0.6833	0.0000	0.5476	0.0000	0.0003	0.0000	0.5726	0.0000	0.5476	0.0000	0.5476	0.5476	0.5476	0.5476	0.5476
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	0.0000	0.0000	0.0000	0.0000
H_2O	0.0099	0.0125	0.0000	0.1769	0.0000	0.3403	0.0000	0.0099	0.0000	0.3092	1.0000	0.3403	0.0000	0.3403	0.3403	0.3403	0.3403	0.3403
N_2	0.7732	0.9783	0.0162	0.0745	0.0162	0.0597	0.0000	0.7732	0.0000	0.0624	0.0000	0.0597	0.0000	0.0597	0.0597	0.0597	0.0597	0.0597
O_2	0.2074	0.0063	0.9495	0.0360	0.9495	0.0289	0.0000	0.2074	0.0000	0.0302	0.0000	0.0289	0.0000	0.0289	0.0289	0.0289	0.0289	0.0289
SO_2	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0011	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	77,700	61,135	5,798	20,220	10,767	23,776	0	1,467	0	70,676	3,334	73,901	0	73,901	73,901	23,776	2,597	47,528
V-L Flowrate (kg/hr)	2,242,198	1,708,687	186,729	761,675	346,782	802,858	0	42,342	0	2,440,646	60,064	2,495,423	0	2,495,423	2,495,423	802,858	87,693	1,604,871
Solids Flowrate (kg/hr)	0	0	0	0	0	0	327,036	0	5,355	21,421	5,193	31,902	31,902	0	0	0	0	0
Temperature (°C)	15	14	14	72	14	103	15	15	145	145	15	91	91	91	100	100	100	100
Pressure (MPa, abs)	0.10	0.31	0.15	0.11	0.15	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Enthalpy (kJ/kg)[A]	30.23	19.81	12.12	278.98	12.12	561.96	---	30.23	---	631.09	304.24	617.20	---	549.30	558.57	558.57	558.57	558.57
Density (kg/m^3)	1.2	3.7	2.0	1.5	2.0	1.1	---	1.2	---	1.0	1,003.1	1.1	---	1.1	1.1	1.1	1.1	1.1
V-L Molecular Weight	28.857	27.949	32.207	37.669	32.207	33.767	---	28.857	---	34.533	18.015	33.767	---	33.767	33.767	33.767	33.767	33.767
V-L Flowrate (lb_{mol}/hr)	171,300	134,780	12,782	44,578	23,738	52,418	0	3,235	0	155,813	7,350	162,924	0	162,924	162,924	52,418	5,725	104,781
V-L Flowrate (lb/hr)	4,943,201	3,767,010	411,667	1,679,205	764,524	1,770,000	0	93,348	0	5,380,703	132,419	5,501,466	0	5,501,466	5,501,466	1,770,000	193,330	3,538,136
Solids Flowrate (lb/hr)	0	0	0	0	0	0	720,990	0	11,806	47,225	11,450	70,331	70,331	0	0	0	0	0
Temperature (°F)	59	57	57	162	57	217	59	59	294	294	59	197	196	196	212	212	212	212
Pressure (psia)	14.7	45.0	22.0	16.1	22.0	15.3	14.7	14.7	14.4	14.4	15.0	14.0	13.8	13.8	14.9	14.9	14.9	14.9
Enthalpy (Btu/lb)[A]	13.0	8.5	5.2	119.9	5.2	241.6	---	13.0	---	271.3	130.8	265.3	---	236.2	240.1	240.1	240.1	240.1
Density (lb/ft^3)	0.076	0.229	0.128	0.091	0.128	0.071	---	0.076	---	0.062	62.622	0.067	---	0.066	0.070	0.070	0.070	0.070

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 7-3 Case S12DSen1 Stream Table (Continued)

	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
V-L Mole Fraction																	
Ar	0.0300	0.0300	0.0292	0.0300	0.0004	0.0000	0.0354	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.7032	0.7032	0.6833	0.7032	0.0076	0.0000	0.8301	0.0000	0.0000	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	0.0000	0.0000	0.0000	0.0000
H_2O	0.1529	0.1529	0.1769	0.1529	0.9913	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.0767	0.0767	0.0745	0.0767	0.0000	0.0000	0.0907	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0371	0.0371	0.0360	0.0371	0.0000	0.0000	0.0439	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	0.0001	0.0001	0.0007	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	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	37,009	17,623	20,220	19,386	2,562	423	16,400	119,359	99,175	99,175	89,013	20,548	20,548	26,633	26,633	41,833	119,359
V-L Flowrate (kg/hr)	1,415,368	673,981	761,675	741,387	46,777	7,620	686,989	2,150,290	1,786,674	1,786,674	1,603,598	370,176	370,176	479,792	479,792	753,630	2,150,290
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	57	57	63	57	57	44	35	593	354	593	38	52	141	52	146	52	176
Pressure (MPa, abs)	0.10	0.10	0.10	0.10	0.10	0.10	15.16	24.23	4.90	4.52	0.01	1.65	1.63	1.65	1.64	1.65	0.91
Enthalpy (kJ/kg)[A]	232.21	232.21	269.78	232.21	146.91	85.19	-145.52	3,476.62	3,081.93	3,652.22	2,206.99	217.35	591.45	217.35	616.44	217.35	744.69
Density (kg/m^3)	1.4	1.4	1.4	1.4	62.3	975.1	560.0	69.2	18.7	11.6	0.1	988.0	926.1	988.0	920.8	988.0	891.1
V-L Molecular Weight	38.244	38.244	37.669	38.244	18.255	18.015	41.889	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	81,591	38,852	44,578	42,738	5,649	933	36,156	263,142	218,645	218,645	196,240	45,300	45,300	58,715	58,715	92,226	263,142
V-L Flowrate (lb/hr)	3,120,352	1,485,875	1,679,205	1,634,477	103,126	16,800	1,514,552	4,740,579	3,938,942	3,938,942	3,535,328	816,098	816,098	1,057,761	1,057,761	1,661,469	4,740,579
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	135	135	145	135	135	111	95	1,100	669	1,100	101	125	285	125	296	125	349
Pressure (psia)	14.7	14.7	14.7	14.7	14.7	14.7	2,199.0	3,514.7	710.8	655.8	1.0	240.0	237.1	240.0	238.5	240.0	132.7
Enthalpy (Btu/lb)[A]	99.8	99.8	116.0	99.8	63.2	36.6	-62.6	1,494.7	1,325.0	1,570.2	948.8	93.4	254.3	93.4	265.0	93.4	320.2
Density (lb/ft^3)	0.088	0.088	0.086	0.088	3.887	60.871	34.962	4.319	1.165	0.722	0.003	61.678	57.814	61.678	57.484	61.678	55.627

Exhibit 7-4 Case S12DSen2 Process Block Flow Diagram

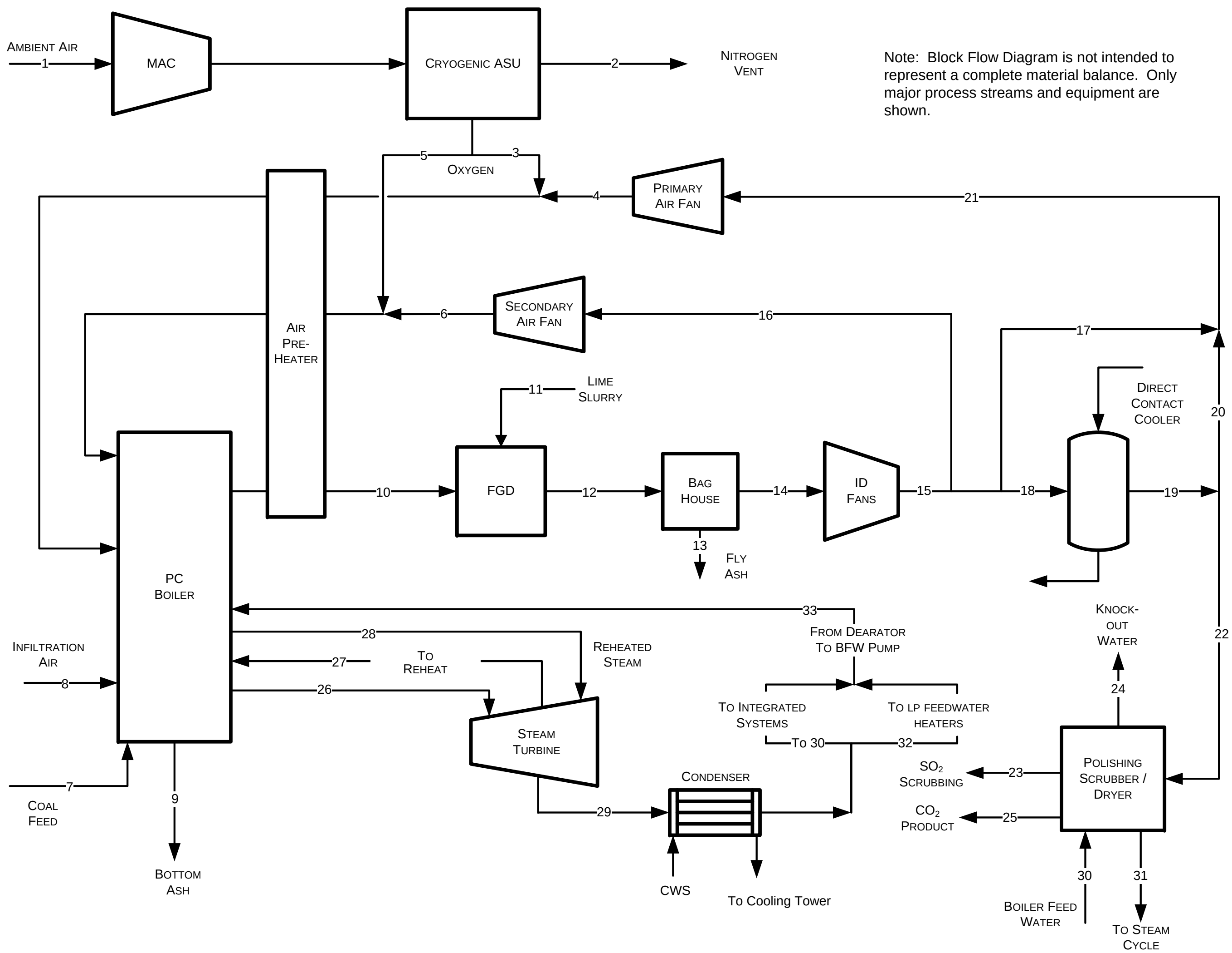

Exhibit 7-5 Case S12DSen2 Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
V-L Mole Fraction																	
Ar	0.0092	0.0025	0.0343	0.0292	0.0343	0.0234	0.0000	0.0092	0.0000	0.0244	0.0000	0.0234	0.0000	0.0234	0.0234	0.0234	0.0234
CO_2	0.0003	0.0004	0.0000	0.6849	0.0000	0.5476	0.0000	0.0003	0.0000	0.5725	0.0000	0.5476	0.0000	0.5476	0.5476	0.5476	0.5476
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	0.0000	0.0000	0.0000
H_2O	0.0099	0.0125	0.0000	0.1752	0.0000	0.3406	0.0000	0.0099	0.0000	0.3095	1.0000	0.3406	0.0000	0.3406	0.3406	0.3406	0.3406
N_2	0.7732	0.9783	0.0162	0.0747	0.0162	0.0597	0.0000	0.7732	0.0000	0.0624	0.0000	0.0597	0.0000	0.0597	0.0597	0.0597	0.0597
O_2	0.2074	0.0063	0.9495	0.0359	0.9495	0.0287	0.0000	0.2074	0.0000	0.0300	0.0000	0.0287	0.0000	0.0287	0.0287	0.0287	0.0287
SO_2	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0011	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	83,994	66,087	6,267	21,841	11,639	27,404	0	1,587	0	78,088	3,674	81,645	0	81,645	81,645	27,404	2,600
V-L Flowrate (kg/hr)	2,423,798	1,847,077	201,852	823,680	374,869	925,248	0	45,786	0	2,696,114	66,187	2,756,581	0	2,756,581	2,756,581	925,248	87,784
Solids Flowrate (kg/hr)	0	0	0	0	0	0	353,632	0	5,791	23,163	5,635	34,518	34,518	0	0	0	0
Temperature (°C)	15	17	13	72	13	103	15	15	145	145	15	91	91	91	100	100	100
Pressure (MPa, abs)	0.10	0.10	0.16	0.11	0.16	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Enthalpy (kJ/kg)[A]	30.23	37.88	10.99	276.20	10.99	562.35	---	30.23	---	630.07	299.27	616.19	---	549.70	558.96	558.96	558.96
Density (kg/m^3)	1.2	1.2	2.2	1.5	2.2	1.1	---	1.2	---	1.0	1,003.1	1.1	---	1.1	1.1	1.1	1.1
V-L Molecular Weight	28.857	27.949	32.207	37.713	32.207	33.763	---	28.857	---	34.527	18.015	33.763	---	33.763	33.763	33.763	33.763
V-L Flowrate (lb_{mol}/hr)	185,174	145,696	13,817	48,151	25,660	60,416	0	3,498	0	172,155	8,100	179,996	0	179,996	179,996	60,416	5,732
V-L Flowrate (lb/hr)	5,343,560	4,072,107	445,009	1,815,905	826,444	2,039,823	0	100,940	0	5,943,913	145,918	6,077,220	0	6,077,220	6,077,220	2,039,823	193,530
Solids Flowrate (lb/hr)	0	0	0	0	0	0	779,625	0	12,766	51,066	12,423	76,099	76,099	0	0	0	0
Temperature (°F)	59	63	55	161	55	217	59	59	294	294	59	197	196	196	212	212	212
Pressure (psia)	14.7	14.7	23.2	16.1	23.2	15.3	14.7	14.7	14.4	14.4	15.0	14.0	13.8	13.8	14.9	14.9	14.9
Enthalpy (Btu/lb)[A]	13.0	16.3	4.7	118.7	4.7	241.8	---	13.0	---	270.9	128.7	264.9	---	236.3	240.3	240.3	240.3
Density (lb/ft^3)	0.076	0.073	0.136	0.091	0.136	0.071	---	0.076	---	0.062	62.622	0.067	---	0.066	0.070	0.070	0.070

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 7-5 Case S12DSen2 Stream Table (Continued)

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
V-L Mole Fraction																
Ar	0.0234	0.0300	0.0300	0.0292	0.0300	0.0004	0.0000	0.0354	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.5476	0.7035	0.7035	0.6849	0.7035	0.0076	0.0000	0.8303	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	0.0000	0.0000	0.0000
H_2O	0.3406	0.1529	0.1529	0.1752	0.1529	0.9913	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.0597	0.0767	0.0767	0.0747	0.0767	0.0000	0.0000	0.0907	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0287	0.0369	0.0369	0.0359	0.0369	0.0000	0.0000	0.0436	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SO_2	0.0001	0.0001	0.0001	0.0001	0.0001	0.0007	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	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	51,641	40,197	19,241	21,841	20,956	2,770	457	17,729	128,968	107,222	107,222	96,415	28,794	28,794	67,621	128,968
V-L Flowrate (kg/hr)	1,743,551	1,537,379	735,897	823,680	801,482	50,563	8,237	742,682	2,323,392	1,931,631	1,931,631	1,736,949	518,733	518,733	1,218,216	2,323,392
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	100	57	57	62	57	57	44	35	593	354	593	38	52	146	52	176
Pressure (MPa, abs)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	15.16	24.23	4.90	4.52	0.01	1.65	1.64	1.65	0.91
Enthalpy (kJ/kg)[A]	558.96	232.20	232.20	267.02	232.20	146.91	85.19	-145.61	3,476.62	3,081.69	3,652.22	2,132.61	217.35	616.44	217.35	744.69
Density (kg/m^3)	1.1	1.4	1.4	1.4	1.4	62.3	975.1	560.3	69.2	18.7	11.6	0.1	988.0	920.8	988.0	891.1
V-L Molecular Weight	33.763	38.246	38.246	37.713	38.246	18.254	18.015	41.892	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	113,848	88,618	42,419	48,151	46,199	6,107	1,008	39,085	284,325	236,384	236,384	212,559	63,480	63,480	149,079	284,325
V-L Flowrate (lb/hr)	3,843,871	3,389,341	1,622,375	1,815,905	1,766,966	111,473	18,160	1,637,333	5,122,203	4,258,517	4,258,517	3,829,318	1,143,610	1,143,610	2,685,707	5,122,203
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	212	135	135	144	135	135	111	95	1,100	668	1,100	101	125	296	125	349
Pressure (psia)	14.9	14.7	14.7	14.7	14.7	14.7	14.7	2,199.0	3,514.7	710.8	655.8	1.0	240.0	238.5	240.0	132.7
Enthalpy (Btu/lb)[A]	240.3	99.8	99.8	114.8	99.8	63.2	36.6	-62.6	1,494.7	1,324.9	1,570.2	916.9	93.4	265.0	93.4	320.2
Density (lb/ft^3)	0.070	0.088	0.088	0.086	0.088	3.892	60.871	34.980	4.319	1.166	0.722	0.004	61.678	57.484	61.678	55.627

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7.3.2 Plant Power Summary

Exhibit 7-6 Case S12DSen1 and S12DSen2 Plant Power Summary

Plant Output			
	Case S12DSen1	**Case S12DSen2**	
Steam Turbine Power	763,900	817,900	kW_e
Total	**763,900**	**817,900**	kW_e
Auxiliary Load			
Coal Handling and Conveying	580	610	kW_e
Pulverizers	4,900	5,300	kW_e
Sorbent Handling & Reagent Preparation	180	200	kW_e
Ash Handling	1,100	1,190	kW_e
Primary Air Fans	2,020	2,180	kW_e
Forced Draft Fans	800	920	kW_e
Induced Draft Fans	6,650	7,350	kW_e
Main Air Compressor	90,010	134,280	kW_e
ASU Auxiliaries	1,000	1,000	kW_e
Baghouse	150	170	kW_e
Spray Dryer FGD	2,980	3,230	kW_e
CPU (including Compression)	82,920	89,640	kW_e
Miscellaneous Balance of Plant[a,b]	2,000	2,000	kW_e
Steam Turbine Auxiliaries	400	400	kW_e
Condensate Pumps	1,010	1,080	kW_e
Circulating Water Pumps	8,570	9,110	kW_e
Ground Water Pumps	740	780	kW_e
Cooling Tower Fans	4,970	5,280	kW_e
Air Cooled Condenser Fans	13,170	13,750	kW_e
Transformer Losses	2,870	3,180	kW_e
Total	227,020	281,650	kW_e
Plant Performance			
Net Plant Power	550,050	550,000	kW_e
Net Exported Power Efficiency (HHV)	30.40%	28.11%	
Net Plant Heat Rate (HHV)	11,843 (11,225)	12,808 (12,139)	kJ/kWhr (Btu/kWhr)
Coal Feed Flowrate	327,036 (720,990)	353,632 (779,625)	kg/hr (lb/hr)
Thermal Input[c]	1,809,585	1,956,751	kW_{th}
Condenser Duty	3,282 (3,110)	3,425 (3,247)	GJ/hr (MMBtu/hr)
Raw Water Withdrawal	30.9 (8,166)	32.8 (8,662)	m^3/min (gpm)

[a] Boiler feed pumps are turbine driven
[b] Includes plant control systems, lighting, HVAC, and miscellaneous low voltage loads
[c] HHV of as-received Rosebud PRB coal is 19,920 kJ/kg (8,564 Btu/lb)

7.3.3 Energy Balance

An overall energy balance for the two plants is shown in Exhibit 7-7

Exhibit 7-7
Cases S12DSen1 and S12DSen2 Overall Energy Balance

	HHV		Sensible + Latent		Power		Total	
	S12DSEN1	S12DSEN2	S12DSEN1	S12DSEN2	S12DSEN1	S12DSEN2	S12DSEN1	S12DSEN2
Heat In, GJ/hr (MMBtu/hr)								
Coal	6,515 (6,175)	7,044 (6,677)	9.0 (8.6)	9.8 (9.3)			6,524 (6,183)	7,054 (6,686)
Combustion/ Infiltration Air			69.1 (65.5)	74.6 (70.8)			69.1 (65.5)	74.6 (70.8)
Raw Water Makeup			116.3 (110.2)	123.4 (116.9)			116.3 (110.2)	123.4 (116.9)
Lime			0.06 (0.06)	0.06 (0.06)			0.06 (0.06)	0.06 (0.06)
Auxiliary Power					770 (730)	964 (914)	770 (730)	964 (914)
Totals	**6,515 (6,175)**	**7,044 (6,677)**	**125.3 (118.8)**	**133.2 (126.2)**	**770 (730)**	**964 (914)**	**7410.3 (7023.2)**	**8141.4 (7716.9)**
Heat Out, GJ/hr (MMBtu/hr)								
Boiler Loss			58.0 (55.0)	62.7 (59.5)			58.0 (55.0)	62.7 (59.5)
Air Heater Loss			5.3 (5.1)	5.9 (5.6)			5.3 (5.1)	5.9 (5.6)
CO_2 Cooling Duty			151.5 (143.6)	163.7 (155.2)			151.5 (143.6)	163.7 (155.2)
DCC Cooling Duty			456.5 (432.6)	496.6 (470.7)			456.5 (432.6)	496.6 (470.7)
SO_2 Polishing Scrubber Cooling Duty			140.1 (132.8)	151.4 (143.5)			140.1 (132.8)	151.4 (143.5)
ASU Cold Box Pre-Cooling			200.4 (189.9)	262.2 (248.5)			200.4 (189.9)	262.2 (248.5)
Bottom Ash			0.6 (0.6)	0.7 (0.6)			0.6 (0.6)	0.7 (0.6)
Fly Ash + FGD Ash			2.3 (2.2)	2.5 (2.4)			2.3 (2.2)	2.5 (2.4)

	HHV		Sensible + Latent		Power		Total	
	S12DSEN1	S12DSEN2	S12DSEN1	S12DSEN2	S12DSEN1	S12DSEN2	S12DSEN1	S12DSEN2
Knockout Water			28.6 (27.1)	31.2 (29.5)			28.6 (27.1)	31.2 (29.5)
CPU Vent			0 (0)	0 (0)			0 (0)	0 (0)
ASU Vent Stream			34 (32)	70 (66)			34 (32)	70 (66)
Condenser			*3,282 (3,110)*	*3,425 (3,247)*			*3,282 (3,110)*	*3,425 (3,247)*
CO_2			*-100 (-95)*	*-108 (-102)*			*-100 (-95)*	*-108 (-102)*
Cooling Tower Blowdown			*55.5 (52.6)*	*58.9 (55.8)*			*55.5 (52.6)*	*58.9 (55.8)*
Process Losses[a]			*344.4 (326.5)*	*574.2 (544.2)*			*344.4 (326.5)*	*574.2 (544.2)*
ST Generator/Exhaust Losses					70 (66)	75 (71)	70 (66)	75 (71)
Power					2,750 (2,607)	2,944 (2,791)	2,750 (2,607)	2,944 (2,791)
Totals			**4,659 (4,416)**	**5,197 (4,926)**	**2,820 (2,673)**	**3,019 (2,862)**	**7,479 (7,089)**	**8,217 (7,788)**

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

7.3.4 Water Balance

An overall water balance for the plant is shown in Exhibit 7-8. Raw water 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 is re-used as internal recycle. Raw water makeup is the difference between water demand and internal recycle.

Exhibit 7-8
Case S12DSen1 and S12DSen2 Water Balance

Water Use	Water Demand, m^3/min (gpm)		Internal Recycle, m^3/min (gpm)		Raw Water Withdrawl, m^3/min (gpm)		Process Water Discharge, m^3/min (gpm)		Raw Water Consumption, m^3/min (gpm)	
	S12DSen1	S12DSen2	S12DSen1	S12DSen2	S12DSen1	S12DSen2	S12DSen1	S12DSen2	S12DSen1	S12DSen2
FGD Makeup	1.00 (265)	1.10 (292)	0.0 (0)	0.0 (0)	1.00 (265)	1.10 (292)	0.00 (0.00)	0.00 (0.00)	1.00 (264.84)	1.10 (291.84)
BFW Makeup	0.36 (95)	0.39 (102)	0.0 (0)	0.0 (0)	0.36 (95)	0.39 (102)	0.00 (0.00)	0.00 (0.00)	0.36 (94.81)	0.39 (102.44)
Cooling Tower Makeup	33.20 (8770)	35.26 (9315)	3.6 (964)	4.0 (1048)	29.55 (7806)	31.30 (8267)	7.47 (1972.43)	7.93 (2094.93)	22.08 (5834.05)	23.37 (6172.41)
Total	**34.6 (9,130)**	**36.8 (9,709)**	**3.65 (964)**	**3.97 (1048)**	**30.9 (8,166)**	**32.8 (8,662)**	**7.47 (1972.43)**	**7.93 (2094.93)**	**23.45 (6193.70)**	**24.86 (6566.69)**

7.3.5 Carbon Balance

The carbon balances for the oxycombustion PC case with CO_2 purification are shown in Exhibit 7-9. The carbon input to the plant consists of carbon in the coal, carbon in the air entering the ASU, and the infiltration air entering the boiler in addition to carbon in the coal. Carbon leaves the plant as CO_2 product, vented to the atmosphere, or as spent materials. Carbon conversion for both the air-fired and oxy-fired cases was assumed to be 100 percent. The percent of total carbon sequestered is defined as the amount of carbon product produced (as sequestration-ready CO_2) divided by the carbon in the coal feedstock, expressed as a percentage.

% Captured = Carbon in Product for Sequestration / Carbon in the Coal

or

360,477/360,986* 100= 99.9% (S12DSen1)

389,792/390,344*100 = 99.9% (S12DSen2)

Exhibit 7-9
Cases S12DSen1 and S12DSen2 Carbon Balance

Carbon In, kg/hr (lb/hr)			Carbon Out, kg/hr (lb/hr)		
	S12DSEN1	S12DSEN2		S12DSEN1	S12DSEN2
Coal	163,7471 (360,986)	177,057 (390,344)	Ash	0 (0)	0 (0)
			ASU Vent	305 (672)	330 (727)
Air (CO_2)	311 (685)	336 (740)	Stack Gas /CPU Vent	0 (0)	0 (0)
Activated Carbon	N/A	N/A	CO_2 Product	163,509 (360,477)	176,807 (389,792)
			SO_2 Scrubber	235 (518)	254 (560)
			DCC Discharge	2 (4)	2 (4)
			Convergence Tolerance[a]	0 (0)	0 (1)
Total	164,051 (361,671)	177,393 (391,084)	Total	164,051 (361,671)	177,393 (391,084)

[a] By difference

7.3.6 Sulfur Balance

Exhibit 7-10 shows the sulfur balances for the ASU sensitivity study cases S12DSen1 and S12DSen2. Sulfur input comes solely from the sulfur in the coal. Sulfur output is the sulfur combined with lime in the ash, sulfur discharge from the DCC and polishing scrubber, and the sulfur sequestered in the CO_2 product stream. The total sulfur capture is represented by the following fraction:

(Sulfur in Ash + Sulfur co-sequestered + Sulfur in waste discharge streams)/Sulfur in the coal) or
(5,245)/ 5,245*100 = 100% (**S12DSen1**)
(5,671)/ 5,671*100 = 100% (**S12DSen2**)

Exhibit 7-10
Cases S12DSen1 and S12DSen2 Sulfur Balance

Sulfur In, kg/hr (lb/hr)			Sulfur Out, kg/hr (lb/hr)		
	S12DSEN1	S12DSEN2		S12DSEN1	S12DSEN2
Coal	2,379 (5,245)	2,573 (5,671)	**Ash**	2,320 (5,115)	2,510 (5,534)
			SO_2 Polishing Scrubber	59 (130)	62 (137)
			CPU Vent	0 (0)	0 (0)
			CO_2 Product	0 (0)	0 (0)
			DCC Discharge	0 (0)	0 (0)
			Convergence Tolerance[a]	0 (0)	0 (0)
Total	2,379 (5,245)	2,573 (5,671)	**Total**	2,379 (5,245)	2,573 (5,671)

[a] By difference

7.3.7 Air Emissions

All particulate is assumed to be removed from the process stream after the baghouse by either the direct contact cooler or the SO_2 polishing scrubber, with no particulate matter being vented to the atmosphere. Mercury was assumed to be absorbed in the desiccant dryer, removed with the condensed water in CO_2 compression train, and co-sequestered with the CO_2 product stream. Eighty percent of the NO_x generated in the boiler is assumed to be vented from the CPU with the remaining NO_x, in the form of NO_2, co-sequestered. SO_2 emissions are controlled using the lime spray dryer absorber and the SO_2 polishing scrubber. Any remaining SO_2 was assumed to be co-sequestered.

Exhibit 7-11
Cases S12DSen1 and S12DSen2 Estimated Air Emissions

	kg/GJ ($lb/10^6$ Btu)		Tonne/year (ton/year) 85% capacity factor		kg/MWh (lb/MWh)	
	S12DSEN1	S12DSEN2	S12DSEN1	S12DSEN2	S12DSEN1	S12DSEN2
SO_2	--	--	--	--	--	--
NO_X	0.030 (0.070)	0.030 (0.070)	1,579 (1,740)	1,460 (1,609)	0.259 (.571)	0.257 (.566)
Particulates	0.006 (0.0130)	0.006 (0.0130)	293 (323)	271 (299)	0.048 (.106)	0.048 (.105)
Hg	1.3E-6 (3.02E-6)	2.57E-6 (5.97E-6)	0.135 (0.148)	0.124 (0.137)	2.21E-5 (4.87E-5)	2.19E-5 (4.82E-5)
CO_2	--	--	--	--	--	--

7.3.8 Heat and Mass Balance Diagrams

Heat and mass balance diagrams are shown for the following subsystems in Exhibit 7-12 through Exhibit 7-15:

- Boiler and flue gas cleanup
- Steam and feedwater

Exhibit 7-12 Case S12DSen1 Boiler and Gas Cleanup System Heat and Mass Balance Diagram

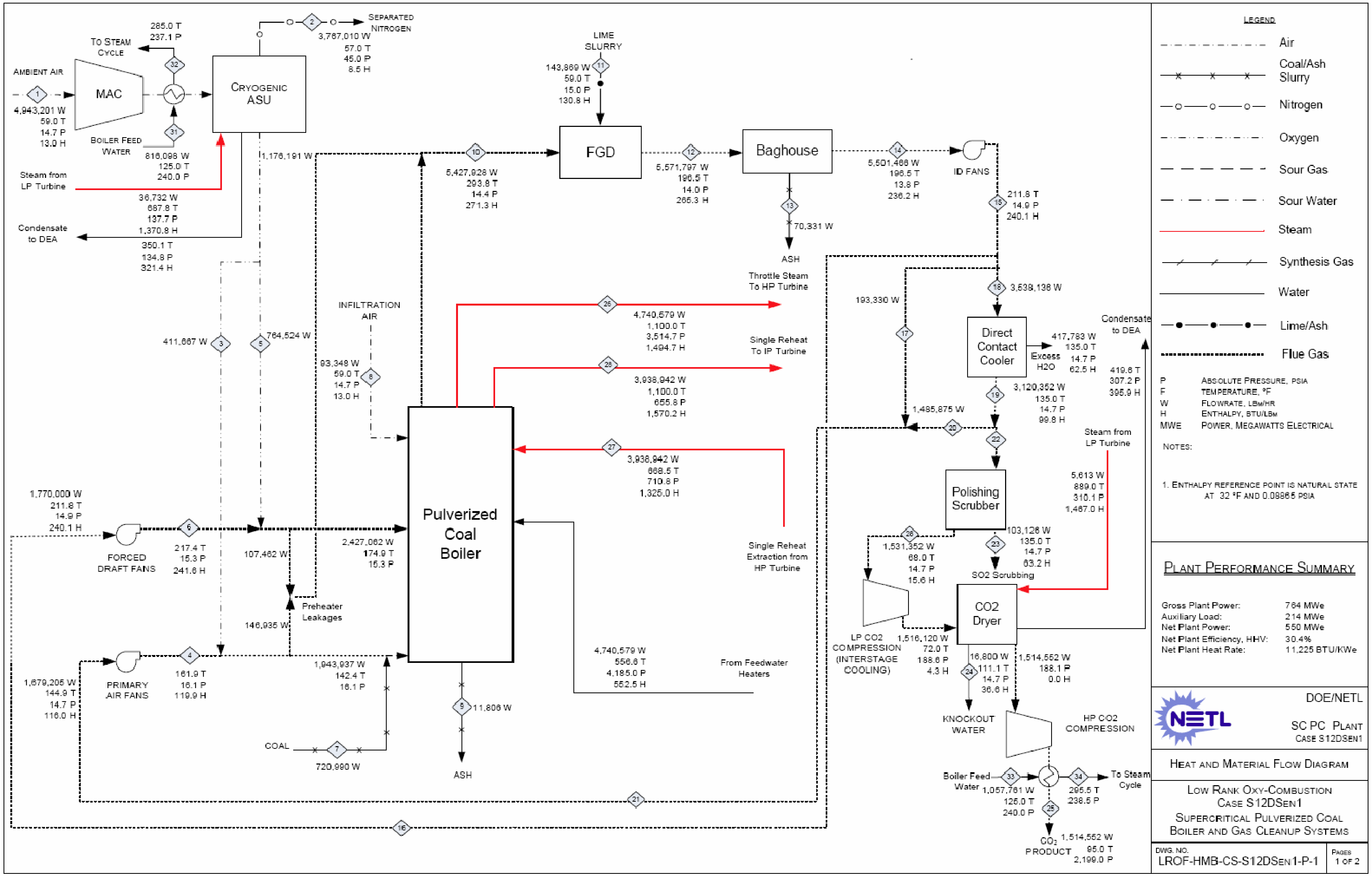


Exhibit 7-13 Case S12DSen1 Power Block System Heat and Mass Balance Diagram

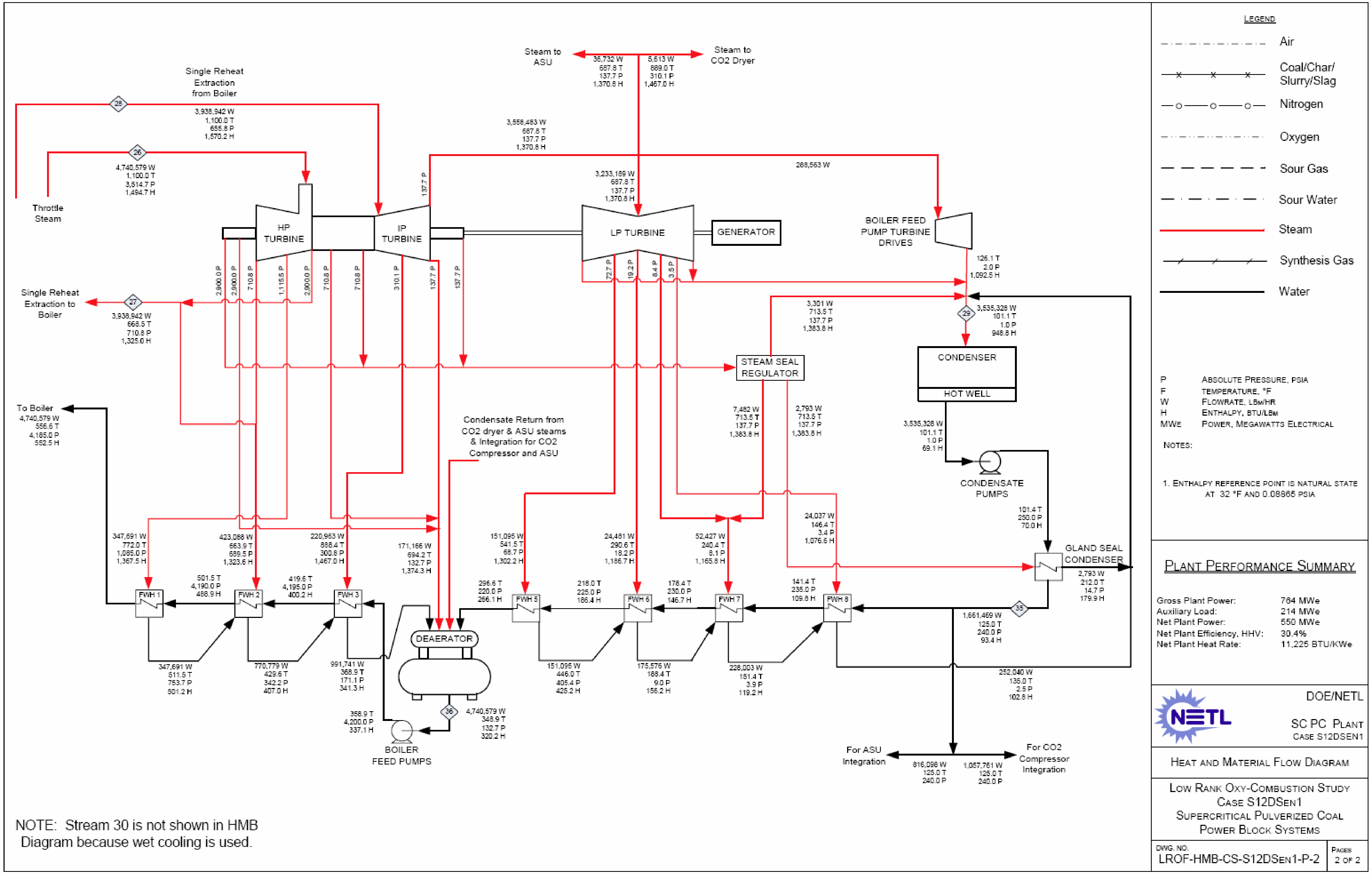


Exhibit 7-14 Case S12DSen2 Boiler and Gas Cleanup System Heat and Mass Balance Diagram

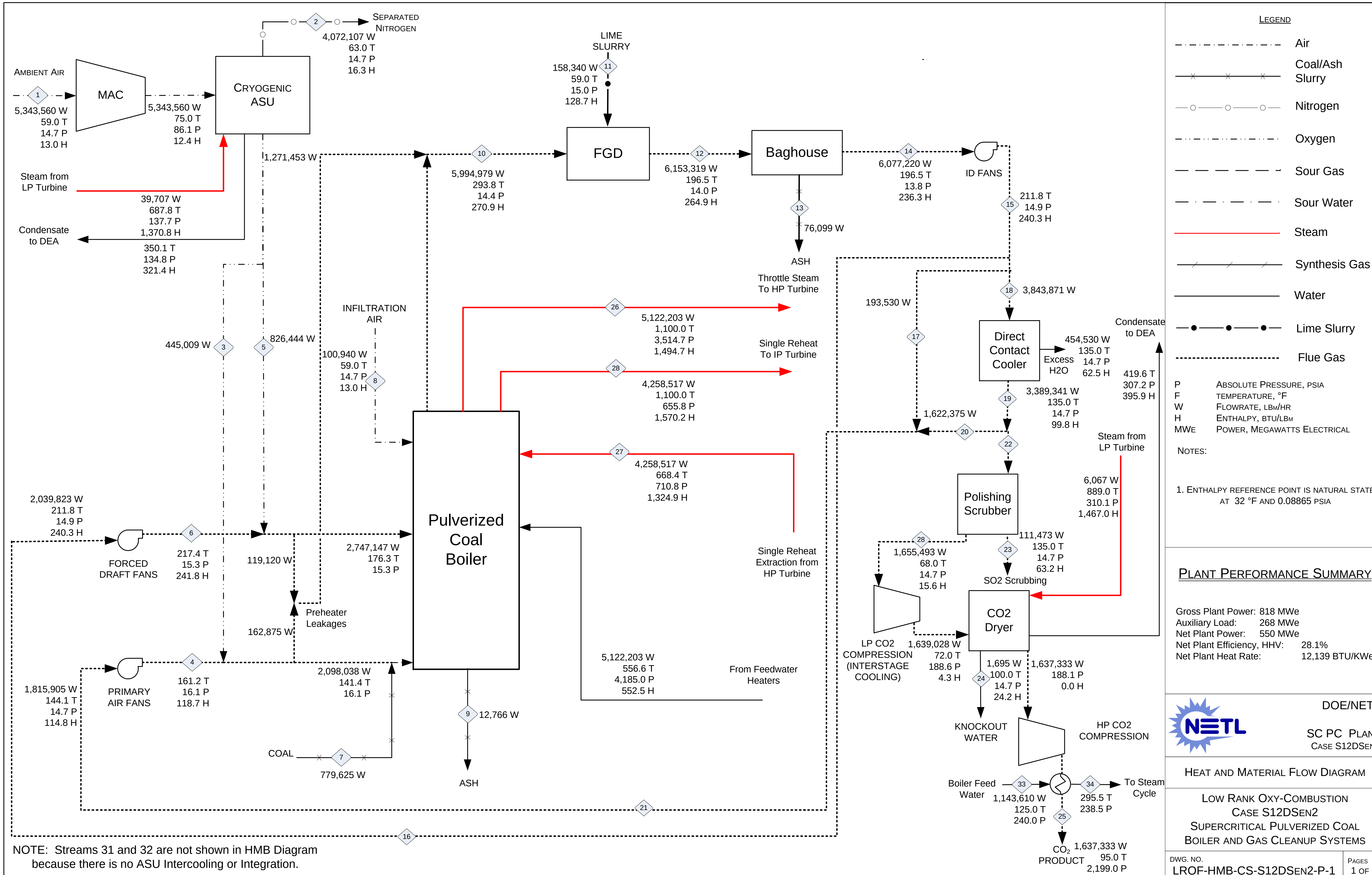
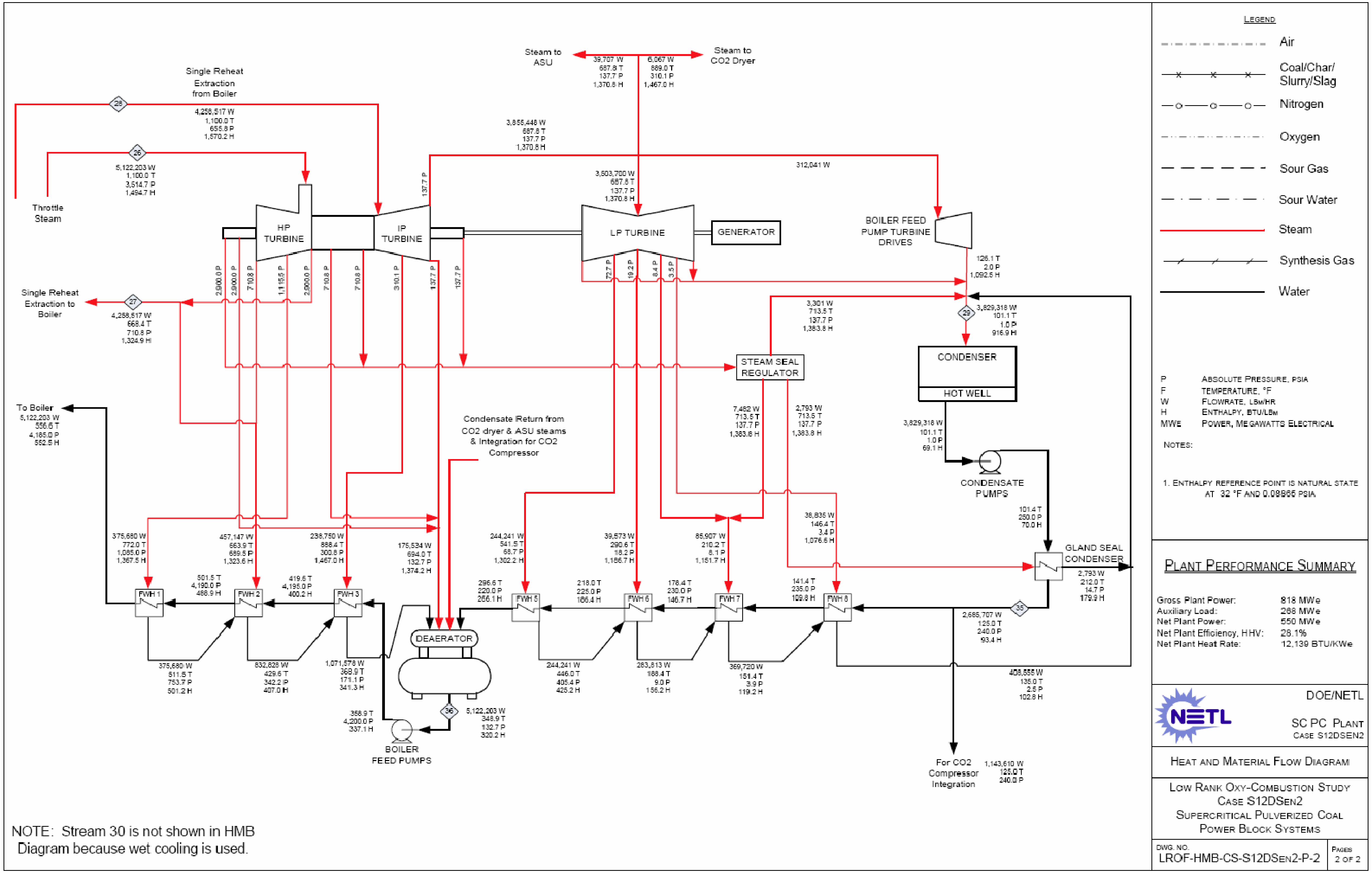


Exhibit 7-15 Case S12DSen2 Power Block System Heat and Mass Balance Diagram



7.3.9 Major Equipment List for Cases S12DSen1 and S12DSen2

Major equipment items for these cases are shown in the following tables. The accounts used in the equipment list correspond to the account numbers used in the cost estimates in Section 7.4. 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	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
1	Bottom Trestle Dumper and Receiving Hoppers	N/A	181 tonne (200 ton)	181 tonne (200 ton)	2 (0)
2	Feeder	Belt	572 tonne/hr (630 tph)	572 tonne/hr (630 tph)	2 (0)
3	Conveyor No. 1	Belt	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1 (0)
4	Transfer Tower No. 1	Enclosed	N/A	N/A	1 (0)
5	Conveyor No. 2	Belt	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1 (0)
6	As-Received Coal Sampling System	Two-stage	N/A	N/A	1 (0)
7	Stacker/Reclaimer	Traveling, linear	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1 (0)
8	Reclaim Hopper	N/A	64 tonne (70 ton)	73 tonne (80 ton)	2 (1)
9	Feeder	Vibratory	272 tonne/hr (300 tph)	290 tonne/hr (320 tph)	2 (1)
10	Conveyor No. 3	Belt w/ tripper	535 tonne/hr (590 tph)	581 tonne/hr (640 tph)	1 (0)
11	Crusher Tower	N/A	N/A	N/A	1 (0)
12	Coal Surge Bin w/ Vent Filter	Dual outlet	272 tonne (300 ton)	290 tonne (320 ton)	2 (0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
13	Crusher	Impactor reduction	8 cm x 0 - 3 cm x 0 (3" x 0 - 1-1/4" x 0)	8 cm x 0 - 3 cm x 0 (3" x 0 - 1-1/4" x 0)	2 (0)
14	As-Fired Coal Sampling System	Swing hammer	N/A	N/A	1 (1)
15	Conveyor No. 4	Belt w/tripper	535 tonne/hr (590 tph)	581 tonne/hr (640 tph)	1 (0)
16	Transfer Tower No. 2	Enclosed	N/A	N/A	1 (0)
17	Conveyor No. 5	Belt w/ tripper	535 tonne/hr (590 tph)	581 tonne/hr (640 tph)	1 (0)
18	Coal Silo w/ Vent Filter and Slide Gates	Field erected	635 tonne (700 ton)	635 tonne (700 ton)	6 (0)
19	Lime Truck Unloading System	N/A	18 tonne/hr (20 tph)	27 tonne/hr (30 tph)	1 (0)
20	Lime Bulk Storage Silo w/Vent Filter	Field erected	635 tonne (700 ton)	726 tonne (800 ton)	3 (0)
21	Lime Live Storage Transport	Pneumatic	8 tonne/hr (9 tph)	9 tonne/hr (10 tph)	1 (0)
22	Lime Day Bin	w/ actuator	73 tonne (80 ton)	73 tonne (80 ton)	2 (0)
23	Activated Carbon Storage Silo and Feeder System with Vent Filter	Shop assembled	#N/A	#N/A	1 (0)

ACCOUNT 2 COAL AND SORBENT PREPARATION AND FEED

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
1	Coal Feeder	Gravimetric	64 tonne/hr (70 tph)	64 tonne/hr (70 tph)	6 (0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
2	Coal Pulverizer	Ball type or equivalent	64 tonne/hr (70 tph)	64 tonne/hr (70 tph)	6 (0)
3	Lime Slaker	N/A	8 tonne/hr (9 tph)	8 tonne/hr (9 tph)	1 (1)
4	Lime Slurry Tank	Field Erected	367,188 liters (97,000 gal)	397,471 liters (105,000 gal)	1 (1)
5	Lime Slurry Feed Pumps	Horizontal centrifugal	379 lpm @ 9m H_2O (100 gpm @ 30 ft H_2O)	416 lpm @ 9m H_2O (110 gpm @ 30 ft H_2O)	1 (1)

ACCOUNT 3 FEEDWATER AND MISCELLANEOUS SYSTEMS AND EQUIPMENT

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
1	Demineralized Water Storage Tank	Vertical, cylindrical, outdoor	1,419,529 liters (375,000 gal)	1,536,877 liters (406,000 gal)	2 (0)
2	Condensate Pumps	Vertical canned	29,526 lpm @ 213 m H_2O (7,800 gpm @ 700 ft H_2O)	32,176 lpm @ 213 m H_2O (8,500 gpm @ 700 ft H_2O)	1 (1)
3	Deaerator and Storage Tank	Horizontal spray type	2,365,484 kg/hr (5,215,000 lb/hr), 5 min. tank	2,555,539 kg/hr (5,634,000 lb/hr), 5 min. tank	1 (0)
4	Boiler Feed Pump/Turbine	Barrel type, multi-stage, centrifugal	39,747 lpm @ 3,475 m H_2O (10,500 gpm @ 11,400 ft H_2O)	42,775 lpm @ 3,475 m H_2O (11,300 gpm @ 11,400 ft H_2O)	1 (1)
5	Startup Boiler Feed Pump, Electric Motor Driven	Barrel type, multi-stage, centrifugal	11,735 lpm @ 3,475 m H_2O (3,100 gpm @ 11,400 ft H_2O)	12,870 lpm @ 3,475 m H_2O (3,400 gpm @ 11,400 ft H_2O)	1 (0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
6	LP Feedwater Heater 1A/1B	Horizontal U-tube	879,969 kg/hr (1,940,000 lb/hr)	957,080 kg/hr (2,110,000 lb/hr)	2 (0)
7	LP Feedwater Heater 2A/2B	Horizontal U-tube	879,969 kg/hr (1,940,000 lb/hr)	957,080 kg/hr (2,110,000 lb/hr)	2 (0)
8	LP Feedwater Heater 3A/3B	Horizontal U-tube	879,969 kg/hr (1,940,000 lb/hr)	957,080 kg/hr (2,110,000 lb/hr)	2 (0)
9	LP Feedwater Heater 4A/4B	Horizontal U-tube	879,969 kg/hr (1,940,000 lb/hr)	957,080 kg/hr (2,110,000 lb/hr)	2 (0)
10	HP Feedwater Heater 6	Horizontal U-tube	2,363,216 kg/hr (5,210,000 lb/hr)	2,553,725 kg/hr (5,630,000 lb/hr)	1 (0)
11	HP Feedwater Heater 7	Horizontal U-tube	2,363,216 kg/hr (5,210,000 lb/hr)	2,553,725 kg/hr (5,630,000 lb/hr)	1 (0)
12	HP Feedwater heater 8	Horizontal U-tube	2,363,216 kg/hr (5,210,000 lb/hr)	2,553,725 kg/hr (5,630,000 lb/hr)	1 (0)
13	Auxiliary Boiler	Shop fabricated, water tube	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)	1 (0)
14	Fuel Oil System	No. 2 fuel oil for light off	1,135,624 liter (300,000 gal)	1,135,624 liter (300,000 gal)	1 (0)
15	Service Air Compressors	Flooded Screw	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	2 (1)
16	Instrument Air Dryers	Duplex, regenerative	28 m^3/min (1,000 scfm)	28 m^3/min (1,000 scfm)	2 (1)
17	Closed Cycle Cooling Heat Exchangers	Shell and tube	53 GJ/hr (50 MMBtu/hr) each	53 GJ/hr (50 MMBtu/hr) each	2 (0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
18	Closed Cycle Cooling Water Pumps	Horizontal centrifugal	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)	2 (1)
19	Engine-Driven Fire Pump	Vertical turbine, diesel engine	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)	1 (1)
20	Fire Service Booster Pump	Two-stage horizontal centrifugal	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)	1 (1)
21	Raw Water Pumps	Stainless steel, single suction	9,274 lpm @ 18 m H_2O (2,450 gpm @ 60 ft H_2O)	9,842 lpm @ 18 m H_2O (2,600 gpm @ 60 ft H_2O)	2 (1)
22	Ground Water Pumps	Stainless steel, single suction	2,650 lpm @ 268 m H_2O (700 gpm @ 880 ft H_2O)	2,801 lpm @ 268 m H_2O (740 gpm @ 880 ft H_2O)	7 (1)
23	Filtered Water Pumps	Stainless steel, single suction	492 lpm @ 49 m H_2O (130 gpm @ 160 ft H_2O)	530 lpm @ 49 m H_2O (140 gpm @ 160 ft H_2O)	2 (1)
24	Filtered Water Tank	Vertical, cylindrical	458,035 liter (121,000 gal)	499,674 liter (132,000 gal)	1 (0)
25	Makeup Water Demineralizer	Multi-media filter, cartridge filter, RO membrane assembly, electrodeionization unit	946 lpm (250 gpm)	1,022 lpm (270 gpm)	1 (1)
26	Liquid Waste Treatment System	--	10 years, 24-hour storm	10 years, 24-hour storm	1 (0)

ACCOUNT 4 BOILER AND ACCESSORIES

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
1	Boiler	Supercritical, drum, wall-fired, low NOx burners, overfire air	2,363,216 kg/hr steam @ 25.5 MPa/602°C/602°C (5,210,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)	2,553,725 kg/hr steam @ 25.5 MPa/602°C/602°C (5,630,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)	1 (0)
2	Primary Air Fan	Centrifugal	#N/A	#N/A	2 (0)
3	Forced Draft Fan	Centrifugal	#N/A	#N/A	2 (0)
4	Induced Draft Fan	Centrifugal	#N/A	#N/A	2 (0)
5	SCR Reactor Vessel	Space for spare layer	2,744,234 kg/hr (6,050,000 lb/hr)	3,029,997 kg/hr (6,680,000 lb/hr)	2 (0)
6	SCR Catalyst	--	--	--	3 (0)
7	Dilution Air Blower	Centrifugal	51 m^3/min @ 108 cm WG (1,800 acfm @ 42 in. WG)	57 m^3/min @ 108 cm WG (2,000 acfm @ 42 in. WG)	2 (1)
8	Ammonia Storage	Horizontal tank	56,781 liter (15,000 gal)	60,567 liter (16,000 gal)	5 (0)
9	Ammonia Feed Pump	Centrifugal	11 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)	12 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)	2 (1)
10	ASU Main Air Compressor	Centrifugal, multi-stage	16,877 m3/min @ 0.3 MPa (596,000 scfm @ 046 psia)	18,236 m3/min @ 0.6 MPa (644,000 scfm @ 087 psia)	2 (0)
11	Cold Box	Vendor design	7,076 tonne/day (7,800 tpd) of 95% purity oxygen	7,620 tonne/day (8,400 tpd) of 95% purity oxygen	2 (0)

ACCOUNT 5 FLUE GAS CLEANUP

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
1	Fabric Filter	Single stage, high-ratio with pulse-jet online cleaning system, air-to-cloth ratio - 3.5 ft/min	#N/A	#N/A	2 (0)
2	Spray Dryer	Co-current open spray	22,682 m^3/min (801,000 acfm)	25,060 m^3/min (885,000 acfm)	2 (0)
3	Atomizer	Rotary	227 lpm @ 64 m H_2O (60 gpm @ 210 ft H_2O)	227 lpm @ 64 m H_2O (60 gpm @ 210 ft H_2O)	2 (1)
4	Spray Dryer Solids Conveying	---	---	---	2 (0)
5	Carbon Injectors	---	#N/A	#N/A	1 (0)

ACCOUNT 7 DUCTING AND STACK

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
1	Stack	Reinforced concrete with FRP liner	#N/A	#N/A	1 (0)

ACCOUNT 8 STEAM TURBINE GENERATOR

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
1	Steam Turbine	Commercially available advanced steam turbine	804 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)	861 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)	1 (0)
2	Steam Turbine Generator	Hydrogen cooled, static excitation	890 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	960 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	1 (0)
3	Surface Condenser	Single pass, divided waterbox including vacuum pumps	3,608 GJ/hr (3,420 MMBtu/hr), Inlet water temperature 16°C (60°F), Water temperature rise 11°C (20°F)	3,767 GJ/hr (3,570 MMBtu/hr), Inlet water temperature 16°C (60°F), Water temperature rise 11°C (20°F)	1 (0)

ACCOUNT 9 COOLING WATER SYSTEM

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
1	Circulating Water Pumps	Vertical, wet pit	855,500 lpm @ 30 m (226,000 gpm @ 100 ft)	908,500 lpm @ 30 m (240,000 gpm @ 100 ft)	2 (1)
2	Cooling Tower	Evaporative, mechanical draft, multi-cell	11°C (51.5°F) wet bulb / 16°C (60°F) CWT / 27°C (80°F) HWT / 4769 GJ/hr (4520 MMBtu/hr) heat duty	11°C (51.5°F) wet bulb / 16°C (60°F) CWT / 27°C (80°F) HWT / 5064 GJ/hr (4800 MMBtu/hr) heat duty	1 (0)

ACCOUNT 10 ASH/SPENT SORBENT RECOVERY AND HANDLING

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
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	--	5.4 tonne/hr (6 tph)	6.4 tonne/hr (7 tph)	1 (1)
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	227 lpm @ 17 m H_2O (60 gpm @ 56 ft H_2O)	265 lpm @ 17 m H_2O (70 gpm @ 56 ft H_2O)	1 (1)
8	Ash Seal Water Pumps	Vertical, wet pit	7,571 lpm @ 9 m H_2O (2000 gpm @ 28 ft H_2O)	7,571 lpm @ 9 m H_2O (2000 gpm @ 28 ft H_2O)	1 (1)
9	Hydrobins	--	227 lpm (60 gpm)	265 lpm (70 gpm)	1 (1)
10	Baghouse Hopper (part of baghouse scope of supply)	--	--	--	24 (0)
11	Air Heater Hopper (part of boiler scope of supply)	--	--	--	10 (0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
12	Air Blower	--	32 m^3/min @ 0.2 MPa (1130 scfm @ 24 psi)	35 m^3/min @ 0.2 MPa (1230 scfm @ 24 psi)	1 (1)
13	Fly Ash Silo	Reinforced concrete	2,090 tonne (2,300 ton)	2,270 tonne (2,500 ton)	2 (0)
14	Slide Gate Valves	--	--	--	2 (0)
15	Unloader	--	--	--	1 (0)
16	Telescoping Unloading Chute	--	200 tonne/hr (220 tph)	209 tonne/hr (230 tph)	1 (0)
17	Recycle Waste Storage Silo	Reinforced concrete	272 tonne (300 ton)	272 tonne (300 ton)	2 (0)
18	Recycle Waste Conveyor	--	36 tonne/hr (40 tph)	36 tonne/hr (40 tph)	1 (0)
19	Recycle Slurry Mixer	--	946 lpm (250 gpm)	1,060 lpm (280 gpm)	1 (1)
20	Recycle Waste Slurry Tank	--	56,780 liters (15,000 gal)	64,350 liters (17,000 gal)	1 (0)
21	Recycle Waste Pump	--	946 lpm (250 gpm)	1,060 lpm (280 gpm)	1 (1)

ACCOUNT 11 ACCESSORY ELECTRIC PLANT

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
1	STG Transformer	Oil-filled	24 kV/345 kV, 650 MVA 3-ph, 60 Hz	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	1 (0)
2	Auxiliary Transformer	Oil-filled	24 kV/4.16 kV, 234 MVA, 3-ph, 60 Hz	24 kV/4.16 kV, 294 MVA, 3-ph, 60 Hz	1 (1)
3	Low Voltage Transformer	Dry ventilated	4.16 kV/480 V, 35 MVA, 3-ph, 60 Hz	4.16 kV/480 V, 44 MVA, 3-ph, 60 Hz	1 (1)
4	STG Isolated Phase Bus Duct and Tap Bus	Aluminum, self-cooled	24 kV, 3-ph, 60 Hz	24 kV, 3-ph, 60 Hz	1 (0)
5	Medium Voltage Switchgear	Metal clad	4.16 kV, 3-ph, 60 Hz	4.16 kV, 3-ph, 60 Hz	1 (1)
6	Low Voltage Switchgear	Metal enclosed	480 V, 3-ph, 60 Hz	480 V, 3-ph, 60 Hz	1 (1)
7	Emergency Diesel Generator	Sized for emergency shutdown	750 kW, 480 V, 3-ph, 60 Hz	750 kW, 480 V, 3-ph, 60 Hz	1 (0)

ACCOUNT 12 INSTRUMENTATION AND CONTROL

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S12DSen1	Case S12DSen2	
1	DCS - Main Control	Monitor/keyboard; Operator printer (laser color); Engineering printer (laser B&W)	Operator stations/printers and engineering stations/printers	Operator Stations/Printers and Engineering Stations/Printers	1 (0)
2	DCS - Processor	Microprocessor with redundant input/output	N/A	N/A	1 (0)
3	DCS - Data Highway	Fiber optic	Fully redundant, 25% spare	Fully redundant, 25% spare	1 (0)

7.4 ECONOMIC ANALYSIS FOR SENSITIVITY OXYCOMBUSTION CASES

Capital and operating costs for the ASU sensitivity cases are presented in Section 7.4.1. A cost and performance summary table for all six cases is given in Section 7.4.2, and additional cost detail sheets for all cases are contained in Section 2.7

7.4.1 Cost Results for Cases 12SDSen1 and 12SDSen2

The capital and operating costs for Cases S12DSen1 and S12DSen2 are shown in Exhibit 7-16 through Exhibit 7-21. Capital and operating cost estimating methodology is explained in Section 2.7.

Exhibit 7-16 Case S12DSen1 Total Plant Costs

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12DSen1 - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.05 MW, net Capital Charge Factor 0.175 Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
	SUBTOTAL 1.	**$19,795**	**$6,001**	**$13,095**	**$0**	**$38,890**		**$3,496**		**$0**		**$6,358**	**$48,743**	**$89**
2	COAL PREP & FEED SYSTEMS													
	SUBTOTAL 2.	**$9,976**	**$804**	**$2,787**	**$0**	**$13,567**		**$1,193**		**$0**		**$2,214**	**$16,974**	**$31**
3	FEEDWATER & MISC. BOP SYSTEMS													
	SUBTOTAL 3.	**$48,387**	**$0**	**$22,577**	**$0**	**$70,964**		**$6,436**		**$0**		**$12,397**	**$89,797**	**$163**
4	PC BOILER & ACCESSORIES													
	SUBTOTAL 4.	**$395,135**	**$0**	**$248,596**	**$0**	**$643,731**		**$62,352**		**$50,491**		**$75,657**	**$832,231**	**$1,513**
5A	FLUE GAS CLEANUP						*							
	SUBTOTAL 5A.	**$89,574**	**$0**	**$20,435**	**$0**	**$110,009**		**$10,461**		**$0**		**$12,047**	**$132,517**	**$241**
5B	CO2 REMOVAL & COMPRESSION													
	SUBTOTAL 5B.	**$45,662**	**$0**	**$35,629**	**$0**	**$81,291**		**$8,129**		**$0**		**$17,744**	**$107,163**	**$195**
6	COMBUSTION TURBINE/ACCESSORIES													
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
	SUBTOTAL 7.	**$58,928**	**$893**	**$12,507**	**$0**	**$72,328**		**$6,993**		**$0**		**$11,867**	**$91,189**	**$166**
8	STEAM TURBINE GENERATOR													
	SUBTOTAL 8.	**$94,398**	**$1,337**	**$27,151**	**$0**	**$122,886**		**$11,293**		**$0**		**$15,834**	**$150,014**	**$273**
9	COOLING WATER SYSTEM													
	SUBTOTAL 9.	**$17,067**	**$10,049**	**$17,588**	**$0**	**$44,703**		**$4,168**		**$0**		**$6,774**	**$55,645**	**$101**
10	ASH/SPENT SORBENT HANDLING SYS													
	SUBTOTAL 10.	**$6,602**	**$210**	**$8,827**	**$0**	**$15,639**		**$1,489**		**$0**		**$1,763**	**$18,890**	**$34**
11	ACCESSORY ELECTRIC PLANT													
	SUBTOTAL 11.	**$16,359**	**$13,685**	**$38,118**	**$0**	**$68,162**		**$6,172**		**$0**		**$9,771**	**$84,105**	**$153**
12	INSTRUMENTATION & CONTROL													
	SUBTOTAL 12.	**$10,724**	**$0**	**$10,874**	**$0**	**$21,598**		**$1,978**		**$0**		**$2,895**	**$26,471**	**$48**
13	IMPROVEMENTS TO SITE													
	SUBTOTAL 13.	**$3,351**	**$1,926**	**$6,754**	**$0**	**$12,031**		**$1,181**		**$0**		**$2,643**	**$15,855**	**$29**
14	BUILDINGS & STRUCTURES													
	SUBTOTAL 14.	**$0**	**$25,970**	**$24,492**	**$0**	**$50,462**		**$4,546**		**$0**		**$8,251**	**$63,259**	**$115**
	Total Cost	**$815,957**	**$60,874**	**$489,429**	**$0**	**$1,366,260**		**$129,887**		**$50,491**		**$186,215**	**$1,732,853**	**$3,150**

Exhibit 7-16 Case S12DSend1 Total Plant Costs (Continued)

Department:	NETL Office of Systems Analysis and Planning
Project:	Oxy-Fuel Combustion Systems Analysis
Case:	Case S12DSen1 - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size:	550.05 MW, net; Capital Charge Factor 0.175; Capacity Factor 0.85
Cost Base:	Jan 2007
Prepared:	19-Sep-09
	x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor		Bare Erected Cost $	Eng'g CM H.O. & Fee		Process Cont.		Project Cont.		TOTAL PLANT COST	
				Direct	Indirect		%	Total	%	Total	%	Total	$	$/kW
1	COAL HANDLING SYSTEM													
1.1	Coal Receive & Unload	4,783	0	2,185	0	6,967	8.9%	622	0%	0	15.0%	1,138	8,728	16
1.2	Coal Stackout & Reclaim	6,181	0	1,400	0	7,582	8.8%	664	0%	0	15.0%	1,237	9,482	17
1.3	Coal Conveyors & Yd Crus	5,747	0	1,386	0	7,132	8.8%	625	0%	0	15.0%	1,164	8,921	16
1.4	Other Coal Handling	1,504	0	321	0	1,824	8.7%	159	0%	0	15.0%	298	2,281	4
1.5	Sorbent Receive & Unload	60	0	18	0	78	8.8%	7	0%	0	15.0%	13	98	0
1.6	Sorbent Stackout & Reclaim	967	0	177	0	1,144	8.7%	100	0%	0	15.0%	187	1,431	3
1.7	Sorbent Conveyors	345	75	85	0	504	8.7%	44	0%	0	15.0%	82	630	1
1.8	Other Sorbent Handling	208	49	109	0	367	8.8%	32	0%	0	15.0%	60	459	1
1.9	Coal & Sorbent Hnd.Foundations	0	5,877	7,414	0	13,291	9.3%	1,242	0%	0	15.0%	2,180	16,714	30
	SUBTOTAL 1.	**$19,795**	**$6,001**	**$13,095**	**$0**	**$38,890**		**$3,496**		**$0**		**$6,358**	**$48,743**	**$89**
2	COAL PREP & FEED SYSTEMS													
2.1	Coal Crushing & Drying	2,802	0	546	0	3,348	8.7%	292	0%	0	15.0%	546	4,186	8
2.2	Prepared Coal Storage & Feed	7,174	0	1,566	0	8,740	8.7%	764	0%	0	15.0%	1,426	10,930	20
2.3	Slurry Prep & Feed	0	0	0	0	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	0.0%	0	0	0
2.5	Sorbent Prep Equipment	0	0	0	0	0	8.7%	0	0%	0	15.0%	0	0	0
2.6	Sorbent Storage & Feed	0	0	0	0	0	8.9%	0	0%	0	15.0%	0	0	0
2.7	Sorbent Injection System	0	0	0	0	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	0.0%	0	0	0
2.9	Coal & Sorbent Feed Foundation	0	804	675	0	1,479	9.2%	136	0%	0	15.0%	242	1,857	3
	SUBTOTAL 2.	**$9,976**	**$804**	**$2,787**	**$0**	**$13,567**		**$1,193**		**$0**		**$2,214**	**$16,974**	**$31**
3	FEEDWATER & MISC. BOP SYSTEMS													
3.1	Feedwater System	21,961	0	7,094	0	29,055	8.8%	2,544	0%	0	15.0%	4,740	36,339	66
3.2	Water Makeup & Pretreating	6,547	0	2,108	0	8,655	9.4%	811	0%	0	20.0%	1,893	11,360	21
3.3	Other Feedwater Subsystems	6,723	0	2,841	0	9,565	8.9%	852	0%	0	15.0%	1,563	11,980	22
3.4	Service Water Systems	1,283	0	698	0	1,982	9.3%	184	0%	0	20.0%	433	2,599	5
3.5	Other Boiler Plant Systems	8,732	0	8,621	0	17,353	9.4%	1,628	0%	0	15.0%	2,847	21,827	40
3.6	FO Supply Sys & Nat Gas	270	0	338	0	608	9.3%	57	0%	0	15.0%	100	764	1
3.7	Waste Treatment Equipment	0	0	0	0	0	9.7%	0	0%	0	20.0%	0	0	0
3.8	Misc. Power Plant Equipment	2,870	0	877	0	3,747	9.6%	360	0%	0	20.0%	821	4,928	9
	SUBTOTAL 3.	**$48,387**	**$0**	**$22,577**	**$0**	**$70,964**		**$6,436**		**$0**		**$12,397**	**$89,797**	**$163**
4	PC BOILER & ACCESSORIES													
4.1	PC (Oxycombustion) Boiler	226,217	0	110,391	0	336,608	9.7%	32,604	15%	50,491	10.0%	41,970	461,673	839
4.2	ASU/Oxidant Compression	168,918	0	138,205	0	307,123	9.7%	29,748	0%	0	10.0%	33,687	370,558	674
4.3	Open	0	0	0	0	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	0.0%	0	0	0
4.5	Primary Air System	w/4.1	0	w/4.1	0	0	0.0%	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	0.0%	0	0	0
4.7	Major Component Rigging	0	w/4.1	w/4.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
4.8	PC Foundations	0	w/14.1	w/14.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 4.	**$395,135**	**$0**	**$248,596**	**$0**	**$643,731**		**$62,352**		**$50,491**		**$75,657**	**$832,231**	**$1,513**
5A	FLUE GAS CLEANUP						*							
5.1	Absorber Vessels & Accessories	68,270	0	11,484	0	79,754	9.5%	7,548	0%	0	10.0%	8,730	96,033	175
5.2	Other FGD	1,175	0	471	0	1,646	9.6%	159	0%	0	10.0%	180	1,985	4
5.3	Bag House & Accessories	w/5.1	0	w/5.1	0	0	9.6%	0	0%	0	10.0%	0	0	0
5.4	Other Particulate Removal Materials	20,129	0	8,480	0	28,609	9.6%	2,754	0%	0	10.0%	3,136	34,499	63
5.5	Gypsum Dewatering System	N/A	N/A	N/A	N/A	0	9.4%	0	0%	0	10.0%	0	0	0
5.6	Mercury Removal System	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.7	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.8	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.9	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 5A.	**$89,574**	**$0**	**$20,435**	**$0**	**$110,009**		**$10,461**		**$0**		**$12,047**	**$132,517**	**$241**

Exhibit 7-16 Case S12DSend1 Total Plant Costs (Continued)

Department:	NETL Office of Systems Analysis and Planning
Project:	Oxy-Fuel Combustion Systems Analysis
Case:	Case S12DSen1 - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size:	550.05 MW, net
Capital Charge Factor	0.175
Capacity Factor	0.85
Cost Base:	Jan 2007
Prepared:	19-Sep-09
	x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
5B	CO2 REMOVAL & COMPRESSION													
5B.1	CO2 Condensing Heat Exchanger	2,357	0	197	0	2,553	10%	255	0%	0	15.0%	421	3,230	6
5B.2	CO2 Compression & Drying	43,306	0	35,432	0	78,737	10%	7,874	0%	0	20.0%	17,322	103,933	189
5B.3	CO2 Pipeline											0	0	0
5B.4	CO2 Storage											0	0	0
5B.5	CO2 Monitoring											0	0	0
	SUBTOTAL 5B.	**$45,662**	**$0**	**$35,629**	**$0**	**$81,291**		**$8,129**		**$0**		**$17,744**	**$107,163**	**$195**
6	COMBUSTION TURBINE/ACCESSORIES													
6.1	Combustion Turbine Generator	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.2	Combustion Turbine Accessories	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.3	Compressed Air Piping	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.4	Combustion Turbine Foundations	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
7.1	Flue Gas Recycle Heat Exhchanger	47,012	0	3,925	0	50,937	10%	5,094	0%	0	15.0%	8,405	64,436	117
7.2	SCR System	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
7.3	Ductwork	10,359	0	6,656	0	17,015	9%	1,486	0%	0	15.0%	2,775	21,276	39
7.4	Stack	1,557	0	911	0	2,468	10%	236	0%	0	10.0%	270	2,974	5
7.9	HRSG, Duct & Stack Foundations	0	893	1,015	0	1,908	9%	178	0%	0	20.0%	417	2,503	5
	SUBTOTAL 7.	**$58,928**	**$893**	**$12,507**	**$0**	**$72,328**		**$6,993**		**$0**		**$11,867**	**$91,189**	**$166**
8	STEAM TURBINE GENERATOR													
8.1	Steam TG & Accessories	63,314	0	8,408	0	71,722	9.6%	6,867	0%	0	10.0%	7,859	86,449	157
8.2	Turbine Plant Auxiliaries	427	0	915	0	1,342	9.7%	130	0%	0	10.0%	147	1,620	3
8.3a	Condenser & Auxiliaries	5,449	0	3,287	0	8,736	9.5%	830	0%	0	10.0%	957	10,523	19
8.3b	Air Cooled Condenser													
8.4	Steam Piping	25,208	0	12,429	0	37,637	8.3%	3,141	0%	0	15.0%	6,117	46,895	85
8.9	TG Foundations	0	1,337	2,112	0	3,448	9.4%	324	0%	0	20.0%	755	4,527	8
	SUBTOTAL 8.	**$94,398**	**$1,337**	**$27,151**	**$0**	**$122,886**		**$11,293**		**$0**		**$15,834**	**$150,014**	**$273**
9	COOLING WATER SYSTEM													
9.1	Cooling Towers	11,977	0	3,730	0	15,707	9.5%	1,491	0%	0	10.0%	1,720	18,918	34
9.2	Circulating Water Pumps	2,982	0	284	0	3,266	8.6%	279	0%	0	10.0%	355	3,900	7
9.3	Circ. Water System Auxiliaries	796	0	106	0	902	9.4%	85	0%	0	10.0%	99	1,086	2
9.4	Circ. Water Piping	0	6,310	6,115	0	12,425	9.2%	1,145	0%	0	15.0%	2,035	15,605	28
9.5	Make-up Water System	682	0	911	0	1,593	9.5%	151	0%	0	15.0%	262	2,006	4
9.6	Component Cooling Water System	630	0	501	0	1,130	9.4%	106	0%	0	15.0%	185	1,422	3
9.9	Circ. Water System Foundations	0	3,739	5,941	0	9,680	9.4%	911	0%	0	20.0%	2,118	12,709	23
	SUBTOTAL 9.	**$17,067**	**$10,049**	**$17,588**	**$0**	**$44,703**		**$4,168**		**$0**		**$6,774**	**$55,645**	**$101**
10	ASH/SPENT SORBENT HANDLING SYS													
10.1	Ash Coolers	N/A	0	N/A	0	0	0%	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%	0	0	0
10.3	HGCU Ash Letdown	N/A	0	N/A	0	0	0%	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%	0	0	0
10.5	Other Ash Recovery Equipment	N/A	0	N/A	0	0	0%	0	0%	0	0.0%	0	0	0
10.6	Ash Storage Silos	883	0	2,722	0	3,605	10%	351	0%	0	10.0%	396	4,352	8
10.7	Ash Transport & Feed Equipment	5,718	0	5,858	0	11,576	9%	1,095	0%	0	10.0%	1,267	13,938	25
10.8	Misc. Ash Handling Equipment	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
10.9	Ash/Spent Sorbent Foundation	0	210	247	0	457	9%	43	0%	0	20.0%	100	600	1
	SUBTOTAL 10.	**$6,602**	**$210**	**$8,827**	**$0**	**$15,639**		**$1,489**		**$0**		**$1,763**	**$18,890**	**$34**

Exhibit 7-16 Case S12DSend1 Total Plant Costs (Continued)

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12DSen1 - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.05 MW, net   Capital Charge Factor 0.175   Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 29-Sep-10
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT													
11.1	Generator Equipment	383	0	62	0	445	9.3%	41	0%	0	7.5%	36	523	1
11.2	Station Service Equipment	6,551	0	2,152	0	8,703	9.6%	832	0%	0	7.5%	715	10,251	19
11.3	Switchgear & Motor Control	7,531	0	1,280	0	8,812	9.3%	816	0%	0	10.0%	963	10,590	19
11.4	Conduit & Cable Tray	0	4,722	16,327	0	21,049	9.6%	2,014	0%	0	15.0%	3,459	26,522	48
11.5	Wire & Cable	0	8,910	17,200	0	26,110	8.4%	2,200	0%	0	15.0%	4,246	32,556	59
11.6	Protective Equipment	270	0	920	0	1,190	9.8%	116	0%	0	10.0%	131	1,437	3
11.7	Standby Equipment	396	0	9	0	405	9.5%	38	0%	0	10.0%	44	488	1
11.8	Main Power Transformers	1,227	0	38	0	1,265	7.6%	96	0%	0	10.0%	136	1,497	3
11.9	Electrical Foundations	0	53	130	0	183	9.5%	17	0%	0	20.0%	40	240	0
	SUBTOTAL 11.	**$16,359**	**$13,685**	**$38,118**	**$0**	**$68,162**		**$6,172**		**$0**		**$9,771**	**$84,105**	**$153**
12	INSTRUMENTATION & CONTROL													
12.1	PC Control Equipment	w/12.7	0	w/12.7	0	0	0%	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%	0	0	0
12.3	Steam Turbine Control	w/8.1	0	w/8.1	0	0	0%	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%	0	0	0
12.5	Signal Processing Equipment	W/12.7	0	w/12.7	0	0	0%	0	0%	0	0.0%	0	0	0
12.6	Control Boards, Panels & Racks	552	0	331	0	883	9.6%	85	0%	0	15.0%	145	1,113	2
12.7	Computer Accessories	5,574	0	974	0	6,549	9.5%	624	0%	0	10.0%	717	7,889	14
12.8	Instrument Wiring & Tubing	3,022	0	5,995	0	9,017	8.5%	768	0%	0	15.0%	1,468	11,253	20
12.9	Other I & C Equipment	1,575	0	3,574	0	5,149	9.7%	502	0%	0	10.0%	565	6,216	11
	SUBTOTAL 12.	**$10,724**	**$0**	**$10,874**	**$0**	**$21,598**		**$1,978**		**$0**		**$2,895**	**$26,471**	**$48**
13	IMPROVEMENTS TO SITE													
13.1	Site Preparation	0	56	1,126	0	1,183	9.9%	117	0%	0	20.0%	260	1,559	3
13.2	Site Improvements	0	1,870	2,322	0	4,192	9.8%	412	0%	0	20.0%	921	5,525	10
13.3	Site Facilities	3,351	0	3,305	0	6,656	9.8%	653	0%	0	20.0%	1,462	8,771	16
	SUBTOTAL 13.	**$3,351**	**$1,926**	**$6,754**	**$0**	**$12,031**		**$1,181**		**$0**		**$2,643**	**$15,855**	**$29**
14	BUILDINGS & STRUCTURES													
14.1	Boiler Building	0	9,815	8,631	0	18,446	9.0%	1,656	0%	0	15.0%	3,015	23,117	42
14.2	Turbine Building	0	12,933	12,054	0	24,987	9.0%	2,250	0%	0	15.0%	4,086	31,322	57
14.3	Administration Building	0	647	684	0	1,332	9.1%	121	0%	0	15.0%	218	1,670	3
14.4	Circulation Water Pumphouse	0	285	226	0	511	8.9%	46	0%	0	15.0%	83	640	1
14.5	Water Treatment Buildings	0	864	712	0	1,576	9.0%	141	0%	0	15.0%	258	1,974	4
14.6	Machine Shop	0	433	291	0	724	8.9%	64	0%	0	15.0%	118	906	2
14.7	Warehouse	0	293	294	0	588	9.0%	53	0%	0	15.0%	96	737	1
14.8	Other Buildings & Structures	0	240	204	0	444	9.0%	40	0%	0	15.0%	73	556	1
14.9	Waste Treating Building & Str.	0	460	1,397	0	1,857	9.4%	175	0%	0	15.0%	305	2,337	4
	SUBTOTAL 14.	**$0**	**$25,970**	**$24,492**	**$0**	**$50,462**		**$4,546**		**$0**		**$8,251**	**$63,259**	**$115**
	Total Cost	**$815,957**	**$60,874**	**$489,429**	**$0**	**$1,366,260**		**$129,887**		**$50,491**		**$186,215**	**$1,732,853**	**$3,150**

Exhibit 7-17 Case S12DSen2 Total Plant Costs

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12DSen2 - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.00 MW, net — Capital Charge Factor 0.175 — Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
	SUBTOTAL 1.	**$20,784**	**$6,299**	**$13,747**	**$0**	**$40,830**		**$3,670**		**$0**		**$6,675**	**$51,175**	**$93**
2	COAL PREP & FEED SYSTEMS													
	SUBTOTAL 2.	**$10,505**	**$845**	**$2,933**	**$0**	**$14,283**		**$1,256**		**$0**		**$2,331**	**$17,869**	**$32**
3	FEEDWATER & MISC. BOP SYSTEMS													
	SUBTOTAL 3.	**$50,880**	**$0**	**$23,781**	**$0**	**$74,661**		**$6,770**		**$0**		**$13,031**	**$94,462**	**$172**
4	PC BOILER & ACCESSORIES													
	SUBTOTAL 4.	**$359,317**	**$0**	**$215,160**	**$0**	**$574,477**		**$55,644**		**$53,284**		**$68,340**	**$751,745**	**$1,367**
5A	FLUE GAS CLEANUP						*							
	SUBTOTAL 5A.	**$94,564**	**$0**	**$21,494**	**$0**	**$116,058**		**$11,035**		**$0**		**$12,709**	**$139,803**	**$254**
5B	CO2 REMOVAL & COMPRESSION													
	SUBTOTAL 5B.	**$47,927**	**$0**	**$37,370**	**$0**	**$85,298**		**$8,530**		**$0**		**$18,616**	**$112,443**	**$204**
6	COMBUSTION TURBINE/ACCESSORIES													
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
	SUBTOTAL 7.	**$62,361**	**$903**	**$13,018**	**$0**	**$76,282**		**$7,382**		**$0**		**$12,513**	**$96,176**	**$175**
8	STEAM TURBINE GENERATOR													
	SUBTOTAL 8.	**$99,087**	**$1,400**	**$28,497**	**$0**	**$128,984**		**$11,851**		**$0**		**$16,631**	**$157,466**	**$286**
9	COOLING WATER SYSTEM													
	SUBTOTAL 9.	**$17,647**	**$10,432**	**$18,234**	**$0**	**$46,313**		**$4,318**		**$0**		**$7,022**	**$57,653**	**$105**
10	ASH/SPENT SORBENT HANDLING SYS													
	SUBTOTAL 10.	**$6,896**	**$219**	**$9,219**	**$0**	**$16,334**		**$1,555**		**$0**		**$1,841**	**$19,730**	**$36**
11	ACCESSORY ELECTRIC PLANT													
	SUBTOTAL 11.	**$17,827**	**$15,083**	**$41,910**	**$0**	**$74,820**		**$6,775**		**$0**		**$10,737**	**$92,332**	**$168**
12	INSTRUMENTATION & CONTROL													
	SUBTOTAL 12.	**$11,038**	**$0**	**$11,193**	**$0**	**$22,230**		**$2,036**		**$0**		**$2,980**	**$27,246**	**$50**
13	IMPROVEMENTS TO SITE													
	SUBTOTAL 13.	**$3,334**	**$1,917**	**$6,719**	**$0**	**$11,969**		**$1,175**		**$0**		**$2,629**	**$15,774**	**$29**
14	BUILDINGS & STRUCTURES													
	SUBTOTAL 14.	**$0**	**$25,973**	**$24,495**	**$0**	**$50,468**		**$4,547**		**$0**		**$8,252**	**$63,267**	**$115**
	Total Cost	**$802,166**	**$63,071**	**$467,770**	**$0**	**$1,333,007**		**$126,544**		**$53,284**		**$184,307**	**$1,697,142**	**$3,086**

Exhibit 7-17 Case S12DSen2 Total Plant Costs (Continued)

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12DSen2 - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.00 MW, net — Capital Charge Factor 0.175 — Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
	1.1 Coal Receive & Unload	5,020	0	2,293	0	7,313	8.9%	653	0%	0	15.0%	1,195	9,161	17
	1.2 Coal Stackout & Reclaim	6,488	0	1,470	0	7,958	8.8%	697	0%	0	15.0%	1,298	9,953	18
	1.3 Coal Conveyors & Yd Crus	6,032	0	1,455	0	7,487	8.8%	656	0%	0	15.0%	1,221	9,364	17
	1.4 Other Coal Handling	1,578	0	337	0	1,915	8.7%	167	0%	0	15.0%	312	2,394	4
	1.5 Sorbent Receive & Unload	63	0	19	0	82	8.8%	7	0%	0	15.0%	13	103	0
	1.6 Sorbent Stackout & Reclaim	1,019	0	187	0	1,206	8.7%	105	0%	0	15.0%	197	1,507	3
	1.7 Sorbent Conveyors	364	79	89	0	531	8.7%	46	0%	0	15.0%	87	664	1
	1.8 Other Sorbent Handling	220	51	115	0	386	8.8%	34	0%	0	15.0%	63	484	1
	1.9 Coal & Sorbent Hnd.Foundations	0	6,169	7,783	0	13,952	9.3%	1,304	0%	0	15.0%	2,288	17,544	32
	SUBTOTAL 1.	**$20,784**	**$6,299**	**$13,747**	**$0**	**$40,830**		**$3,670**		**$0**		**$6,675**	**$51,175**	**$93**
2	COAL PREP & FEED SYSTEMS													
	2.1 Coal Crushing & Drying	2,950	0	575	0	3,525	8.7%	308	0%	0	15.0%	575	4,408	8
	2.2 Prepared Coal Storage & Feed	7,554	0	1,649	0	9,203	8.7%	805	0%	0	15.0%	1,501	11,509	21
	2.3 Slurry Prep & Feed	0	0	0	0	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	0.0%	0	0	0
	2.5 Sorbent Prep Equipment	0	0	0	0	0	8.7%	0	0%	0	15.0%	0	0	0
	2.6 Sorbent Storage & Feed	0	0	0	0	0	8.9%	0	0%	0	15.0%	0	0	0
	2.7 Sorbent Injection System	0	0	0	0	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	0.0%	0	0	0
	2.9 Coal & Sorbent Feed Foundation	0	845	709	0	1,554	9.2%	143	0%	0	15.0%	255	1,952	4
	SUBTOTAL 2.	**$10,505**	**$845**	**$2,933**	**$0**	**$14,283**		**$1,256**		**$0**		**$2,331**	**$17,869**	**$32**
3	FEEDWATER & MISC. BOP SYSTEMS													
	3.1 Feedwater System	23,166	0	7,483	0	30,649	8.8%	2,684	0%	0	15.0%	5,000	38,333	70
	3.2 Water Makeup & Pretreating	6,827	0	2,198	0	9,025	9.4%	846	0%	0	20.0%	1,974	11,845	22
	3.3 Other Feedwater Subsystems	7,092	0	2,997	0	10,089	8.9%	899	0%	0	15.0%	1,648	12,637	23
	3.4 Service Water Systems	1,338	0	728	0	2,066	9.3%	192	0%	0	20.0%	452	2,710	5
	3.5 Other Boiler Plant Systems	9,254	0	9,136	0	18,390	9.4%	1,725	0%	0	15.0%	3,017	23,132	42
	3.6 FO Supply Sys & Nat Gas	276	0	345	0	620	9.3%	58	0%	0	15.0%	102	780	1
	3.7 Waste Treatment Equipment	0	0	0	0	0	9.7%	0	0%	0	20.0%	0	0	0
	3.8 Misc. Power Plant Equipment	2,927	0	894	0	3,821	9.6%	367	0%	0	20.0%	838	5,025	9
	SUBTOTAL 3.	**$50,880**	**$0**	**$23,781**	**$0**	**$74,661**		**$6,770**		**$0**		**$13,031**	**$94,462**	**$172**
4	PC BOILER & ACCESSORIES													
	4.1 PC (Oxycombustion) Boiler	238,728	0	116,496	0	355,224	9.7%	34,407	15%	53,284	10.0%	44,291	487,206	886
	4.2 ASU/Oxidant Compression	120,589	0	98,664	0	219,253	9.7%	21,237	0%	0	10.0%	24,049	264,539	481
	4.3 Open	0	0	0	0	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	0.0%	0	0	0
	4.5 Primary Air System	w/4.1	0	w/4.1	0	0	0.0%	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	0.0%	0	0	0
	4.7 Major Component Rigging	0	w/4.1	w/4.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
	4.8 PC Foundations	0	w/14.1	w/14.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 4.	**$359,317**	**$0**	**$215,160**	**$0**	**$574,477**		**$55,644**		**$53,284**		**$68,340**	**$751,745**	**$1,367**
5A	FLUE GAS CLEANUP						*							
	5.1 Absorber Vessels & Accessories	72,386	0	12,176	0	84,562	9.5%	8,003	0%	0	10.0%	9,257	101,822	185
	5.2 Other FGD	1,223	0	490	0	1,713	9.6%	165	0%	0	10.0%	188	2,066	4
	5.3 Bag House & Accessories	w/5.1	0	w/5.1	0	0	9.6%	0	0%	0	10.0%	0	0	0
	5.4 Other Particulate Removal Materials	20,955	0	8,828	0	29,783	9.6%	2,867	0%	0	10.0%	3,265	35,916	65
	5.5 Gypsum Dewatering System	N/A	N/A	N/A	N/A	0	9.4%	0	0%	0	10.0%	0	0	0
	5.6 Mercury Removal System	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
	5.7 Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
	5.8 Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
	5.9 Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 5A.	**$94,564**	**$0**	**$21,494**	**$0**	**$116,058**		**$11,035**		**$0**		**$12,709**	**$139,803**	**$254**

Exhibit 7-17 Case S12DSen2 Total Plant Costs (Continued)

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12DSen2 - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.00 MW, net   Capital Charge Factor 0.175   Capacity Factor 0.85
Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
5B	CO2 REMOVAL & COMPRESSION													
5B.1	CO2 Condensing Heat Exchanger	2,508	0	209	0	2,717	10%	272	0%	0	15.0%	448	3,437	6
5B.2	CO2 Compression & Drying	45,419	0	37,161	0	82,580	10%	8,258	0%	0	20.0%	18,168	109,006	198
5B.3	CO2 Pipeline											0	0	0
5B.4	CO2 Storage											0	0	0
5B.5	CO2 Monitoring											0	0	0
	SUBTOTAL 5B.	**$47,927**	**$0**	**$37,370**	**$0**	**$85,298**		**$8,530**		**$0**		**$18,616**	**$112,443**	**$204**
6	COMBUSTION TURBINE/ACCESSORIES													
6.1	Combustion Turbine Generator	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.2	Combustion Turbine Accessories	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.3	Compressed Air Piping	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.4	Combustion Turbine Foundations	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
7.1	Flue Gas Recycle Heat Exhchanger	50,056	0	4,180	0	54,236	10%	5,424	0%	0	15.0%	8,949	68,608	125
7.2	SCR System	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
7.3	Ductwork	10,672	0	6,856	0	17,528	9%	1,531	0%	0	15.0%	2,859	21,918	40
7.4	Stack	1,633	0	956	0	2,589	10%	247	0%	0	10.0%	284	3,120	6
7.9	HRSG, Duct & Stack Foundations	0	903	1,026	0	1,929	9%	180	0%	0	20.0%	422	2,530	5
	SUBTOTAL 7.	**$62,361**	**$903**	**$13,018**	**$0**	**$76,282**		**$7,382**		**$0**		**$12,513**	**$96,176**	**$175**
8	STEAM TURBINE GENERATOR													
8.1	Steam TG & Accessories	66,419	0	8,821	0	75,240	9.6%	7,204	0%	0	10.0%	8,244	90,688	165
8.2	Turbine Plant Auxiliaries	448	0	960	0	1,408	9.7%	137	0%	0	10.0%	154	1,699	3
8.3a	Condenser & Auxiliaries	5,608	0	3,383	0	8,991	9.5%	854	0%	0	10.0%	985	10,830	20
8.3b	Air Cooled Condenser													
8.4	Steam Piping	26,612	0	13,121	0	39,733	8.3%	3,316	0%	0	15.0%	6,457	49,507	90
8.9	TG Foundations	0	1,400	2,212	0	3,612	9.4%	340	0%	0	20.0%	790	4,743	9
	SUBTOTAL 8.	**$99,087**	**$1,400**	**$28,497**	**$0**	**$128,984**		**$11,851**		**$0**		**$16,631**	**$157,466**	**$286**
9	COOLING WATER SYSTEM													
9.1	Cooling Towers	12,342	0	3,843	0	16,186	9.5%	1,537	0%	0	10.0%	1,772	19,495	35
9.2	Circulating Water Pumps	3,115	0	297	0	3,412	8.6%	292	0%	0	10.0%	370	4,074	7
9.3	Circ. Water System Auxiliaries	826	0	110	0	936	9.4%	88	0%	0	10.0%	102	1,127	2
9.4	Circ. Water Piping	0	6,551	6,349	0	12,900	9.2%	1,188	0%	0	15.0%	2,113	16,201	29
9.5	Make-up Water System	710	0	948	0	1,658	9.5%	157	0%	0	15.0%	272	2,087	4
9.6	Component Cooling Water System	654	0	520	0	1,173	9.4%	110	0%	0	15.0%	193	1,476	3
9.9	Circ. Water System Foundations	0	3,881	6,166	0	10,048	9.4%	946	0%	0	20.0%	2,199	13,192	24
	SUBTOTAL 9.	**$17,647**	**$10,432**	**$18,234**	**$0**	**$46,313**		**$4,318**		**$0**		**$7,022**	**$57,653**	**$105**
10	ASH/SPENT SORBENT HANDLING SYS													
10.1	Ash Coolers	N/A	0	N/A	0	0	0%	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%	0	0	0
10.3	HGCU Ash Letdown	N/A	0	N/A	0	0	0%	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%	0	0	0
10.5	Other Ash Recovery Equipment	N/A	0	N/A	0	0	0%	0	0%	0	0.0%	0	0	0
10.6	Ash Storage Silos	923	0	2,843	0	3,766	10%	367	0%	0	10.0%	413	4,546	8
10.7	Ash Transport & Feed Equipment	5,973	0	6,118	0	12,091	9%	1,143	0%	0	10.0%	1,323	14,558	26
10.8	Misc. Ash Handling Equipment	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
10.9	Ash/Spent Sorbent Foundation	0	219	258	0	477	9%	45	0%	0	20.0%	104	626	1
	SUBTOTAL 10.	**$6,896**	**$219**	**$9,219**	**$0**	**$16,334**		**$1,555**		**$0**		**$1,841**	**$19,730**	**$36**

Exhibit 7-17 Case S12DSen2 Total Plant Costs (Continued)

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S12DSen2 - Oxyfuel Supercritical PC w/ CO2 Capture
Plant Size: 550.00 MW, net   Capital Charge Factor 0.175   Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT													
	11.1 Generator Equipment	397	0	65	0	462	9.3%	43	0%	0	7.5%	38	543	1
	11.2 Station Service Equipment	7,222	0	2,373	0	9,594	9.6%	918	0%	0	7.5%	788	11,300	21
	11.3 Switchgear & Motor Control	8,302	0	1,411	0	9,713	9.3%	899	0%	0	10.0%	1,061	11,674	21
	11.4 Conduit & Cable Tray	0	5,205	17,998	0	23,203	9.6%	2,221	0%	0	15.0%	3,814	29,237	53
	11.5 Wire & Cable	0	9,822	18,960	0	28,782	8.4%	2,425	0%	0	15.0%	4,681	35,888	65
	11.6 Protective Equipment	270	0	920	0	1,190	9.8%	116	0%	0	10.0%	131	1,437	3
	11.7 Standby Equipment	409	0	9	0	418	9.5%	40	0%	0	10.0%	46	503	1
	11.8 Main Power Transformers	1,227	0	38	0	1,265	7.6%	96	0%	0	10.0%	136	1,497	3
	11.9 Electrical Foundations	0	56	136	0	192	9.5%	18	0%	0	20.0%	42	252	0
	SUBTOTAL 11.	**$17,827**	**$15,083**	**$41,910**	**$0**	**$74,820**		**$6,775**		**$0**		**$10,737**	**$92,332**	**$168**
12	INSTRUMENTATION & CONTROL													
	12.1 PC Control Equipment	w/12.7	0	w/12.7	0	0	0%	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%	0	0	0
	12.3 Steam Turbine Control	w/8.1	0	w/8.1	0	0	0%	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%	0	0	0
	12.5 Signal Processing Equipment	W/12.7	0	w/12.7	0	0	0%	0	0%	0	0.0%	0	0	0
	12.6 Control Boards, Panels & Racks	568	0	340	0	909	10%	87	0%	0	15.0%	149	1,146	2
	12.7 Computer Accessories	5,737	0	1,003	0	6,740	10%	642	0%	0	10.0%	738	8,120	15
	12.8 Instrument Wiring & Tubing	3,111	0	6,171	0	9,282	9%	791	0%	0	15.0%	1,511	11,583	21
	12.9 Other I & C Equipment	1,621	0	3,679	0	5,300	10%	516	0%	0	10.0%	582	6,398	12
	SUBTOTAL 12.	**$11,038**	**$0**	**$11,193**	**$0**	**$22,230**		**$2,036**		**$0**		**$2,980**	**$27,246**	**$50**
13	IMPROVEMENTS TO SITE													
	13.1 Site Preparation	0	56	1,121	0	1,177	9.9%	116	0%	0	20.0%	259	1,551	3
	13.2 Site Improvements	0	1,860	2,311	0	4,171	9.8%	410	0%	0	20.0%	916	5,497	10
	13.3 Site Facilities	3,334	0	3,288	0	6,622	9.8%	650	0%	0	20.0%	1,454	8,726	16
	SUBTOTAL 13.	**$3,334**	**$1,917**	**$6,719**	**$0**	**$11,969**		**$1,175**		**$0**		**$2,629**	**$15,774**	**$29**
14	BUILDINGS & STRUCTURES													
	14.1 Boiler Building	0	9,802	8,620	0	18,422	9.0%	1,654	0%	0	15.0%	3,011	23,087	42
	14.2 Turbine Building	0	12,906	12,029	0	24,935	9.0%	2,245	0%	0	15.0%	4,077	31,258	57
	14.3 Administration Building	0	646	683	0	1,328	9.1%	120	0%	0	15.0%	217	1,666	3
	14.4 Circulation Water Pumphouse	0	295	234	0	529	8.9%	47	0%	0	15.0%	87	663	1
	14.5 Water Treatment Buildings	0	898	740	0	1,638	9.0%	147	0%	0	15.0%	268	2,053	4
	14.6 Machine Shop	0	432	290	0	722	8.9%	64	0%	0	15.0%	118	904	2
	14.7 Warehouse	0	293	293	0	586	9.0%	53	0%	0	15.0%	96	735	1
	14.8 Other Buildings & Structures	0	239	204	0	443	9.0%	40	0%	0	15.0%	72	555	1
	14.9 Waste Treating Building & Str.	0	462	1,402	0	1,865	9.4%	176	0%	0	15.0%	306	2,347	4
	SUBTOTAL 14.	**$0**	**$25,973**	**$24,495**	**$0**	**$50,468**		**$4,547**		**$0**		**$8,252**	**$63,267**	**$115**
	Total Cost	**$802,166**	**$63,071**	**$467,770**	**$0**	**$1,333,007**		**$126,544**		**$53,284**		**$184,307**	**$1,697,142**	**$3,086**

Exhibit 7-18 Case S12DSen1 Initial and Annual O&M Expense

INITIAL & ANNUAL O&M EXPENSES

Case:	Case S12DSen1 - Oxyfuel Supercritical PC w/ CO2 Capture		
Plant Size (MWe):	550.05	**Heat Rate (Btu/kWh):**	11,225
Primary/Secondary Fuel:	Montana Rosebud PRB Coal	**Fuel Cost ($/MM Btu):**	0.76
Design/Construction	4 years	**Book Life (yrs):**	20
TPC (Plant Cost) Year:	Jan 2007	**TPI Year:**	2015
Capacity Factor (%):	85	**CO_2 Captured (TPD):**	15850

OPERATING & MAINTENANCE LABOR

Operating Labor

Operating Labor Rate (base):	$33.00	$/hour
Operating Labor Burden:	30.00	% of base
Labor Overhead Charge:	25.00	% of labor

Operating Labor Requirements per Shift:	**units/mod.**	**Total Plant**
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 Operating Jobs	14.0	14.0

	$	**$/kW-net**
Annual Operating Labor Cost (calc'd)	5,261,256	9.57
Maintenance Labor Cost (calc'd)	12,043,768	21.90
Administrative & Support Labor (calc'd)	4,326,256	7.87
	21,631,280	**39.33**

VARIABLE OPERATING COSTS

	$	**$/kWh-net**
Maintenance Material Costs (calc'd)	**$18,065,652**	**0.00441**

Consumables	**Consumption Initial**	**Consumption /Day**	**Unit Cost**	**Initial Cost**	**$**	**$/kWh-net**
Water (/1000 gallons)	0	6,968	1.03	$0	$2,226,809	0.00054
Chemicals						
MU & WT Chem. (lb)	236,121	33,732	0.16	$38,913	$1,724,670	0.00042
Limestone (ton)	938	134	20.60	$19,328	$856,640	0.00021
Carbon (Hg Removal) (lb)	0	0	1.00	$0	$0	0.00000
MEA Solvent (ton)	1,123	0	2142.40	$2,405,192	$0	0.00000
Caustic Soda, NaOH (ton)	0	0	412.96	$0	$0	0.00000
Sulfuric acid, H_2SO_4 (ton)	0	0	132.15	$0	$0	0.00000
Corrosion Inhibitor	0	0	0.00	$0	$0	0.00000
Activated C, MEA (lb)	0	0	1.00	$0	$0	0.00000
Ammonia, 28% soln (ton)	0	0	123.60	$0	$0	0.00000
Subtotal Chemicals				**$2,463,433**	**$2,581,310**	**0.00063**
Other						
Supplemental Fuel (MMBtu)	0	0	6.75	$0	$0	0.00000
SCR Catalyst Replacement (m^3)	w/equip.	0.0000	5500.00	$0	$0	0.00000
Emission Penalties	0	0	0.00	$0	$0	0.00000
Subtotal Other				**$0**	**$0**	**0.00000**
Waste Disposal						
Spent Mercury Catalyst (lb)	0	0	0.31	$0	$0	0.00000
Flyash (ton)	0	823	15.45	$0	$3,944,065	0.00096
Bottom Ash (ton)	0	138	15.45	$0	$662,016	0.00016
Subtotal Solid Waste Disposal				**$0**	**$4,606,081**	**0.00112**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	0.00000
Sulfur (tons)	0	0	0.00	$0	$0	0.00000
Subtotal By-Products				**$0**	**$0**	**0.00000**
TOTAL VARIABLE OPERATING COSTS					**$27,479,853**	**0.00671**
Coal FUEL (tons)	**259,557**	**8,652**	**12.96**	**$3,363,852**	**$34,787,840**	**0.00849**
NATURAL GAS FUEL (Mscf)	**0**	**0**	**6.93**	**$0**	**$0**	**0.00000**

Exhibit 7-19 Case S12DSen1 Capital Investment and Operating Cost Summary

CAPITAL INVESTMENT & REVENUE REQUIREMENT SUMMARY			
Case:	Case S12DSen1 - Oxyfuel Supercritical PC w/ CO2 Capture		
Plant Size (MWe):	550.05	**Heat Rate (Btu/kWh):**	11,225
Primary/Secondary Fuel:	Montana Rosebud PRB Coal	**Fuel Cost ($/MM Btu):**	0.76
Design/Construction	4 years	**Book Life (yrs):**	20
TPC (Plant Cost) Year:	Jan 2007	**TPI Year:**	2015
Capacity Factor (%):	85	**CO_2 Captured (TPD):**	15,850

CAPITAL INVESTMENT	**$x1000**		**$/kW**
Process Capital & Facilities	1,366,260		2,484
Engineering (incl. C.M., H.O. & Fee) `	129,887		236
Process Contingency	50,491		92
Project Contingency	186,215		338.5
TOTAL PLANT COST (TPC)	**1,732,853**		**3,150.36**
OPERATING & MAINTENANCE COSTS (2007 Dollars)	**$x1000**		**$/kW**
Operating Labor	5,261		9.6
Maintenance Labor	12,044		21.9
Maintenance Material	18,066		32.8
Administrative & Support Labor	4,326		7.9
TOTAL OPERATION & MAINTENANCE	**39,697**		**72.17**
FIXED O&M		39.33	**$/kW-net**
VARIABLE O&M		0.44	**cents/kWh**
CONSUMABLE OPERATING COSTS, Less Fuel (2007 Dollars)	**$x1000**		**cents/kWh**
Water	$2,227		0.05437
Chemicals	$2,581		0.06303
Other Consumables	$0		0.00000
Waste Disposal	$4,606		0.11246
TOTAL CONSUMABLE OPERATING COSTS	**$9,414**		**0.23**
BY-PRODUCTS CREDITS (2007 Dollars)	**$0**		**0.00**
FUEL COST (2007 Dollars) Coal	**$34,788**		**0.85**
FUEL COST (2007 Dollars) Natural Gas	**$0**		**0.00**

PRODUCTION COST SUMMARY	LF	**cents/kWh**	
Fixed O & M	1.1607	0.61	
Variable O & M	1.1607	0.51	
Consumables	1.1607	0.27	
By-product Credit	1.1607	0.00	
Fuel (Coal)	1.1439	0.97	
Fuel (Natural Gas)	1.1607	0.00	
TOTAL PRODUCTION COST		**2.36**	
LEVELIZED CARRYING CHARGES (Capital)			
Fixed Charge Rate (%)	**17.5**	**7.40**	
20 YEAR LEVELIZED COST OF ELECTRICITY		**9.77**	**cents/kWh**

Exhibit 7-20 Case S12DSen2 Initial and Annual O&M Expense

INITIAL & ANNUAL O&M EXPENSES

Case:	Case S12DSen2 - Oxyfuel Supercritical PC w/ CO2 Capture		
Plant Size (MWe):	550.00	**Heat Rate (Btu/kWh):**	12,139
Primary/Secondary Fuel:	Montana Rosebud PRB Coal	**Fuel Cost ($/MM Btu):**	0.76
Design/Construction	4 years	**Book Life (yrs):**	20
TPC (Plant Cost) Year:	Jan 2007	**TPI Year:**	2015
Capacity Factor (%):	85	**CO_2 Captured (TPD):**	17139

OPERATING & MAINTENANCE LABOR

Operating Labor

Operating Labor Rate (base):	$33.00	$/hour
Operating Labor Burden:	30.00	% of base
Labor Overhead Charge:	25.00	% of labor

Operating Labor Requirements per Shift:	**units/mod.**	**Total Plant**
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 Operating Jobs	14.0	14.0

	$	**$/kW-net**
Annual Operating Labor Cost (calc'd)	5,261,256	9.57
Maintenance Labor Cost (calc'd)	11,750,638	21.36
Administrative & Support Labor (calc'd)	4,252,973	7.73
	21,264,867	**38.66**

VARIABLE OPERATING COSTS

	$	**$/kWh-net**
Maintenance Material Costs (calc'd)	**$17,625,957**	**0.00430**

Consumables	**Consumption Initial**	**Consumption /Day**	**Unit Cost**	**Initial Cost**	**$**	**$/kWh-net**
Water (/1000 gallons)	0	6,968	1.03	$0	$2,226,809	0.00054
Chemicals						
MU & WT Chem. (lb)	236,121	33,732	0.16	$38,913	$1,724,670	0.00042
Limestone (ton)	938	134	20.60	$19,328	$856,640	0.00021
Carbon (Hg Removal) (lb)	0	0	1.00	$0	$0	0.00000
MEA Solvent (ton)	1,214	0	2142.40	$2,600,793	$0	0.00000
Caustic Soda, NaOH (ton)	0	0	412.96	$0	$0	0.00000
Sulfuric acid, H_2SO_4 (ton)	0	0	132.15	$0	$0	0.00000
Corrosion Inhibitor	0	0	0.00	$0	$0	0.00000
Activated C, MEA (lb)	0	0	1.00	$0	$0	0.00000
Ammonia, 28% soln (ton)	0	0	123.60	$0	$0	0.00000
Subtotal Chemicals				**$2,659,034**	**$2,581,310**	**0.00063**
Other						
Supplemental Fuel (MMBtu)	0	0	6.75	$0	$0	0.00000
SCR Catalyst Replacement (m^3)	w/equip.	0.0000	5500.00	$0	$0	0.00000
Emission Penalties	0	0	0.00	$0	$0	0.00000
Subtotal Other				**$0**	**$0**	**0.00000**
Waste Disposal						
Spent Mercury Catalyst (lb)	0	0	0.31	$0	$0	0.00000
Flyash (ton)	0	823	15.45	$0	$3,944,065	0.00096
Bottom Ash (ton)	0	138	15.45	$0	$662,016	0.00016
Subtotal Solid Waste Disposal				**$0**	**$4,606,081**	**0.00112**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	0.00000
Sulfur (tons)	0	0	0.00	$0	$0	0.00000
Subtotal By-Products				**$0**	**$0**	**0.00000**
TOTAL VARIABLE OPERATING COSTS					**$27,040,157**	**0.00660**
Coal FUEL (tons)	**280,665**	**9,356**	**12.96**	**$3,637,419**	**$37,616,980**	**0.00919**
NATURAL GAS FUEL (Mscf)	**0**	**0**	**6.93**	**$0**	**$0**	**0.00000**

Exhibit 7-21 Case S12DSen2 Capital Investment and Operating Cost Summary

CAPITAL INVESTMENT & REVENUE REQUIREMENT SUMMARY				
Case:	Case S12DSen2 - Oxyfuel Supercritical PC w/ CO2 Capture			
Plant Size (MWe):	550.00		**Heat Rate (Btu/kWh):**	12,139
Primary/Secondary Fuel:	Montana Rosebud PRB Coal		**Fuel Cost ($/MM Btu):**	0.76
Design/Construction	4 years		**Book Life (yrs):**	20
TPC (Plant Cost) Year:	Jan 2007		**TPI Year:**	2015
Capacity Factor (%):	85		**CO_2 Captured (TPD):**	17,139
CAPITAL INVESTMENT		**$x1000**		**$/kW**
Process Capital & Facilities		1,333,007		2,424
Engineering (incl. C.M., H.O. & Fee) `		126,544		230
Process Contingency		53,284		97
Project Contingency		184,307		335.1
TOTAL PLANT COST (TPC)		**1,697,142**		**3,085.71**
OPERATING & MAINTENANCE COSTS (2007 Dollars)		**$x1000**		**$/kW**
Operating Labor		5,261		9.6
Maintenance Labor		11,751		21.4
Maintenance Material		17,626		32.0
Administrative & Support Labor		4,253		7.7
TOTAL OPERATION & MAINTENANCE		**38,891**		**70.71**
FIXED O&M			**38.66**	**$/kW-net**
VARIABLE O&M			**0.43**	**cents/kWh**
CONSUMABLE OPERATING COSTS, Less Fuel (2007 Dollars)		**$x1000**		**cents/kWh**
Water		$2,227		0.05437
Chemicals		$2,581		0.06303
Other Consumables		$0		0.00000
Waste Disposal		$4,606		0.11247
TOTAL CONSUMABLE OPERATING COSTS		**$9,414**		**0.23**
BY-PRODUCTS CREDITS (2007 Dollars)		**$0**		**0.00**
FUEL COST (2007 Dollars) Coal		**$37,617**		**0.92**
FUEL COST (2007 Dollars) Natural Gas		**$0**		**0.00**
PRODUCTION COST SUMMARY	LF		**cents/kWh**	
Fixed O & M	1.1607		0.60	
Variable O & M	1.1607		0.50	
Consumables	1.1607		0.27	
By-product Credit	1.1607		0.00	
Fuel (Coal)	1.1439		1.05	
Fuel (Natural Gas)	1.1607		0.00	
TOTAL PRODUCTION COST			**2.42**	
LEVELIZED CARRYING CHARGES (Capital)				
Fixed Charge Rate (%)	**17.5**		**7.25**	
20 YEAR LEVELIZED COST OF ELECTRICITY			**9.67**	**cents/kWh**

7.4.2 Cost and Performance Summary for ASU Sensitivity Cases

A summary of plant costs and performance for the ASU sensitivity cases is shown in Exhibit 7-22 ,along with the base case (air-fired without capture), S12A.

Exhibit 7-22 Cost and Performance Results for ASU Sensitivity Cases

Case	S12A	S12DSen1	S12DSen2
Gross Power Output, MW_e	582.7	763.9	817.9
Net Power Output, MW_e	550.0	550.1	550.0
Net Plant Efficiency, % (HHV)	38.7	30.4	28.1
Net Plant Heat Rate, Btu/kWh (HHV)	8,822	11,225	12,139
Total Plant Cost, $x1000	1,018,074	1,732,853	1,697,142
Total Plant Cost, $/kW	1,851	3,150	3,086
CO_2 Capital Cost Penalty[a], $/kW	0.0	1,299.4	1,234.8
Levelized Cost of Electricity, ¢/kWh (85% Capacity Factor)	5.88	9.77	9.67
Levelized COE CO_2 Penalty[b], ¢/kWh (85% Capacity Factor)	0.00	3.89	3.79
Percent increase in COE[c], (85% Capacity Factor)	0.00%	43.88%	42.80%
Total CO_2 Emitted, lb/MWh_{net}	1,894	0	0
Cost of CO_2 Avoided[d], $/ton	--	41.0	40.0
Total CO_2 Captured, lb/MWh_{net}	0	2,401	2,597
Cost of CO_2 Captured[e], $/ton	--	32.4	29.2

a. CO_2 Capital Cost Penalty = TPC with capture – TPC case S12A air-fired without capture
b. CO_2 LCOE Cost Penalty = LCOE with capture – LCOE case S12A air-fired without capture
c. Relative to Case S12A ("Base Case")
d. CO_2 Cost Avoided = (COE with capture – COE without capture)/(Emissions without capture – Emissions with capture)
e. CO_2 Cost Captured (or Removal) = (COE with capture – COE without capture)/(CO_2 Captured)
Costs do not include CO_2 Transport, Storage, and Monitoring

Case S12DSen2 has higher gross power output due to the conventional ASU employed. This type of ASU is not optimized for oxycombustion, causing a higher auxiliary load. However, the conventional ASU reduces the TPC. The benefit of lower TPC outweighs the higher operational cost; as a result, the total LCOE for Case S12DSen2 is slightly lower than that of S12DSen1.

8. ULTRA-SUPERCRITICAL OXYCOMBUSTION CASES

Both USC PC-fired, Rankine–cycle, oxycombustion power plant configurations were evaluated and are presented in this section. All plant designs employ a cryogenic distillation ASU to generate the oxygen. Between these two cases, one of them utilizes Montana PRB coal and the other utilizes North Dakota lignite coal.

8.1 PLANT CONFIGURATION SUMMARY

All the designs have a nominal net output of 550 MWe. All two USC oxycombustion plants use a single reheat 27.6 MPa/649°C/649°C (4,000 psig/1,200°F/1,200°F) cycle. Case L13F differs from Case S13F only through the use of a different coal type (lignite instead of PRB). The following is a brief description of these two cases, which are covered in this section:

Case S13F – This case includes a USC PC oxycombustion plant with dry FGD, SO_2 polishing scrubber, and a cryogenic distillation CPU to reduce oxygen levels in the CO_2 product stream to approximately 1 ppm. Rosebud PRB coal is the fuel and the plant is located at a generic site in Montana.

Case L13F – This case includes an USC PC oxycombustion plant with dry FGD, SO_2 polishing scrubber, and a cryogenic distillation CPU to reduce oxygen levels in the CO_2 product stream to approximately 1 ppm. North Dakota lignite coal is the fuel and the plant is located at a minemouth site in North Dakota.

Oxycombustion PC plants are assumed to be built on a greenfield site and utilize flue gas recycle for flame temperature control. Major systems for each plant (described in Section 3) include the following:

1. Oxycombustion optimized ASU
2. USC PC Boiler/Steam Generator
3. Dry FGD
4. CPU with Distillation (Specification 3b)
5. Steam Generator

Support facilities include coal handling (receiving, crushing, storing, and drying), limestone handling (including receiving, crushing, storing, and feeding), solid waste disposal, circulating water system with evaporative mechanical draft cooling towers, wastewater treatment, and other ancillary systems equipment necessary for an efficient, highly available, and completely operable facility.

The plant designs are based on using components suitable for a 30-year life, with provision for periodic maintenance and replacement of critical parts. All equipment is based on compliance with the latest applicable codes and standards. ASME, ANSI, IEEE, NFPA, CAA, state regulations, and OSHA codes are all adhered to in the design approach.

8.2 MODEL ASSUMPTIONS FOR SC OXYCOMBUSTION CASES

The modeling assumptions that were used to generate the SC oxycombustion PC case material and energy balances are summarized in Exhibit 8-1

Exhibit 8-1 Ultra-Supercritical Oxycombustion Cases Modeling Assumptions

	PRB	Lignite
	S13F	L13F
Throttle pressure, psig	4000	4000
Throttle temperature, ºF	1200	1200
Reheat temperature, ºF	1200	1200
Condenser pressure, in Hg	1.4	1.4
Cooling water to condenser, ºF	60	60
Cooling water from condenser, ºF	80	80
CO_2 Purifier Vent temperature, °F	48	48
Coal HHV (PRB and Lignite), Btu/lb	8,564	6,617
FGD efficiency, %	93	93
SOx emissions, lb/MMBtu	0.1	0.1
NOx emissions, lb/MMBtu	0.07	0.07
Baghouse efficiency, %	99.8	99.8
Particulate emissions PM/PM_{10}, lb/MMBtu	0.015	0.015
Mercury removal, %	90	90
ASU Oxygen Purity, %	95	95
CO_2 Capture Efficiency, %[a]	90.9	90.9
Product CO_2 Condition, psia/°F	2220/81	2220/81
Product CO_2 Specification	3b[b]	3b[b]

[a] Percentage of CO_2 in flue gas

[b] Refer to Section 3.6.1 for more description of product CO_2 specification.

Material and energy balance information, environmental performance, and a major equipment list for the two CO_2 non-capture cases are summarized in Section 4.

8.3 PERFORMANCE RESULTS FOR CASE S13F AND L13F

A process block flow diagram for the USC CO_2 capture case (with cryogenic distillation CO_2 purification option), S13F, is shown in Exhibit 8-2, and the corresponding stream tables are shown in Exhibit 8-3**.**

A process block flow diagram for the USC CO_2 capture case (with cryogenic distillation CO_2 purification option), L13F, is shown in Exhibit 8-4, and the corresponding stream tables are shown in Exhibit 8-5.

Overall performance for cases S13F and L13F is summarized in Exhibit 8-6, which includes auxiliary power requirements.

8.3.1 Block Flow Diagram and Stream Table

Exhibit 8-2 Case S13F USC PC Oxycombustion with CO_2 Cryogenic Distillation Block Flow Diagram

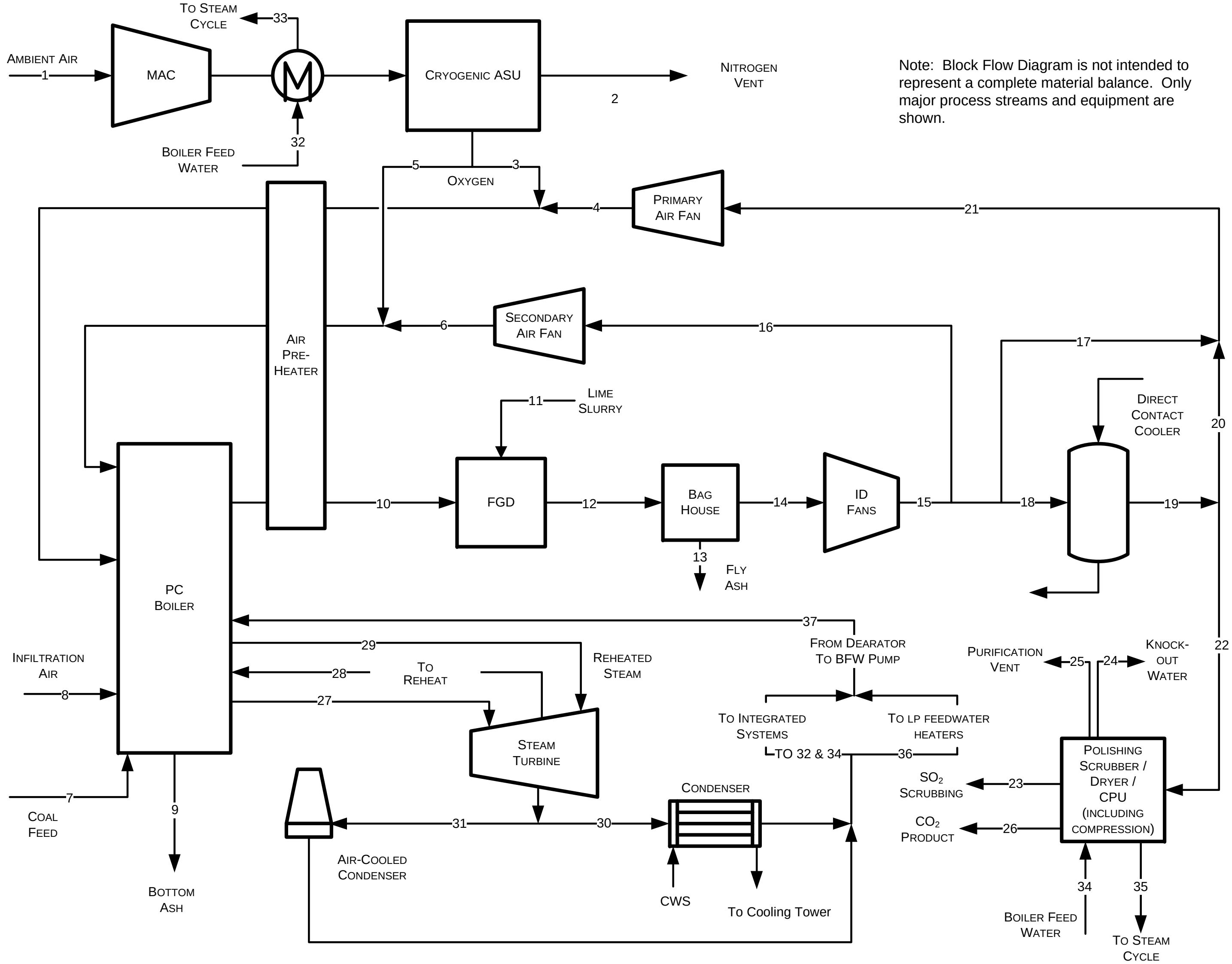


Exhibit 8-3 Case S13F USC PC Oxycombustion with CO_2 Cryogenic Distillation Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
V-L Mole Fraction																		
Ar	0.0093	0.0025	0.0343	0.0285	0.0343	0.0231	0.0000	0.0093	0.0000	0.0242	0.0000	0.0231	0.0000	0.0231	0.0231	0.0231	0.0231	0.0231
CO_2	0.0003	0.0004	0.0000	0.6793	0.0000	0.5502	0.0000	0.0003	0.0000	0.5765	0.0000	0.5502	0.0000	0.5502	0.5502	0.5502	0.5502	0.5502
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	0.0000	0.0000	0.0000	0.0000
H_2O	0.0064	0.0081	0.0000	0.1968	0.0000	0.3494	0.0000	0.0064	0.0000	0.3173	1.0000	0.3494	0.0000	0.3494	0.3494	0.3494	0.3494	0.3494
N_2	0.7759	0.9826	0.0162	0.0740	0.0162	0.0599	0.0000	0.7759	0.0000	0.0628	0.0000	0.0599	0.0000	0.0599	0.0599	0.0599	0.0599	0.0599
O_2	0.2081	0.0064	0.9495	0.0214	0.9495	0.0173	0.0000	0.2081	0.0000	0.0182	0.0000	0.0173	0.0000	0.0173	0.0173	0.0173	0.0173	0.0173
SO_2	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0012	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	70,884	55,719	5,308	19,111	9,857	18,992	0	1,367	0	62,700	3,099	65,698	0	65,698	65,698	18,992	2,613	44,093
V-L Flowrate (kg/hr)	2,048,190	1,559,774	170,946	713,617	317,471	639,420	0	39,492	0	2,160,992	55,837	2,211,903	0	2,211,903	2,211,903	639,420	87,988	1,484,495
Solids Flowrate (kg/hr)	0	0	0	0	0	0	305,022	0	4,995	19,979	4,838	29,743	29,743	0	0	0	0	0
Temperature (°C)	6	17	14	74	14	105	6	6	149	149	6	91	91	91	101	101	101	101
Pressure (MPa, abs)	0.09	0.10	0.14	0.10	0.14	0.09	0.09	0.09	0.09	0.09	0.10	0.08	0.08	0.08	0.09	0.09	0.09	0.09
Enthalpy (kJ/kg)[A]	15.26	30.70	12.15	307.32	12.15	577.95	---	15.26	---	651.96	264.90	636.40	---	563.39	573.95	573.95	573.95	573.95
Density (kg/m^3)	1.1	1.2	1.9	1.3	1.9	1.0	---	1.1	---	0.9	1,012.1	0.9	---	0.9	1.0	1.0	1.0	1.0
V-L Molecular Weight	28.895	27.994	32.207	37.340	32.207	33.668	---	28.895	---	34.466	18.015	33.668	---	33.668	33.668	33.668	33.668	33.668
V-L Flowrate (lb_{mol}/hr)	156,272	122,839	11,702	42,134	21,731	41,870	0	3,013	0	138,229	6,833	144,839	0	144,839	144,839	41,870	5,762	97,207
V-L Flowrate (lb/hr)	4,515,487	3,438,712	376,871	1,573,255	699,904	1,409,679	0	87,065	0	4,764,173	123,099	4,876,412	0	4,876,412	4,876,412	1,409,679	193,981	3,272,752
Solids Flowrate (lb/hr)	0	0	0	0	0	0	672,457	0	11,012	44,046	10,667	65,573	65,573	0	0	0	0	0
Temperature (°F)	42	63	57	165	57	220	42	42	300	300	42	197	196	196	214	214	214	214
Pressure (psia)	13.0	14.7	20.3	14.4	20.3	13.6	13.0	13.0	12.7	12.7	15.0	12.3	12.1	12.1	13.2	13.2	13.2	13.2
Enthalpy (Btu/lb)[A]	6.6	13.2	5.2	132.1	5.2	248.5	---	6.6	---	280.3	113.9	273.6	---	242.2	246.8	246.8	246.8	246.8
Density (lb/ft^3)	0.070	0.073	0.118	0.081	0.118	0.063	---	0.070	---	0.054	63.181	0.059	---	0.058	0.062	0.062	0.062	0.062

Exhibit 8-3 Case S13F USC PC Oxycombustion with CO_2 Cryogenic Distillation Stream Table (Continued)

	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
V-L Mole Fraction																			
Ar	0.0293	0.0293	0.0285	0.0293	0.0003	0.0000	0.1525	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.6997	0.6997	0.6793	0.6997	0.0067	0.0000	0.3332	0.9998	0.0000	0.0000	0.0000	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	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.1726	0.1726	0.1968	0.1726	0.9923	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.0762	0.0762	0.0740	0.0762	0.0000	0.0000	0.3988	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0221	0.0221	0.0214	0.0221	0.0000	0.0000	0.1154	0.0000	0.0000	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	0.0001	0.0001	0.0007	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	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	34,670	16,498	19,111	18,172	2,710	448	3,472	11,543	119,221	90,341	90,341	37,211	37,211	21,054	21,054	12,478	12,478	42,081	49,231
V-L Flowrate (kg/hr)	1,314,751	625,628	713,617	689,122	49,403	8,068	123,677	507,975	2,147,795	1,627,515	1,627,515	670,361	670,361	379,301	379,301	224,795	224,795	758,105	886,911
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	57	57	63	57	57	40	21	27	649	450	649	32	32	57	141	57	146	57	134
Pressure (MPa, abs)	0.09	0.09	0.09	0.09	0.09	0.10	0.10	15.31	27.68	8.27	7.78	0.00	0.00	0.86	0.84	0.86	0.85	0.86	0.30
Enthalpy (kJ/kg)[A]	257.88	257.88	296.85	257.88	147.24	65.51	17.23	-233.12	3,608.80	3,269.39	3,757.26	2,263.66	2,263.66	238.79	590.93	238.79	615.94	238.79	561.51
Density (kg/m^3)	1.2	1.2	1.2	1.2	60.8	979.3	1.5	685.0	72.8	27.2	18.8	0.0	0.0	985.1	925.7	985.1	920.4	985.1	931.4
V-L Molecular Weight	37.921	37.921	37.340	37.921	18.228	18.015	35.625	44.009	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	76,435	36,372	42,134	40,063	5,975	987	7,654	25,447	262,837	199,167	199,167	82,036	82,036	46,417	46,417	27,509	27,509	92,773	108,536
V-L Flowrate (lb/hr)	2,898,529	1,379,274	1,573,255	1,519,255	108,915	17,787	272,660	1,119,892	4,735,078	3,588,057	3,588,057	1,477,894	1,477,894	836,215	836,215	495,588	495,588	1,671,335	1,955,304
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	135	135	146	135	135	103	70	81	1,200	842	1,200	90	90	135	285	135	296	135	273
Pressure (psia)	13.0	13.0	13.0	13.0	13.0	14.7	15.0	2,220.0	4,014.7	1,200.0	1,128.0	0.7	0.7	125.0	122.1	125.0	123.5	125.0	43.8
Enthalpy (Btu/lb)[A]	110.9	110.9	127.6	110.9	63.3	28.2	7.4	-100.2	1,551.5	1,405.6	1,615.3	973.2	973.2	102.7	254.1	102.7	264.8	102.7	241.4
Density (lb/ft^3)	0.077	0.077	0.075	0.077	3.796	61.138	0.094	42.765	4.542	1.698	1.176	0.002	0.002	61.496	57.787	61.496	57.456	61.496	58.143

Exhibit 8-4 Case L13F USC PC Oxycombustion with CO_2 Cryogenic Distillation Block Flow Diagram

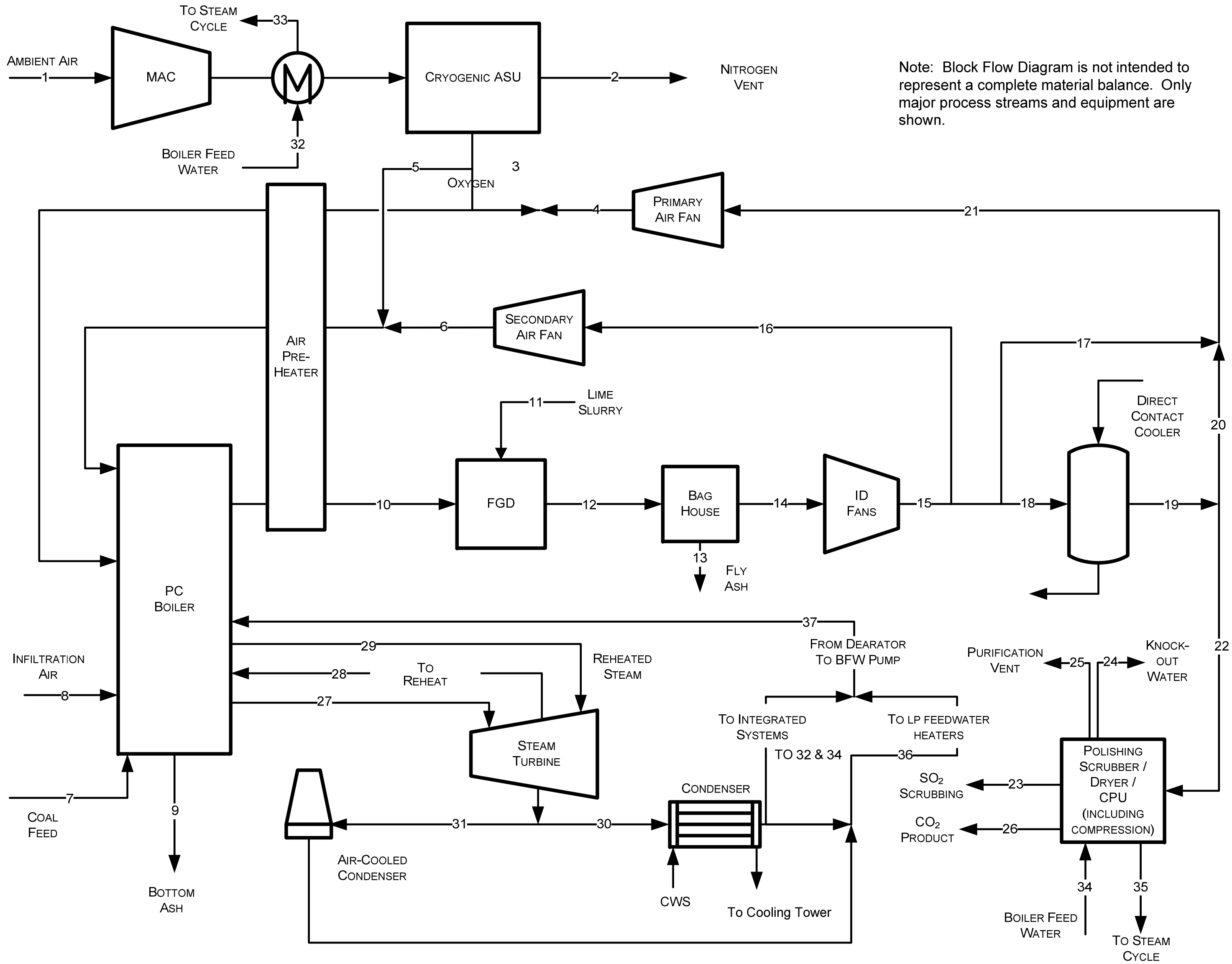


Exhibit 8-5 Case L13F USC PC Oxycombustion with CO_2 Cryogenic Distillation Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
V-L Mole Fraction																		
Ar	0.0093	0.0025	0.0343	0.0284	0.0343	0.0221	0.0000	0.0093	0.0000	0.0232	0.0000	0.0221	0.0000	0.0221	0.0221	0.0221	0.0221	0.0221
CO_2	0.0003	0.0004	0.0000	0.6831	0.0000	0.5325	0.0000	0.0003	0.0000	0.5581	0.0000	0.5325	0.0000	0.5325	0.5325	0.5325	0.5325	0.5325
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	0.0000	0.0000	0.0000	0.0000
H_2O	0.0062	0.0078	0.0000	0.1919	0.0000	0.3702	0.0000	0.0062	0.0000	0.3386	1.0000	0.3702	0.0000	0.3702	0.3702	0.3702	0.3702	0.3702
N_2	0.7761	0.9829	0.0162	0.0742	0.0162	0.0578	0.0000	0.7761	0.0000	0.0606	0.0000	0.0578	0.0000	0.0578	0.0578	0.0578	0.0578	0.0578
O_2	0.2082	0.0064	0.9495	0.0222	0.9495	0.0173	0.0000	0.2082	0.0000	0.0182	0.0000	0.0173	0.0000	0.0173	0.0173	0.0173	0.0173	0.0173
SO_2	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0013	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	74,466	58,531	5,577	26,879	10,358	8,215	0	1,434	0	64,873	3,245	68,002	0	68,002	68,002	8,215	3,791	55,996
V-L Flowrate (kg/hr)	2,151,885	1,638,664	179,627	1,006,701	333,594	272,463	0	41,448	0	2,202,568	58,460	2,255,348	0	2,255,348	2,255,348	272,463	125,724	1,857,160
Solids Flowrate (kg/hr)	0	0	0	0	0	0	409,082	0	8,069	32,278	5,594	43,552	43,552	0	0	0	0	0
Temperature (°C)	4	17	14	73	14	104	4	4	149	149	4	91	91	91	100	100	100	100
Pressure (MPa, abs)	0.10	0.10	0.14	0.10	0.14	0.10	0.10	0.10	0.09	0.09	0.10	0.09	0.09	0.09	0.10	0.10	0.10	0.10
Enthalpy (kJ/kg)[A]	13.75	30.21	12.15	300.00	12.15	613.75	---	13.75	---	736.00	293.84	719.23	---	599.86	609.93	609.93	609.93	609.93
Density (kg/m^3)	1.2	1.2	1.9	1.4	1.9	1.1	---	1.2	---	0.9	1,013.1	1.0	---	1.0	1.0	1.0	1.0	1.0
V-L Molecular Weight	28.898	27.997	32.207	37.453	32.207	33.166	---	28.898	---	33.952	18.015	33.166	---	33.166	33.166	33.166	33.166	33.166
V-L Flowrate (lb_{mol}/hr)	164,169	129,038	12,296	59,257	22,835	18,111	0	3,162	0	143,021	7,154	149,918	0	149,918	149,918	18,111	8,357	123,450
V-L Flowrate (lb/hr)	4,744,095	3,612,637	396,010	2,219,396	735,448	600,679	0	91,378	0	4,855,832	128,882	4,972,191	0	4,972,191	4,972,191	600,679	277,174	4,094,338
Solids Flowrate (lb/hr)	0	0	0	0	0	0	901,871	0	17,790	71,160	12,332	96,016	96,016	0	0	0	0	0
Temperature (°F)	40	63	57	164	57	219	40	40	300	300	40	197	196	196	213	213	213	213
Pressure (psia)	13.8	14.7	20.3	15.2	20.3	14.4	13.8	13.8	13.5	13.5	15.0	13.1	12.9	12.9	14.0	14.0	14.0	14.0
Enthalpy (Btu/lb)[A]	5.9	13.0	5.2	129.0	5.2	263.9	---	5.9	---	316.4	126.3	309.2	---	257.9	262.2	262.2	262.2	262.2
Density (lb/ft^3)	0.074	0.073	0.118	0.085	0.118	0.066	---	0.074	---	0.056	63.247	0.062	---	0.061	0.064	0.064	0.064	0.064

Exhibit 8-5 (continued)
Case L13F USC PC Oxycombustion with CO_2 Cryogenic Distillation Stream Table

	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
V-L Mole Fraction																			
Ar	0.0293	0.0293	0.0284	0.0293	0.0003	0.0000	0.1438	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.6871	0.6871	0.6659	0.6871	0.0066	0.0000	0.3088	0.9998	0.0000	0.0000	0.0000	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	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H_2O	0.1726	0.1726	0.1982	0.1726	0.9924	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.0751	0.0751	0.0727	0.0751	0.0000	0.0000	0.3707	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	0.0358	0.0358	0.0347	0.0358	0.0000	0.0000	0.1766	0.0000	0.0000	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	0.0001	0.0001	0.0006	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	1.0000	1.0000	1.0000	1.0000	1.0000
V-L Flowrate (kg_{mol}/hr)	35,006	16,407	19,215	18,598	2,773	458	3,766	11,601	119,888	90,865	90,865	37,485	37,485	21,556	21,556	12,548	12,548	40,866	119,724
V-L Flowrate (kg/hr)	1,322,328	619,777	714,122	702,551	50,540	8,257	133,200	510,554	2,159,819	1,636,952	1,636,952	675,307	675,307	388,345	388,345	226,048	226,048	736,220	2,156,866
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	57	57	64	57	57	40	21	27	649	450	649	32	32	57	141	57	146	57	192
Pressure (MPa, abs)	0.09	0.09	0.09	0.09	0.09	0.10	0.10	15.31	27.68	8.27	7.78	0.00	0.00	0.86	0.84	0.86	0.85	0.86	32.41
Enthalpy (kJ/kg)[A]	258.73	258.73	300.17	258.73	147.20	65.51	17.22	-233.12	3,608.80	3,269.39	3,757.26	2,264.61	2,264.61	238.98	590.93	238.98	615.94	238.98	830.16
Density (kg/m^3)	1.2	1.2	1.2	1.2	61.9	979.3	1.5	685.0	72.8	27.2	18.8	0.0	0.0	985.1	925.7	985.1	920.4	985.1	894.9
V-L Molecular Weight	37.775	37.775	37.164	37.775	18.223	18.015	35.374	44.009	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	77,174	36,172	42,362	41,003	6,114	1,010	8,302	25,576	264,308	200,322	200,322	82,641	82,641	47,524	47,524	27,663	27,663	90,095	263,947
V-L Flowrate (lb/hr)	2,915,235	1,366,375	1,574,370	1,548,859	111,421	18,204	293,656	1,125,578	4,761,587	3,608,862	3,608,862	1,488,796	1,488,796	856,154	856,154	498,351	498,351	1,623,087	4,755,075
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	135	135	147	135	135	103	69	81	1,200	842	1,200	90	90	135	285	135	296	135	377
Pressure (psia)	13.0	13.0	13.0	13.0	13.0	14.7	15.0	2,220.0	4,014.7	1,200.0	1,128.0	0.7	0.7	125.0	122.1	125.0	123.5	125.0	4,700.0
Enthalpy (Btu/lb)[A]	111.2	111.2	129.1	111.2	63.3	28.2	7.4	-100.2	1,551.5	1,405.6	1,615.3	973.6	973.6	102.7	254.1	102.7	264.8	102.7	356.9
Density (lb/ft^3)	0.077	0.077	0.074	0.077	3.867	61.138	0.093	42.764	4.542	1.698	1.176	0.002	0.002	61.495	57.787	61.495	57.456	61.495	55.865

8.3.2 Plant Power Summary

Exhibit 8-6 Case S13F and L13F Plant Power Summary

Plant Output			
	Case S13F	**Case L13F**	
Steam Turbine Power	741,700	747,900	kW_e
Total	**741,700**	**747,900**	kW_e
Auxiliary Load			
Coal Handling and Conveying	560	660	kW_e
Pulverizers	4,570	6,130	kW_e
Sorbent Handling & Reagent Preparation	170	170	kW_e
Ash Handling	1,030	1,530	kW_e
Primary Air Fans	2,020	2,860	kW_e
Forced Draft Fans	700	300	kW_e
Induced Draft Fans	6,300	6,540	kW_e
SCR	0	0	kW_e
Main Air Compressor	89,760	88,600	kW_e
ASU Auxiliaries	1,000	1,000	kW_e
Baghouse	140	210	kW_e
Spray Dryer FGD	2,780	3,210	kW_e
CPU (including Compression)	62,090	65,780	kW_e
Miscellaneous Balance of Plant[a,b]	2,000	2,000	kW_e
Steam Turbine Auxiliaries	400	400	kW_e
Condensate Pumps	430	430	kW_e
Circulating Water Pumps	4,970	5,470	kW_e
Ground Water Pumps	370	420	kW_e
Cooling Tower Fans	3,210	3,310	kW_e
Air Cooled Condenser Fans	6,410	6,050	kW_e
Transformer Losses	2,740	2,780	kW_e
Total	191,650	197,850	kW_e
Plant Performance			
Net Plant Power	550,050	550,050	kW_e
Net Exported Power Efficiency (HHV)	32.6%	31.5%	
Net Plant Heat Rate (HHV)	11,049 (10,472)	11,447 (10,849)	kJ/kWhr (Btu/kWhr)
Coal Feed Flowrate	305,092 (672,613)	409,082 (901,871)	kg/hr (lb/hr)
Thermal Input[c]	1,688,166	1,748,955	kW_{th}
Condenser Duty	2,853 (2,704)	2,866 (2,716)	GJ/hr (MMBtu/hr)
Raw Water Withdrawal	15.6 (4,112)	17.5 (4,621)	m^3/min (gpm)

[a] Boiler feed pumps are turbine driven
[b] Includes plant control systems, lighting, HVAC, and miscellaneous low voltage loads
[c] HHV of As Received Rosebud PRB coal is 19,920 kJ/kg (8,564 Btu/lb)

8.3.3 Energy Balance

An overall energy balance for the plant is shown in Exhibit 8-7.

Exhibit 8-7
Cases S13F and L13F Overall Energy Balance

	HHV		Sensible + Latent		Power		Total	
	S13F	L13F	S13F	L13F	S13F	L13F	S13F	L13F
Heat In, GJ/hr (MMBtu/hr)								
Coal	6,076 (5,759)	6,296 (5,968)	3.1 (3.0)	3.6 (3.5)			6,079 (5,762)	6,300 (5,971)
Combustion/ Infiltration Air			31.9 (30.2)	30.2 (28.6)			31.9 (30.2)	30.2 (28.6)
Raw Water Makeup			21.7 (20.6)	19.5 (18.5)			21.7 (20.6)	19.5 (18.5)
Lime			0.02 (0.02)	0.02 (0.02)			0.02 (0.02)	0.02 (0.02)
Auxiliary Power					690 (654)	712 (675)	690 (654)	712 (675)
Totals	**6,076 (5,759)**	**6,296 (5,968)**	**56.7 (53.7)**	**53.3 (50.5)**	**690 (654)**	**712 (675)**	**6,823 (6,467)**	**7,062 (6,693)**
Heat Out, GJ/hr (MMBtu/hr)								
Boiler Loss			54.1 (51.3)	54.6 (51.7)			54.1 (51.3)	54.6 (51.7)
Air Heater Loss			4.9 (4.7)	5.1 (4.9)			4.9 (4.7)	5.1 (4.9)
CO_2 Cooling Duty			275.0 (260.6)	291.4 (276.2)			275.0 (260.6)	291.4 (276.2)
DCC Cooling Duty			386.6 (366.5)	592.9 (562.0)			386.6 (366.5)	592.9 (562.0)
SO_2 Polishing Scrubber Cooling Duty			135.8 (128.7)	143.9 (136.4)			135.8 (128.7)	143.9 (136.4)
ASU Cold Box Pre-Cooling			171.3 (162.3)	179.1 (169.7)			171.3 (162.3)	179.1 (169.7)
Bottom Ash			0.6 (0.6)	0.9 (0.9)			0.6 (0.6)	0.9 (0.9)
Fly Ash + FGD Ash			2.2 (2.1)	3.2 (3.0)			2.2 (2.1)	3.2 (3.0)

	HHV		Sensible + Latent		Power		Total	
	S13F	L13F	S13F	L13F	S13F	L13F	S13F	L13F
Knockout Water			25.8 (24.5)	37.5 (35.5)			25.8 (24.5)	37.5 (35.5)
Flue Gas/CPU Vent			2 (2)	2 (2)			2 (2)	2 (2)
ASU Vent Stream			48 (45)	50 (47)			48 (45)	50 (47)
Condenser			2,852 (2,703)	2,866 (2,716)			2,852 (2,703)	2,866 (2,716)
CO_2			-118 (-112)	-125 (-119)			-118 (-112)	-125 (-119)
Cooling Tower Blowdown			24.0 (22.7)	25.6 (24.3)			24.0 (22.7)	25.6 (24.3)
Process Losses[a]			226.8 (214.9)	180.5 (171.1)			226.8 (214.9)	180.5 (171.1)
ST Generator/Exhaust Losses					62 (59)	62 (59)	62 (59)	62 (59)
Power					2,670 (2,531)	2,692 (2,552)	2,670 (2,531)	2,692 (2,552)
Totals			**4,091 (3,877)**	**4,307 (4,082)**	**2,732 (2,589)**	**2,755 (2,611)**	**6,823 (6,467)**	**7,062 (6,693)**

[a] Process losses from combustion reactions and gas cooling are estimated to match the heat input to the plant.

8.3.4 Water Balance

An overall water balance for the plant is shown in Exhibit 8-8. Raw water 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 is re-used as internal recycle. The difference between water withdrawal and process water discharge is defined as water consumption, and can be represented by the portion of the raw water withdrawn that is evaporated, transpired, incorporated into products, or otherwise not returned to the water source from which it was withdrawn. Water consumption represents the net impact of the plant process on the water source balance.

Exhibit 8-8
Cases S13F and L13F Water Balance

Water Use	Water Demand, m^3/min (gpm)		Internal Recycle, m^3/min (gpm)		Raw Water Withdrawl, m^3/min (gpm)		Process Water Discharge, m^3/min (gpm)		Raw Water Consumption, m^3/min (gpm)	
	S13F	L13F	S13F	L13F	S13F	L13F	S13F	L13F	S13F	L13F
FGD Makeup	0.93 (246)	0.98 (258)	0.0 (0)	0.0 (0)	0.93 (246)	0.98 (258)	0.00 (0.00)	0.00 (0.00)	0.93 (245.16)	0.95 (252.03)
BFW Makeup	0.14 (38)	0.15 (40)	0.0 (0)	0.0 (0)	0.14 (38)	0.15 (40)	0.00 (0.00)	0.00 (0.00)	0.14 (38.01)	0.15 (39.94)
Cooling Tower Makeup	19.15 (5,058)	21.0 (5554)	4.7 (1,231)	4.7 (1231)	14.49 (3,827)	16.37 (4324)	4.35 (1,148.91)	4.77 (1,259.99)	10.33 (2,728.76)	11.78 (3,111.60)
Total	**20.2 (5,342)**	**22.2 (5,852)**	**4.7 (1,231)**	**4.7 (1231)**	**15.6 (4,111)**	**17.5 (4,621)**	**4.35 (1,148.91)**	**4.77 (1,259.99)**	**11.40 (3,011.93)**	**12.88 (3,403.57)**

8.3.5 Carbon Balance

The carbon balances for the oxycombustion PC case with CO_2 purification are shown in Exhibit 8-9. The carbon input to the plant consists of carbon in the coal, carbon in the air entering the ASU, and the infiltration air entering the boiler in addition to carbon in the coal. The carbon entering the ASU is removed before entering the boiler island. Carbon leaves the plant as CO_2 product, vented to the atmosphere, or as spent. Carbon conversion for both the air-fired and oxy-fired cases was assumed to be 100 percent. The percent of total carbon sequestered is defined as the amount of carbon product produced (as sequestration-ready CO_2) divided by the carbon in the coal feedstock, expressed as a percentage.

% Captured = Carbon in Product for Sequestration / Carbon in the Coal

or

307,127/339,037*100 = 90.6% (S13F)

325,161/358,944*100 = 90.6% (L13F)

Exhibit 8-9
Cases S13F and L13F Carbon Balance

Carbon In, kg/hr (lb/hr)			Carbon Out, kg/hr (lb/hr)		
	S13F	**L13F**		**S13F**	**L13F**
Coal	153,493 (338,395)	162,508 (358,268)	**Ash**	0 (0)	0 (0)
			ASU Vent	286 (630)	301 (664)
Air (CO_2)	291 (642)	306 (676)	**Stack Gas /CPU Vent**	13,966 (30,790)	14,786 (32,598)
Activated Carbon	N/A	N/A	**CO_2 Product**	139,311 (307,127)	147,490 (325,161)
			SO_2 Scrubber	220 (486)	233 (514)
			DCC Discharge	1 (3)	2 (5)
			Convergence Tolerance*	0 (1)	1 (3)
Total	153,784 (339,037)	162,814 (358,944)	**Total**	153,784 (339,037)	162,814 (358,944)

8.3.6 Sulfur Balance

Exhibit 8-10 shows the sulfur balances for the non-capture case and oxycombustion case with CO_2 purification. Sulfur input comes solely from the sulfur in the coal. Sulfur output is the sulfur combined with lime in the ash, sulfur discharge from the direct contact cooler (DCC) and polishing scrubber, and the sulfur sequestered in the CO_2 product stream. The total sulfur capture is represented by the following fraction:

(Sulfur in Ash + Sulfur co-sequestered + Sulfur in waste discharge streams)/Sulfur in the coal) or
(4,794 + 0 + 122)/ 4,917*100 = 100% (S13F)
(5,522 + 0 + 152)/ 5,674*100 = 100% (L13F)

Exhibit 8-10
Cases S13F and L13F Sulfur Balance

Sulfur In, kg/hr (lb/hr)			Sulfur Out, kg/hr (lb/hr)		
	S13F	**L13F**		**S13F**	**L13F**
Coal	2,230 (4,917)	2,574 (5,674)	**Ash**	2,175 (4,794)	2,505 (5,522)
			SO_2 Polishing Scrubber	56 (122)	69 (152)
			Stack Gas /CPU Vent	0 (0)	0 (0)
			CO_2 Product	0 (0)	0 (0)
			DCC Discharge	0 (0)	0 (0)
			Convergence Tolerance	0 (0)	0 (0)
Total	2,230 (4,917)	2,574 (5,674)	**Total**	2,230 (4,917)	2,574 (5,674)

8.3.7 Air Emissions

For the oxycombustion case, all particulate is assumed to be removed from the process stream after the baghouse by either the direct contact cooler or the SO_2 polishing scrubber, with no particulate matter being vented to the atmosphere. Mercury was assumed to be absorbed in the desiccant dryer, removed with the condensed water in CO_2 compression train, and co-sequestered with the CO_2 product stream. Eighty percent of the NO_x generated in the boiler is assumed to be vented from the CPU with the remaining NO_x, in the form of NO_2, co-sequestered. SO_2 emissions are controlled using the lime spray dryer absorber and the SO_2 polishing scrubber. Any remaining SO_2 was assumed to be co-sequestered.

Exhibit 8-11
Cases S13F and L13F Estimated Air Emissions

	kg/GJ ($lb/10^6$ Btu)		Tonne/year (ton/year) 85% capacity factor		kg/MWh (lb/MWh)	
	S13F	L13F	S13F	L13F	S13F	L13F
SO_2	0.000 (0.000)	0.000 (0.000)	0 (0)	0 (0)	0.000 (0.00)	0.000 (0.00)
NO_X	0.024 (0.056)	0.024 (0.056)	1,089 (1,201)	1,140 (1,256)	0.197 (.435)	0.203 (.447)
Particulates	0.0000 (0.000)	0.0000 (0.000)	0.00 (0.00)	0.00 (0.00)	0.000 (0.000)	0.000 (0.000)
Hg	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
CO_2	8.4 (19.5)	8.6 (19.9)	379,119 (417,907)	401,679 (442,775)	69 (151)	72 (159)
CO_2 [a]					93 (204)	98 (216)

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

8.3.8 Heat and Mass Balance Diagrams

Heat and mass balance diagrams are shown for the following subsystems in Exhibit 8-12 through Exhibit 8-15:

- Boiler and flue gas cleanup
- Steam and feedwater

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Exhibit 8-12 Case S13F Heat and Mass Balance, Ultra-Supercritical PC Boiler and Gas Cleanup Systems

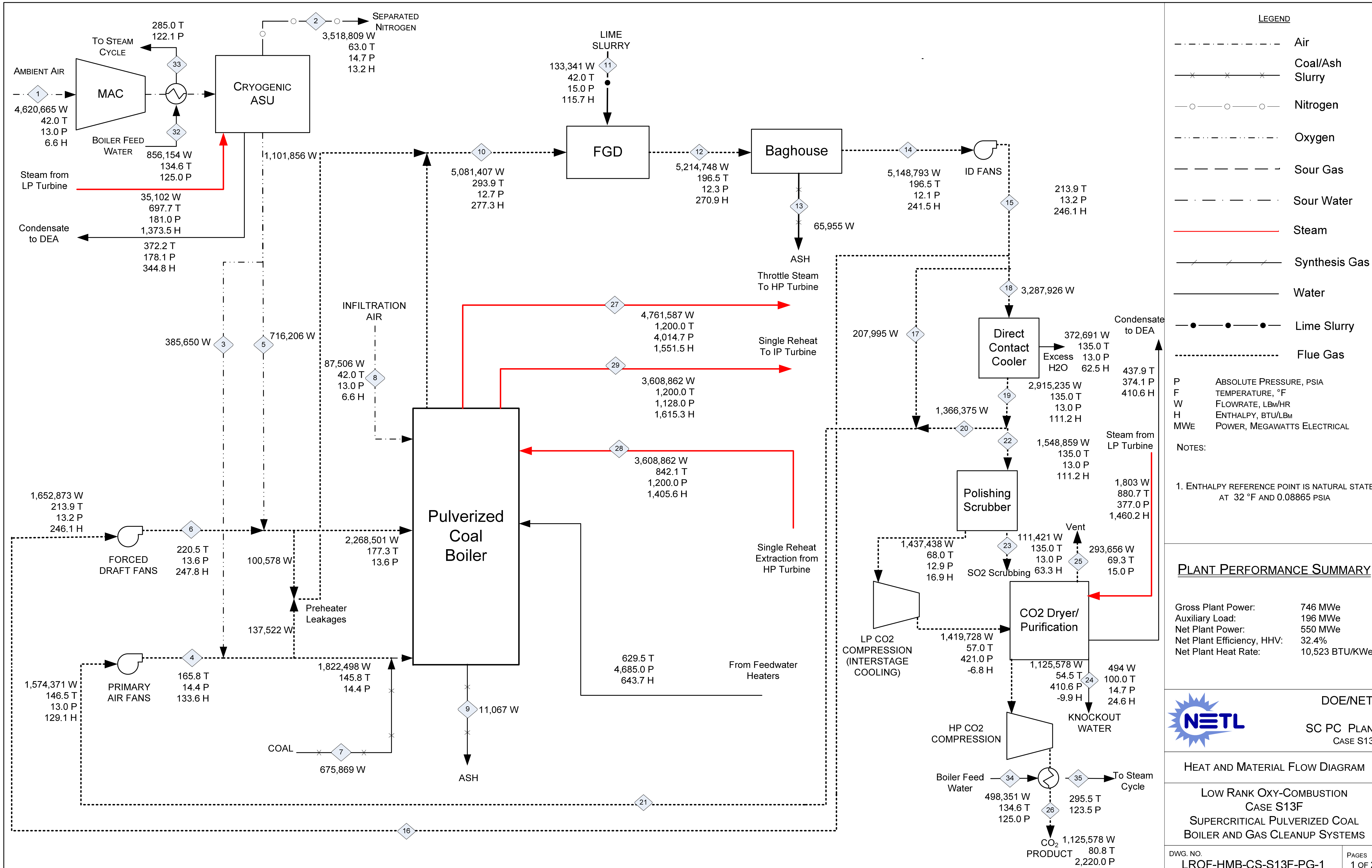


Exhibit 8-13 Case S13F Heat and Mass Balance, Power Block Systems

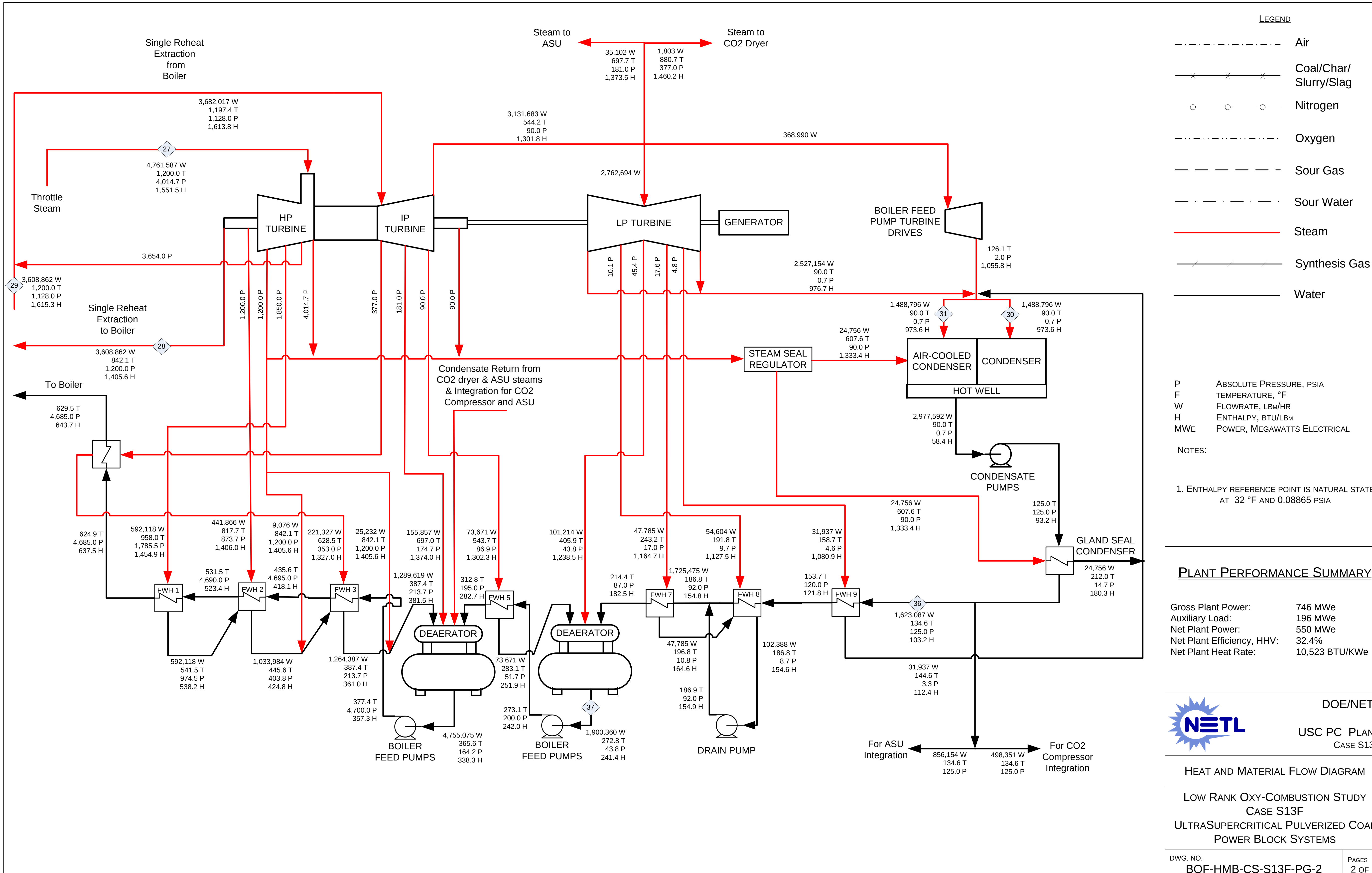


Exhibit 8-14 Case L13F Heat and Mass Balance, Ultra-Supercritical PC Boiler and Gas Cleanup Systems

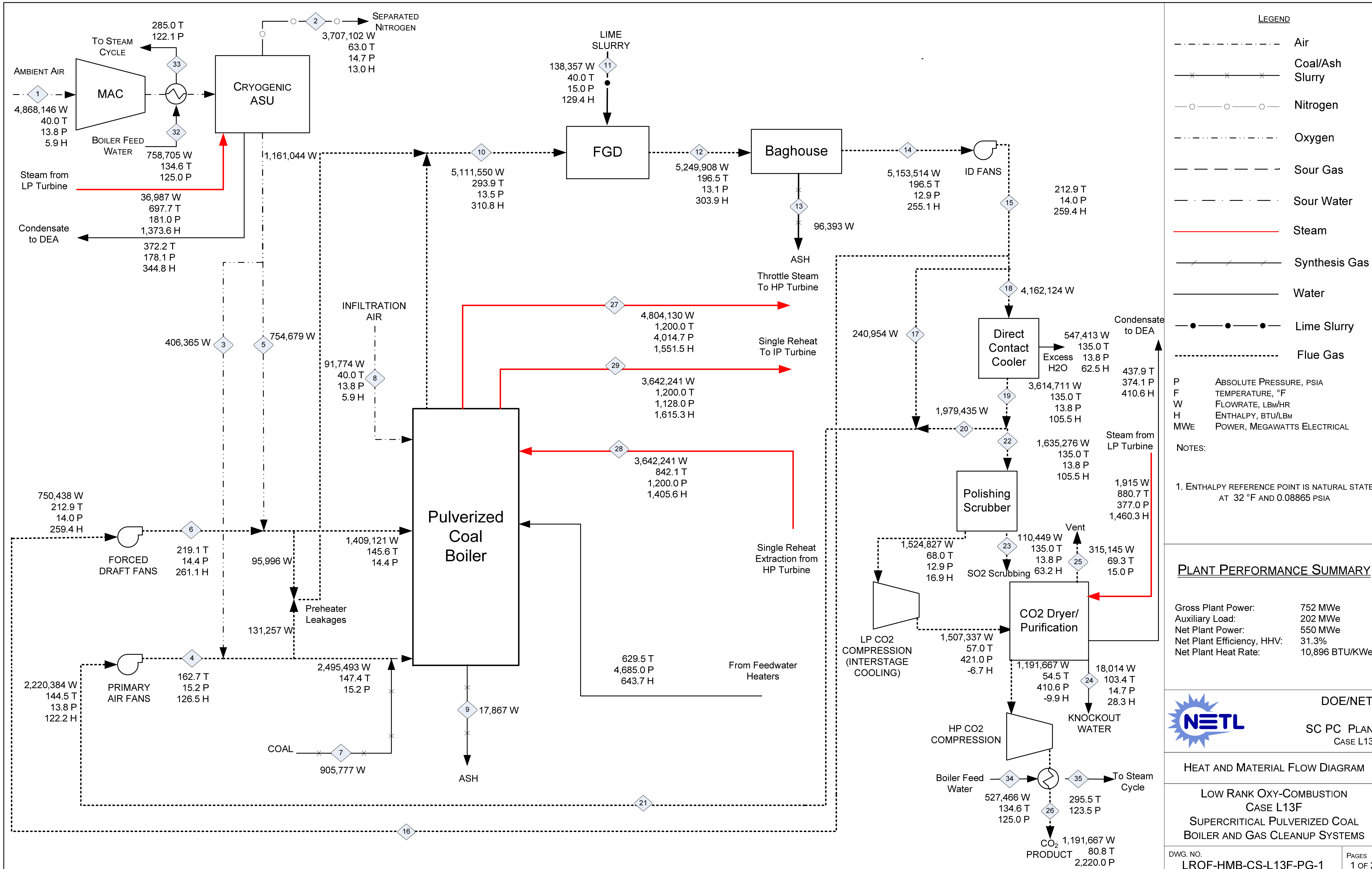
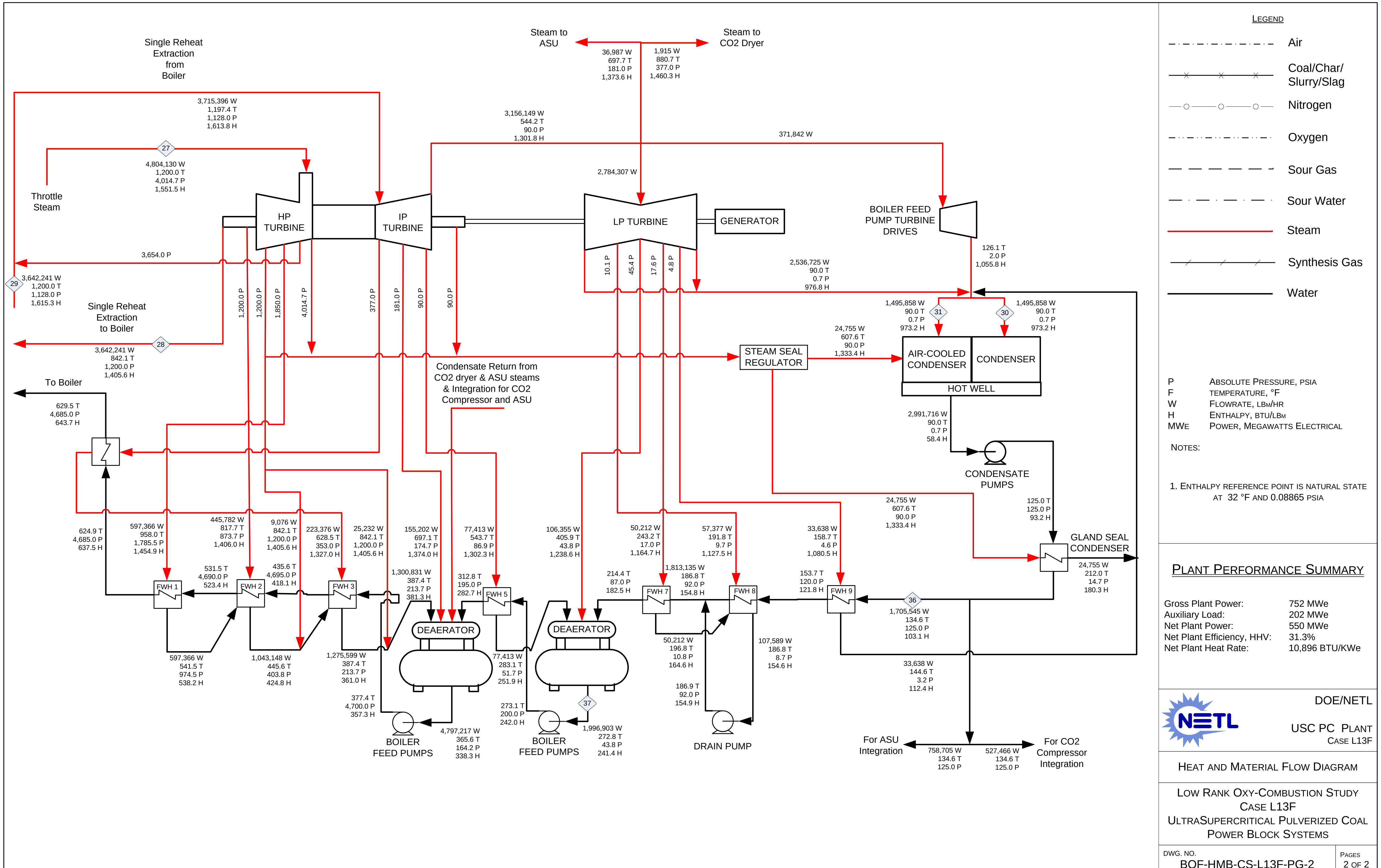


Exhibit 8-15 Case L13F Heat and Mass Balance, Power Block Systems



8.3.9 Major Equipment List for Cases S13F and L13F

Major equipment items for these cases are shown in the following tables. The accounts used in the equipment list correspond to the account numbers used in the cost estimates in Section 4.6 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	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
1	Bottom Trestle Dumper and Receiving Hoppers	N/A	181 tonne (200 ton)	181 tonne (200 ton)	2(0)
2	Feeder	Belt	572 tonne/hr (630 tph)	572 tonne/hr (630 tph)	2(0)
3	Conveyor No. 1	Belt	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1(0)
4	Transfer Tower No. 1	Enclosed	N/A	N/A	1(0)
5	Conveyor No. 2	Belt	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1(0)
6	As-Received Coal Sampling System	Two-stage	N/A	N/A	1(0)
7	Stacker/Reclaimer	Traveling, linear	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1(0)
8	Reclaim Hopper	N/A	64 tonne (70 ton)	82 tonne (90 ton)	2(1)
9	Feeder	Vibratory	254 tonne/hr (280 tph)	336 tonne/hr (370 tph)	2(1)
10	Conveyor No. 3	Belt w/ tripper	508 tonne/hr (560 tph)	680 tonne/hr (750 tph)	1(0)
11	Crusher Tower	N/A	N/A	N/A	1(0)
12	Coal Surge Bin w/ Vent Filter	Dual outlet	254 tonne (280 ton)	336 tonne (370 ton)	2(0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
13	Crusher	Impactor reduction	8 cm x 0 - 3 cm x 0 (3" x 0 - 1-1/4" x 0)	8 cm x 0 - 3 cm x 0 (3" x 0 - 1-1/4" x 0)	2(0)
14	As-Fired Coal Sampling System	Swing hammer	N/A	N/A	1(1)
15	Conveyor No. 4	Belt w/tripper	508 tonne/hr (560 tph)	680 tonne/hr (750 tph)	1(0)
16	Transfer Tower No. 2	Enclosed	N/A	N/A	1(0)
17	Conveyor No. 5	Belt w/ tripper	508 tonne/hr (560 tph)	680 tonne/hr (750 tph)	1(0)
18	Coal Silo w/ Vent Filter and Slide Gates	Field erected	544 tonne (600 ton)	726 tonne (800 ton)	6(0)
19	Lime Truck Unloading System	N/A	18 tonne/hr (20 tph)	27 tonne/hr (30 tph)	1(0)
20	Lime Bulk Storage Silo w/Vent Filter	Field erected	635 tonne (700 ton)	726 tonne (800 ton)	3(0)
21	Lime Live Storage Transport	Pneumatic	8 tonne/hr (9 tph)	9 tonne/hr (10 tph)	1(0)
22	Lime Day Bin	w/ actuator	64 tonne (70 ton)	73 tonne (80 ton)	2(0)
23	Activated Carbon Storage Silo and Feeder System with Vent Filter	Shop assembled	#N/A	#N/A	1(0)

ACCOUNT 2 COAL AND SORBENT PREPARATION AND FEED

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
1	Coal Feeder	Gravimetric	54 tonne/hr (60 tph)	73 tonne/hr (80 tph)	6(0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
2	Coal Pulverizer	Ball type or equivalent	54 tonne/hr (60 tph)	73 tonne/hr (80 tph)	6(0)
3	Lime Slaker	N/A	7 tonne/hr (8 tph)	8 tonne/hr (9 tph)	1(1)
4	Lime Slurry Tank	Field Erected	344,475 liters (91,000 gal)	393,686 liters (104,000 gal)	1(1)
5	Lime Slurry Feed Pumps	Horizontal centrifugal	341 lpm @ 9m H_2O (90 gpm @ 30 ft H_2O)	416 lpm @ 9m H_2O (110 gpm @ 30 ft H_2O)	1(1)

ACCOUNT 3 FEEDWATER AND MISCELLANEOUS SYSTEMS AND EQUIPMENT

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
1	Demineralized Water Storage Tank	Vertical, cylindrical, outdoor	571,597 liters (151,000 gal)	598,095 liters (158,000 gal)	2(0)
2	Condensate Pumps	Vertical canned	#N/A	#VALUE!	1(1)
3	Deaerator and Storage Tank	Horizontal spray type	948,008 kg/hr (2,090,000 lb/hr), 5 min. tank	996,542 kg/hr (2,197,000 lb/hr), 5 min. tank	1(0)
4	Boiler Feed Pump/Turbine	Barrel type, multi-stage, centrifugal	15,899 lpm @ 122 m H_2O (4,200 gpm @ 400 ft H_2O)	16,656 lpm @ 122 m H_2O (4,400 gpm @ 400 ft H_2O)	1(1)
5	Startup Boiler Feed Pump, Electric Motor Driven	Barrel type, multi-stage, centrifugal	4,921 lpm @ 122 m H_2O (1,300 gpm @ 400 ft H_2O)	4,921 lpm @ 122 m H_2O (1,300 gpm @ 400 ft H_2O)	1(0)
6	LP Feedwater Heater 1A/1B	Horizontal U-tube	#N/A	0 kg/hr (0 lb/hr)	2(0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
7	LP Feedwater Heater 2A/2B	Horizontal U-tube	#N/A	0 kg/hr (0 lb/hr)	2(0)
8	LP Feedwater Heater 3A/3B	Horizontal U-tube	#N/A	0 kg/hr (0 lb/hr)	2(0)
9	LP Feedwater Heater 4A/4B	Horizontal U-tube	#N/A	0 kg/hr (0 lb/hr)	2(0)
10	HP Feedwater Heater 6	Horizontal U-tube	948,008 kg/hr (2,090,000 lb/hr)	997,903 kg/hr (2,200,000 lb/hr)	1(0)
11	HP Feedwater Heater 7	Horizontal U-tube	948,008 kg/hr (2,090,000 lb/hr)	997,903 kg/hr (2,200,000 lb/hr)	1(0)
12	HP Feedwater heater 8	Horizontal U-tube	948,008 kg/hr (2,090,000 lb/hr)	997,903 kg/hr (2,200,000 lb/hr)	1(0)
13	Auxiliary Boiler	Shop fabricated, water tube	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)	1(0)
14	Fuel Oil System	No. 2 fuel oil for light off	1,135,624 liter (300,000 gal)	1,135,624 liter (300,000 gal)	1(0)
15	Service Air Compressors	Flooded Screw	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	2(1)
16	Instrument Air Dryers	Duplex, regenerative	28 m^3/min (1,000 scfm)	28 m^3/min (1,000 scfm)	2(1)
17	Closed Cycle Cooling Heat Exchangers	Shell and tube	53 GJ/hr (50 MMBtu/hr) each	53 GJ/hr (50 MMBtu/hr) each	2(0)
18	Closed Cycle Cooling Water Pumps	Horizontal centrifugal	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)	2(1)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
19	Engine-Driven Fire Pump	Vertical turbine, diesel engine	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)	1(1)
20	Fire Service Booster Pump	Two-stage horizontal centrifugal	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)	1(1)
21	Raw Water Pumps	Stainless steel, single suction	5,375 lpm @ 18 m H_2O (1,420 gpm @ 60 ft H_2O)	5,905 lpm @ 18 m H_2O (1,560 gpm @ 60 ft H_2O)	2(1)
22	Ground Water Pumps	Stainless steel, single suction	2,688 lpm @ 268 m H_2O (710 gpm @ 880 ft H_2O)	2,953 lpm @ 268 m H_2O (780 gpm @ 880 ft H_2O)	4(1)
23	Filtered Water Pumps	Stainless steel, single suction	227 lpm @ 49 m H_2O (60 gpm @ 160 ft H_2O)	265 lpm @ 49 m H_2O (70 gpm @ 160 ft H_2O)	2(1)
24	Filtered Water Tank	Vertical, cylindrical	219,554 liter (58,000 gal)	238,481 liter (63,000 gal)	1(0)
25	Makeup Water Demineralizer	Multi-media filter, cartridge filter, RO membrane assembly, electrodeionization unit	454 lpm (120 gpm)	492 lpm (130 gpm)	1(1)
26	Liquid Waste Treatment System	--	10 years, 24-hour storm	10 years, 24-hour storm	1(0)

ACCOUNT 4 BOILER AND ACCESSORIES

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
1	Boiler	Ultra-supercritical, wall-fired, low NOx burners, overfire air	2,376,824 kg/hr steam @ 29.0 MPa/657°C/657°C (5,240,000 lb/hr steam @ 4,200 psig/1,215°F/1,215°F)	2,394,968 kg/hr steam @ 29.0 MPa/657°C/657°C (5,280,000 lb/hr steam @ 4,200 psig/1,215°F/1,215°F)	1 (0)
2	Primary Air Fan	Centrifugal	#N/A	#N/A	2 (0)
3	Forced Draft Fan	Centrifugal	#N/A	#N/A	2 (0)
4	Induced Draft Fan	Centrifugal	#N/A	#N/A	2 (0)
5	SCR Reactor Vessel	Space for spare layer	2,567,333 kg/hr (5,660,000 lb/hr)	2,571,869 kg/hr (5,670,000 lb/hr)	2 (0)
6	SCR Catalyst	--	--	--	
7	Dilution Air Blower	Centrifugal	48 m^3/min @ 108 cm WG (1,700 acfm @ 42 in. WG)	51 m^3/min @ 108 cm WG (1,800 acfm @ 42 in. WG)	
8	Ammonia Storage	Horizontal tank	52,996 liter (14,000 gal)	56,781 liter (15,000 gal)	
9	Ammonia Feed Pump	Centrifugal	10 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)	11 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)	
10	ASU Main Air Compressor	Centrifugal, multi-stage	#N/A	#N/A	
11	Cold Box	Vendor design	#N/A	#N/A	3 (0)
12	Oxygen Compressor	Centrifugal, multi-stage	#N/A	#N/A	2 (1)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
13	Nitrogen Compressor	Centrifugal, multi-stage	#N/A	#N/A	5 (0)
14	Nitrogen Boost Compressor	Centrifugal, multi-stage	#N/A	#N/A	2 (1)

ACCOUNT 5 FLUE GAS CLEANUP

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
1	Fabric Filter	Single stage, high-ratio with pulse-jet online cleaning system, air-to-cloth ratio - 3.5 ft/min	1,284,574 kg/hr (2,832,000 lb/hr) 99.9% efficiency	1,285,481 kg/hr (2,834,000 lb/hr) 99.9% efficiency	2(0)
2	Spray Dryer	Co-current open spray	24,239 m^3/min (856,000 acfm)	23,107 m^3/min (816,000 acfm)	2(0)
3	Atomizer	Rotary	189 lpm @ 64 m H_2O (50 gpm @ 210 ft H_2O)	227 lpm @ 64 m H_2O (60 gpm @ 210 ft H_2O)	2(1)
4	Spray Dryer Solids Conveying	---	---	---	2(0)
5	Carbon Injectors	---	#N/A	#N/A	1(0)

ACCOUNT 7 DUCTING AND STACK

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case 1	Case 2	

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case 1	Case 2	
1	Stack	Reinforced concrete with FRP liner	#N/A	#N/A	1 (0)

ACCOUNT 8 STEAM TURBINE GENERATOR

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
1	Steam Turbine	Commercially available	785 MW 27.6 MPa/649°C/649°C (4000 psig/ 1200°F/1200°F)	792 MW 27.6 MPa/649°C/649°C (4000 psig/ 1200°F/1200°F)	1(0)
2	Steam Turbine Generator	Hydrogen cooled, static excitation	870 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	880 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	1(0)
3	Surface Condenser	Single pass, divided waterbox including vacuum pumps	1,580 GJ/hr (1,500 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 9°C (48°F), Water temperature rise 11°C (20°F)	1,593 GJ/hr (1,510 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 9°C (48°F), Water temperature rise 11°C (20°F)	1(0)
4	Air-cooled Condenser	---	1,580 GJ/hr (1,500 MMBtu/hr), Condensing temperature 32°C (90°F), Ambient temperature 6°C (42°F)	1,593 GJ/hr (1,510 MMBtu/hr), Condensing temperature 32°C (90°F), Inlet water temperature 9°C (48°F), Water temperature rise 11°C (20°F)	1(0)

ACCOUNT 9 COOLING WATER SYSTEM

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
1	Circulating Water Pumps	Vertical, wet pit	499,700 lpm @ 30 m (132,000 gpm @ 100 ft)	545,100 lpm @ 30 m (144,000 gpm @ 100 ft)	1 (0)
2	Cooling Tower	Evaporative, mechanical draft, multi-cell	3°C (37°F) wet bulb / 9°C (48°F) CWT / 20°C (68°F) HWT / 2775 GJ/hr (2630 MMBtu/hr) heat duty	2°C (36°F) wet bulb / 8°C (47°F) CWT / 19°C (67°F) HWT / 3049 GJ/hr (2890 MMBtu/hr) heat duty	2 (1)

ACCOUNT 10 ASH/SPENT SORBENT RECOVERY AND HANDLING

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
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	--	5.4 tonne/hr (6 tph)	3.6 tonne/hr (4 tph)	1 (1)
4	Pyrites Hopper (part of pulverizer scope of supply included with boiler)	--	--	--	6 (0)
5	Hydroejectors	--	--		
6	Economizer /Pyrites Transfer Tank	--	--	--	4(0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
7	Ash Sluice Pumps	Vertical, wet pit	227 lpm @ 17 m H_2O (60 gpm @ 56 ft H_2O)	--	2(0)
8	Ash Seal Water Pumps	Vertical, wet pit	7,571 lpm @ 9 m H_2O (2000 gpm @ 28 ft H_2O)	--	1(1)
9	Hydrobins	--	227 lpm (60 gpm)	9.1 tonne/hr (10 tph)	6(0)
10	Baghouse Hopper (part of baghouse scope of supply)	--	--	--	12()
11	Air Heater Hopper (part of boiler scope of supply)	--	--	--	1(0)
12	Air Blower	--	30 m^3/min @ 0.2 MPa (1060 scfm @ 24 psi)	--	1(1)
13	Fly Ash Silo	Reinforced concrete	2,000 tonne (2,200 ton)	341 lpm @ 17 m H_2O (90 gpm @ 56 ft H_2O)	1(1)
14	Slide Gate Valves	--	--	7,571 lpm @ 9 m H_2O (2000 gpm @ 28 ft H_2O)	1(1)
15	Unloader	--	--	341 lpm (90 gpm)	24(0)
16	Telescoping Unloading Chute	--	181 tonne/hr (200 tph)	--	10(0)
17	Recycle Waste Storage Silo	Reinforced concrete	272 tonne (300 ton)	--	1(1)
18	Recycle Waste Conveyor	--	36 tonne/hr (40 tph)	44 m^3/min @ 0.2 MPa (1550 scfm @ 24 psi)	2(0)
19	Recycle Slurry Mixer	--	871 lpm (230 gpm)	2,900 tonne (3,200 ton)	2(0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
20	Recycle Waste Slurry Tank	--	53,000 liters (14,000 gal)	--	1(0)
21	Recycle Waste Pump	--	871 lpm (230 gpm)	--	1(0)

ACCOUNT 11 ACCESSORY ELECTRIC PLANT

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
1	STG Transformer	Oil-filled	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	1(0)
2	Auxiliary Transformer	Oil-filled	24 kV/4.16 kV, 215 MVA, 3-ph, 60 Hz	24 kV/4.16 kV, 28 MVA, 3-ph, 60 Hz	1(1)
3	Low Voltage Transformer	Dry ventilated	4.16 kV/480 V, 32 MVA, 3-ph, 60 Hz	4.16 kV/480 V, 4 MVA, 3-ph, 60 Hz	1(1)
4	STG Isolated Phase Bus Duct and Tap Bus	Aluminum, self-cooled	24 kV, 3-ph, 60 Hz	24 kV, 3-ph, 60 Hz	1(0)
5	Medium Voltage Switchgear	Metal clad	4.16 kV, 3-ph, 60 Hz	4.16 kV, 3-ph, 60 Hz	1(1)
6	Low Voltage Switchgear	Metal enclosed	480 V, 3-ph, 60 Hz	480 V, 3-ph, 60 Hz	1(1)
7	Emergency Diesel Generator	Sized for emergency shutdown	750 kW, 480 V, 3-ph, 60 Hz	750 kW, 480 V, 3-ph, 60 Hz	1(0)

ACCOUNT 12 INSTRUMENTATION AND CONTROL

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S13F	Case L13F	
1	DCS - Main Control	Monitor/keyboard; Operator printer (laser color); Engineering printer (laser B&W)	Operator stations/printers and engineering stations/printers	Operator stations/printers and engineering stations/printers	1(0)
2	DCS - Processor	Microprocessor with redundant input/output	N/A	N/A	1(0)
3	DCS - Data Highway	Fiber optic	Fully redundant, 25% spare	Fully redundant, 25% spare	1(0)

8.4 ECONOMIC ANALYSIS FOR ULTRA-SUPERCRITICAL OXYCOMBUSTION CASES

Capital and operating costs for the USC oxycombustion cases are presented in Section 8.4.1. A cost and performance summary table for cases S13F and L13F is given in Exhibit 8-22, and additional cost detail sheets for all cases are contained in Exhibit 8-16 through Exhibit 8-21.

8.4.1 Cost Results for Cases S13F and L13F

The capital and operating costs for Cases S13F and L13F are shown in Exhibit 8-16 and Exhibit 8-17. Capital and operating cost estimating methodology is explained Section 2.7.

Exhibit 8-16 Case S13F Total Plant Costs

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S13F - Oxyfuel Ultra-Supercritical PC w/ CO2 Capture
Plant Size: 550.04 MW, net   Capital Charge Factor 0.175   Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 29-Sep-10
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
	SUBTOTAL 1.	$19,016	$5,765	$12,581	$0	$37,362		$3,358		$0		$6,108	$46,828	$85
2	COAL PREP & FEED SYSTEMS													
	SUBTOTAL 2.	$9,560	$772	$2,671	$0	$13,003		$1,143		$0		$2,122	$16,268	$30
3	FEEDWATER & MISC. BOP SYSTEMS													
	SUBTOTAL 3.	$45,474	$0	$21,549	$0	$67,023		$6,066		$0		$11,526	$84,615	$154
4	PC BOILER & ACCESSORIES													
	SUBTOTAL 4.	$421,840	$0	$263,173	$0	$685,013		$66,351		$58,453		$80,982	$890,798	$1,620
5A	FLUE GAS CLEANUP							*						
	SUBTOTAL 5A.	$92,118	$0	$20,845	$0	$112,963		$10,740		$0		$12,370	$136,074	$247
5B	CO2 REMOVAL & COMPRESSION													
	SUBTOTAL 5B.	$45,481	$0	$34,385	$0	$79,866		$7,987		$0		$17,341	$105,194	$191
6	COMBUSTION TURBINE/ACCESSORIES													
	SUBTOTAL 6.	$0	$0	$0	$0	$0		$0		$0		$0	$0	$0
7	HRSG, DUCTING & STACK													
	SUBTOTAL 7.	$50,479	$886	$11,679	$0	$63,044		$6,070		$0		$10,331	$79,445	$144
8	STEAM TURBINE GENERATOR													
	SUBTOTAL 8.	$93,318	$1,322	$26,788	$0	$121,428		$11,153		$0		$15,677	$148,258	$270
9	COOLING WATER SYSTEM													
	SUBTOTAL 9.	$9,733	$6,997	$11,521	$0	$28,251		$2,631		$0		$4,392	$35,273	$64
10	ASH/SPENT SORBENT HANDLING SYS													
	SUBTOTAL 10.	$6,367	$202	$8,513	$0	$15,083		$1,436		$0		$1,700	$18,219	$33
11	ACCESSORY ELECTRIC PLANT													
	SUBTOTAL 11.	$15,552	$13,182	$36,745	$0	$65,479		$5,933		$0		$9,393	$80,805	$147
12	INSTRUMENTATION & CONTROL													
	SUBTOTAL 12.	$10,605	$0	$10,754	$0	$21,359		$1,956		$0		$2,863	$26,179	$48
13	IMPROVEMENTS TO SITE													
	SUBTOTAL 13.	$3,354	$1,928	$6,760	$0	$12,042		$1,183		$0		$2,645	$15,870	$29
14	BUILDINGS & STRUCTURES													
	SUBTOTAL 14.	$0	$25,567	$24,117	$0	$49,684		$4,476		$0		$8,124	$62,284	$113
	Total Cost	$822,899	$56,621	$492,080	$0	$1,371,601		$130,482		$58,453		$185,573	$1,746,109	$3,175

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S13F - Oxyfuel Ultra-Supercritical PC w/ CO2 Capture
Plant Size: 550.04 MW, net   Capital Charge Factor 0.175   Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
1.1	Coal Receive & Unload	4,595	0	2,099	0	6,694	8.9%	598	0%	0	15.0%	1,094	8,385	15
1.2	Coal Stackout & Reclaim	5,938	0	1,345	0	7,284	8.8%	638	0%	0	15.0%	1,188	9,110	17
1.3	Coal Conveyors & Yd Crus	5,521	0	1,331	0	6,852	8.8%	601	0%	0	15.0%	1,118	8,571	16
1.4	Other Coal Handling	1,444	0	308	0	1,753	8.7%	153	0%	0	15.0%	286	2,192	4
1.5	Sorbent Receive & Unload	57	0	17	0	75	8.8%	7	0%	0	15.0%	12	94	0
1.6	Sorbent Stackout & Reclaim	928	0	170	0	1,099	8.7%	96	0%	0	15.0%	179	1,374	2
1.7	Sorbent Conveyors	331	72	81	0	484	8.7%	42	0%	0	15.0%	79	605	1
1.8	Other Sorbent Handling	200	47	105	0	352	8.8%	31	0%	0	15.0%	58	441	1
1.9	Coal & Sorbent Hnd.Foundations	0	5,646	7,123	0	12,769	9.3%	1,194	0%	0	15.0%	2,094	16,057	29
	SUBTOTAL 1.	**$19,016**	**$5,765**	**$12,581**	**$0**	**$37,362**		**$3,358**		**$0**		**$6,108**	**$46,828**	**$85**
2	COAL PREP & FEED SYSTEMS													
2.1	Coal Crushing & Drying	2,685	0	523	0	3,208	8.7%	280	0%	0	15.0%	523	4,011	7
2.2	Prepared Coal Storage & Feed	6,875	0	1,501	0	8,375	8.7%	733	0%	0	15.0%	1,366	10,474	19
2.3	Slurry Prep & Feed	0	0	0	0	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	0.0%	0	0	0
2.5	Sorbent Prep Equipment	0	0	0	0	0	8.7%	0	0%	0	15.0%	0	0	0
2.6	Sorbent Storage & Feed	0	0	0	0	0	8.9%	0	0%	0	15.0%	0	0	0
2.7	Sorbent Injection System	0	0	0	0	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	0.0%	0	0	0
2.9	Coal & Sorbent Feed Foundation	0	772	648	0	1,419	9.2%	131	0%	0	15.0%	232	1,782	3
	SUBTOTAL 2.	**$9,560**	**$772**	**$2,671**	**$0**	**$13,003**		**$1,143**		**$0**		**$2,122**	**$16,268**	**$30**
3	FEEDWATER & MISC. BOP SYSTEMS													
3.1	Feedwater System	22,028	0	7,116	0	29,144	8.8%	2,552	0%	0	15.0%	4,754	36,450	66
3.2	Water Makeup & Pretreating	4,057	0	1,306	0	5,362	9.4%	503	0%	0	20.0%	1,173	7,038	13
3.3	Other Feedwater Subsystems	6,744	0	2,850	0	9,594	8.9%	855	0%	0	15.0%	1,567	12,016	22
3.4	Service Water Systems	795	0	433	0	1,228	9.3%	114	0%	0	20.0%	268	1,610	3
3.5	Other Boiler Plant Systems	8,761	0	8,649	0	17,410	9.4%	1,633	0%	0	15.0%	2,857	21,900	40
3.6	FO Supply Sys & Nat Gas	266	0	333	0	599	9.3%	56	0%	0	15.0%	98	752	1
3.7	Waste Treatment Equipment	0	0	0	0	0	9.7%	0	0%	0	20.0%	0	0	0
3.8	Misc. Power Plant Equipment	2,824	0	863	0	3,687	9.6%	354	0%	0	20.0%	808	4,849	9
	SUBTOTAL 3.	**$45,474**	**$0**	**$21,549**	**$0**	**$67,023**		**$6,066**		**$0**		**$11,526**	**$84,615**	**$154**
4	PC BOILER & ACCESSORIES													
4.1	PC (Oxycombustion) Boiler	259,411	0	130,276	0	389,687	9.7%	37,745	15%	58,453	10.0%	48,589	534,474	972
4.2	ASU/Oxidant Compression	162,429	0	132,896	0	295,325	9.7%	28,605	0%	0	10.0%	32,393	356,324	648
4.3	Open	0	0	0	0	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	0.0%	0	0	0
4.5	Primary Air System	w/4.1	0	w/4.1	0	0	0.0%	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	0.0%	0	0	0
4.7	Major Component Rigging	0	w/4.1	w/4.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
4.8	PC Foundations	0	w/14.1	w/14.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 4.	**$421,840**	**$0**	**$263,173**	**$0**	**$685,013**		**$66,351**		**$58,453**		**$80,982**	**$890,798**	**$1,620**
5A	FLUE GAS CLEANUP						*							
5.1	Absorber Vessels & Accessories	70,888	0	11,924	0	82,812	9.5%	7,838	0%	0	10.0%	9,065	99,715	181
5.2	Other FGD	1,144	0	458	0	1,602	9.6%	154	0%	0	10.0%	176	1,932	4
5.3	Bag House & Accessories	w/5.1	0	w/5.1	0	0	9.6%	0	0%	0	10.0%	0	0	0
5.4	Other Particulate Removal Materials	20,086	0	8,462	0	28,549	9.6%	2,748	0%	0	10.0%	3,130	34,427	63
5.5	Gypsum Dewatering System	N/A	N/A	N/A	N/A	0	9.4%	0	0%	0	10.0%	0	0	0
5.6	Mercury Removal System	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.7	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.8	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.9	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 5A.	**$92,118**	**$0**	**$20,845**	**$0**	**$112,963**		**$10,740**		**$0**		**$12,370**	**$136,074**	**$247**

	Department:	NETL Office of Systems Analysis and Planning									**Cost Base:** Jan 2007			
	Project:	Oxy-Fuel Combustion Systems Analysis									**Prepared:**		19-Sep-09	
	Case:	Case S13F - Oxyfuel Ultra-Supercritical PC w/ CO2 Capture											**x $1, 000**	
	Plant Size:	550.04 MW, net				Capital Charge Factor 0.175		Capacity Factor 0.85						

		Equipment		Labor		Bare Erected	Eng'g CM H.O. &		Process Cont.		Project Cont.		TOTAL PLANT COST	
Acct No.	**Item/Description**	**Cost**	**Material Cost**	**Direct**	**Indirect**	**Cost $**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**$**	**$/kW**
5B	CO2 REMOVAL & COMPRESSION													
5B.1	CO2 Condensing Heat Exchanger	3,848	0	321	0	4,169	10%	417	0%	0	15.0%	688	5,274	10
5B.2	CO2 Compression & Drying	41,633	0	34,063	0	75,697	10%	7,570	0%	0	20.0%	16,653	99,919	182
5B.3	CO2 Pipeline											0	0	0
5B.4	CO2 Storage											0	0	0
5B.5	CO2 Monitoring											0	0	0
	SUBTOTAL 5B.	**$45,481**	**$0**	**$34,385**	**$0**	**$79,866**		**$7,987**		**$0**		**$17,341**	**$105,194**	**$191**
6	COMBUSTION TURBINE/ACCESSORIES													
6.1	Combustion Turbine Generator	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.2	Combustion Turbine Accessories	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.3	Compressed Air Piping	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.4	Combustion Turbine Foundations	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
7.1	Flue Gas Recycle Heat Exhchanger	38,761	0	3,237	0	41,997	10%	4,200	0%	0	15.0%	6,930	53,126	97
7.2	SCR System	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
7.3	Ductwork	10,108	0	6,494	0	16,602	9%	1,450	0%	0	15.0%	2,708	20,760	38
7.4	Stack	1,611	0	942	0	2,553	10%	244	0%	0	10.0%	280	3,077	6
7.9	HRSG, Duct & Stack Foundations	0	886	1,006	0	1,892	9%	176	0%	0	20.0%	414	2,482	5
	SUBTOTAL 7.	**$50,479**	**$886**	**$11,679**	**$0**	**$63,044**		**$6,070**		**$0**		**$10,331**	**$79,445**	**$144**
8	STEAM TURBINE GENERATOR													
8.1	Steam TG & Accessories	62,621	0	8,316	0	70,937	9.6%	6,792	0%	0	10.0%	7,773	85,502	155
8.2	Turbine Plant Auxiliaries	422	0	905	0	1,327	9.7%	129	0%	0	10.0%	146	1,602	3
8.3a	Condenser & Auxiliaries	4,989	0	3,010	0	7,998	9.5%	760	0%	0	10.0%	876	9,634	18
8.3b	Air Cooled Condenser													
8.4	Steam Piping	25,286	0	12,468	0	37,754	8.3%	3,151	0%	0	15.0%	6,136	47,041	86
8.9	TG Foundations	0	1,322	2,089	0	3,411	9.4%	321	0%	0	20.0%	746	4,479	8
	SUBTOTAL 8.	**$93,318**	**$1,322**	**$26,788**	**$0**	**$121,428**		**$11,153**		**$0**		**$15,677**	**$148,258**	**$270**
9	COOLING WATER SYSTEM													
9.1	Cooling Towers	6,388	0	1,989	0	8,378	9.5%	795	0%	0	10.0%	917	10,090	18
9.2	Circulating Water Pumps	1,956	0	186	0	2,142	8.6%	183	0%	0	10.0%	233	2,558	5
9.3	Circ. Water System Auxiliaries	554	0	74	0	628	9.4%	59	0%	0	10.0%	69	756	1
9.4	Circ. Water Piping	0	4,394	4,258	0	8,652	9.2%	797	0%	0	15.0%	1,417	10,867	20
9.5	Make-up Water System	395	0	528	0	923	9.5%	88	0%	0	15.0%	152	1,163	2
9.6	Component Cooling Water System	439	0	349	0	788	9.4%	74	0%	0	15.0%	129	991	2
9.9	Circ. Water System Foundations	0	2,603	4,136	0	6,739	9.4%	634	0%	0	20.0%	1,475	8,848	16
	SUBTOTAL 9.	**$9,733**	**$6,997**	**$11,521**	**$0**	**$28,251**		**$2,631**		**$0**		**$4,392**	**$35,273**	**$64**
10	ASH/SPENT SORBENT HANDLING SYS													
10.1	Ash Coolers	N/A	0	N/A	0	0	0%	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%	0	0	0
10.3	HGCU Ash Letdown	N/A	0	N/A	0	0	0%	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%	0	0	0
10.5	Other Ash Recovery Equipment	N/A	0	N/A	0	0	0%	0	0%	0	0.0%	0	0	0
10.6	Ash Storage Silos	852	0	2,625	0	3,477	10%	339	0%	0	10.0%	382	4,198	8
10.7	Ash Transport & Feed Equipment	5,515	0	5,650	0	11,165	9%	1,056	0%	0	10.0%	1,222	13,443	24
10.8	Misc. Ash Handling Equipment	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
10.9	Ash/Spent Sorbent Foundation	0	202	238	0	441	9%	41	0%	0	20.0%	96	578	1
	SUBTOTAL 10.	**$6,367**	**$202**	**$8,513**	**$0**	**$15,083**		**$1,436**		**$0**		**$1,700**	**$18,219**	**$33**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S13F - Oxyfuel Ultra-Supercritical PC w/ CO2 Capture
Plant Size: 550.04 MW, net Capital Charge Factor 0.175 Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT													
11.1	Generator Equipment	380	0	62	0	441	9.3%	41	0%	0	7.5%	36	518	1
11.2	Station Service Equipment	6,309	0	2,073	0	8,383	9.6%	802	0%	0	7.5%	689	9,873	18
11.3	Switchgear & Motor Control	7,254	0	1,233	0	8,487	9.3%	786	0%	0	10.0%	927	10,200	19
11.4	Conduit & Cable Tray	0	4,548	15,725	0	20,273	9.6%	1,940	0%	0	15.0%	3,332	25,545	46
11.5	Wire & Cable	0	8,581	16,566	0	25,147	8.4%	2,119	0%	0	15.0%	4,090	31,356	57
11.6	Protective Equipment	270	0	920	0	1,190	9.8%	116	0%	0	10.0%	131	1,437	3
11.7	Standby Equipment	394	0	9	0	403	9.5%	38	0%	0	10.0%	44	485	1
11.8	Main Power Transformers	946	0	29	0	975	7.6%	74	0%	0	10.0%	105	1,154	2
11.9	Electrical Foundations	0	52	129	0	181	9.5%	17	0%	0	20.0%	40	238	0
	SUBTOTAL 11.	**$15,552**	**$13,182**	**$36,745**	**$0**	**$65,479**		**$5,933**		**$0**		**$9,393**	**$80,805**	**$147**
12	INSTRUMENTATION & CONTROL													
12.1	PC Control Equipment	w/12.7	0	w/12.7	0	0	0%	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%	0	0	0
12.3	Steam Turbine Control	w/8.1	0	w/8.1	0	0	0%	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%	0	0	0
12.5	Signal Processing Equipment	W/12.7	0	w/12.7	0	0	0%	0	0%	0	0.0%	0	0	0
12.6	Control Boards, Panels & Racks	546	0	327	0	873	10%	84	0%	0	15.0%	144	1,101	2
12.7	Computer Accessories	5,513	0	963	0	6,476	10%	617	0%	0	10.0%	709	7,802	14
12.8	Instrument Wiring & Tubing	2,989	0	5,929	0	8,917	9%	760	0%	0	15.0%	1,452	11,129	20
12.9	Other I & C Equipment	1,558	0	3,535	0	5,092	10%	496	0%	0	10.0%	559	6,147	11
	SUBTOTAL 12.	**$10,605**	**$0**	**$10,754**	**$0**	**$21,359**		**$1,956**		**$0**		**$2,863**	**$26,179**	**$48**
13	IMPROVEMENTS TO SITE													
13.1	Site Preparation	0	56	1,127	0	1,184	9.9%	117	0%	0	20.0%	260	1,561	3
13.2	Site Improvements	0	1,872	2,325	0	4,196	9.8%	412	0%	0	20.0%	922	5,530	10
13.3	Site Facilities	3,354	0	3,308	0	6,662	9.8%	654	0%	0	20.0%	1,463	8,779	16
	SUBTOTAL 13.	**$3,354**	**$1,928**	**$6,760**	**$0**	**$12,042**		**$1,183**		**$0**		**$2,645**	**$15,870**	**$29**
14	BUILDINGS & STRUCTURES													
14.1	Boiler Building	0	9,817	8,633	0	18,450	9.0%	1,657	0%	0	15.0%	3,016	23,123	42
14.2	Turbine Building	0	12,938	12,058	0	24,996	9.0%	2,251	0%	0	15.0%	4,087	31,334	57
14.3	Administration Building	0	648	685	0	1,332	9.1%	121	0%	0	15.0%	218	1,671	3
14.4	Circulation Water Pumphouse	0	206	164	0	369	8.9%	33	0%	0	15.0%	60	463	1
14.5	Water Treatment Buildings	0	554	456	0	1,010	9.0%	90	0%	0	15.0%	165	1,265	2
14.6	Machine Shop	0	433	291	0	724	8.9%	64	0%	0	15.0%	118	906	2
14.7	Warehouse	0	293	294	0	588	9.0%	53	0%	0	15.0%	96	737	1
14.8	Other Buildings & Structures	0	240	204	0	444	9.0%	40	0%	0	15.0%	73	556	1
14.9	Waste Treating Building & Str.	0	439	1,332	0	1,771	9.4%	167	0%	0	15.0%	291	2,229	4
	SUBTOTAL 14.	**$0**	**$25,567**	**$24,117**	**$0**	**$49,684**		**$4,476**		**$0**		**$8,124**	**$62,284**	**$113**
	Total Cost	**$822,899**	**$56,621**	**$492,080**	**$0**	**$1,371,601**		**$130,482**		**$58,453**		**$185,573**	**$1,746,109**	**$3,175**

Exhibit 8-17 Case L13F Total Plant Costs

Department:	NETL Office of Systems Analysis and Planning
Project:	Oxy-Fuel Combustion Systems Analysis
Case:	Case L13F - Oxyfuel Ultra-Supercritical PC w/ CO2 Capture
Plant Size:	550.07 MW, net
Capital Charge Factor	0.175
Capacity Factor	0.85
Cost Base:	Jan 2007
Prepared:	19-Sep-09
	x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
	SUBTOTAL 1.	**$22,638**	**$6,891**	**$15,033**	**$0**	**$44,561**		**$4,006**		**$0**		**$7,285**	**$55,852**	**$102**
2	COAL PREP & FEED SYSTEMS													
	SUBTOTAL 2.	**$11,598**	**$928**	**$3,235**	**$0**	**$15,761**		**$1,385**		**$0**		**$2,572**	**$19,718**	**$36**
3	FEEDWATER & MISC. BOP SYSTEMS													
	SUBTOTAL 3.	**$46,354**	**$0**	**$21,905**	**$0**	**$68,259**		**$6,181**		**$0**		**$11,774**	**$86,215**	**$157**
4	PC BOILER & ACCESSORIES													
	SUBTOTAL 4.	**$485,587**	**$0**	**$296,824**	**$0**	**$782,411**		**$75,785**		**$71,650**		**$92,985**	**$1,022,830**	**$1,859**
5A	FLUE GAS CLEANUP						*							
	SUBTOTAL 5A.	**$89,768**	**$0**	**$20,367**	**$0**	**$110,136**		**$10,472**		**$0**		**$12,061**	**$132,668**	**$241**
5B	CO2 REMOVAL & COMPRESSION													
	SUBTOTAL 5B.	**$47,145**	**$0**	**$35,606**	**$0**	**$82,751**		**$8,275**		**$0**		**$17,965**	**$108,991**	**$198**
6	COMBUSTION TURBINE/ACCESSORIES													
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
	SUBTOTAL 7.	**$51,917**	**$922**	**$12,486**	**$0**	**$65,325**		**$6,273**		**$0**		**$10,711**	**$82,309**	**$150**
8	STEAM TURBINE GENERATOR													
	SUBTOTAL 8.	**$93,837**	**$1,329**	**$26,936**	**$0**	**$122,102**		**$11,214**		**$0**		**$15,765**	**$149,082**	**$271**
9	COOLING WATER SYSTEM													
	SUBTOTAL 9.	**$9,999**	**$7,439**	**$12,150**	**$0**	**$29,589**		**$2,754**		**$0**		**$4,622**	**$36,965**	**$67**
10	ASH/SPENT SORBENT HANDLING SYS													
	SUBTOTAL 10.	**$7,930**	**$252**	**$10,602**	**$0**	**$18,784**		**$1,788**		**$0**		**$2,117**	**$22,689**	**$41**
11	ACCESSORY ELECTRIC PLANT													
	SUBTOTAL 11.	**$15,702**	**$13,350**	**$37,202**	**$0**	**$66,254**		**$6,003**		**$0**		**$9,507**	**$81,764**	**$149**
12	INSTRUMENTATION & CONTROL													
	SUBTOTAL 12.	**$10,645**	**$0**	**$10,795**	**$0**	**$21,440**		**$1,964**		**$0**		**$2,874**	**$26,278**	**$48**
13	IMPROVEMENTS TO SITE													
	SUBTOTAL 13.	**$3,412**	**$1,962**	**$6,877**	**$0**	**$12,251**		**$1,203**		**$0**		**$2,691**	**$16,145**	**$29**
14	BUILDINGS & STRUCTURES													
	SUBTOTAL 14.	**$0**	**$25,771**	**$24,306**	**$0**	**$50,077**		**$4,511**		**$0**		**$8,188**	**$62,776**	**$114**
	Total Cost	**$896,533**	**$58,845**	**$534,324**	**$0**	**$1,489,701**		**$141,816**		**$71,650**		**$201,116**	**$1,904,283**	**$3,462**

Department:	NETL Office of Systems Analysis and Planning	**Cost Base:**	Jan 2007
Project:	Oxy-Fuel Combustion Systems Analysis	**Prepared:**	19-Sep-09
Case:	Case L13F - Oxyfuel Ultra-Supercritical PC w/ CO2 Capture		**x $1, 000**
Plant Size:	550.07 MW, net	Capital Charge Factor 0.175	Capacity Factor 0.85

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
1.1	Coal Receive & Unload	5,509	0	2,517	0	8,026	8.9%	717	0%	0	15.0%	1,311	10,054	18
1.2	Coal Stackout & Reclaim	7,120	0	1,613	0	8,733	8.8%	764	0%	0	15.0%	1,425	10,923	20
1.3	Coal Conveyors & Yd Crus	6,620	0	1,596	0	8,216	8.8%	720	0%	0	15.0%	1,340	10,277	19
1.4	Other Coal Handling	1,732	0	369	0	2,101	8.7%	184	0%	0	15.0%	343	2,628	5
1.5	Sorbent Receive & Unload	63	0	19	0	82	8.8%	7	0%	0	15.0%	13	102	0
1.6	Sorbent Stackout & Reclaim	1,013	0	186	0	1,199	8.7%	105	0%	0	15.0%	196	1,500	3
1.7	Sorbent Conveyors	362	78	89	0	529	8.7%	46	0%	0	15.0%	86	661	1
1.8	Other Sorbent Handling	219	51	115	0	385	8.8%	34	0%	0	15.0%	63	481	1
1.9	Coal & Sorbent Hnd.Foundations	0	6,761	8,529	0	15,290	9.3%	1,429	0%	0	15.0%	2,508	19,227	35
	SUBTOTAL 1.	**$22,638**	**$6,891**	**$15,033**	**$0**	**$44,561**		**$4,006**		**$0**		**$7,285**	**$55,852**	**$102**
2	COAL PREP & FEED SYSTEMS													
2.1	Coal Crushing & Drying	3,257	0	635	0	3,892	8.7%	340	0%	0	15.0%	635	4,866	9
2.2	Prepared Coal Storage & Feed	8,340	0	1,820	0	10,161	8.7%	889	0%	0	15.0%	1,657	12,707	23
2.3	Slurry Prep & Feed	0	0	0	0	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	0.0%	0	0	0
2.5	Sorbent Prep Equipment	0	0	0	0	0	8.7%	0	0%	0	15.0%	0	0	0
2.6	Sorbent Storage & Feed	0	0	0	0	0	8.9%	0	0%	0	15.0%	0	0	0
2.7	Sorbent Injection System	0	0	0	0	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	0.0%	0	0	0
2.9	Coal & Sorbent Feed Foundation	0	928	779	0	1,708	9.2%	157	0%	0	15.0%	280	2,145	4
	SUBTOTAL 2.	**$11,598**	**$928**	**$3,235**	**$0**	**$15,761**		**$1,385**		**$0**		**$2,572**	**$19,718**	**$36**
3	FEEDWATER & MISC. BOP SYSTEMS													
3.1	Feedwater System	22,164	0	7,159	0	29,323	8.8%	2,568	0%	0	15.0%	4,784	36,674	67
3.2	Water Makeup & Pretreating	4,399	0	1,416	0	5,815	9.4%	545	0%	0	20.0%	1,272	7,632	14
3.3	Other Feedwater Subsystems	6,785	0	2,868	0	9,653	8.9%	860	0%	0	15.0%	1,577	12,090	22
3.4	Service Water Systems	862	0	469	0	1,331	9.3%	124	0%	0	20.0%	291	1,746	3
3.5	Other Boiler Plant Systems	8,819	0	8,707	0	17,527	9.4%	1,644	0%	0	15.0%	2,876	22,047	40
3.6	FO Supply Sys & Nat Gas	286	0	358	0	644	9.3%	60	0%	0	15.0%	106	809	1
3.7	Waste Treatment Equipment	0	0	0	0	0	9.7%	0	0%	0	20.0%	0	0	0
3.8	Misc. Power Plant Equipment	3,038	0	928	0	3,967	9.6%	381	0%	0	20.0%	870	5,217	9
	SUBTOTAL 3.	**$46,354**	**$0**	**$21,905**	**$0**	**$68,259**		**$6,181**		**$0**		**$11,774**	**$86,215**	**$157**
4	PC BOILER & ACCESSORIES													
4.1	PC (Oxycombustion) Boiler	317,978	0	159,689	0	477,667	9.7%	46,267	15%	71,650	10.0%	59,558	655,143	1,191
4.2	ASU/Oxidant Compression	167,609	0	137,135	0	304,744	9.7%	29,518	0%	0	10.0%	33,426	367,688	668
4.3	Open	0	0	0	0	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	0.0%	0	0	0
4.5	Primary Air System	w/4.1	0	w/4.1	0	0	0.0%	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	0.0%	0	0	0
4.7	Major Component Rigging	0	w/4.1	w/4.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
4.8	PC Foundations	0	w/14.1	w/14.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 4.	**$485,587**	**$0**	**$296,824**	**$0**	**$782,411**		**$75,785**		**$71,650**		**$92,985**	**$1,022,830**	**$1,859**
5A	FLUE GAS CLEANUP						*							
5.1	Absorber Vessels & Accessories	68,856	0	11,582	0	80,438	9.5%	7,613	0%	0	10.0%	8,805	96,856	176
5.2	Other FGD	1,219	0	488	0	1,707	9.6%	164	0%	0	10.0%	187	2,058	4
5.3	Bag House & Accessories	w/5.1	0	w/5.1	0	0	9.6%	0	0%	0	10.0%	0	0	0
5.4	Other Particulate Removal Materials	19,694	0	8,297	0	27,991	9.6%	2,695	0%	0	10.0%	3,069	33,754	61
5.5	Gypsum Dewatering System	N/A	N/A	N/A	N/A	0	9.4%	0	0%	0	10.0%	0	0	0
5.6	Mercury Removal System	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.7	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.8	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
5.9	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 5A.	**$89,768**	**$0**	**$20,367**	**$0**	**$110,136**		**$10,472**		**$0**		**$12,061**	**$132,668**	**$241**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case L13F - Oxyfuel Ultra-Supercritical PC w/ CO2 Capture
Plant Size: 550.07 MW, net — Capital Charge Factor 0.175 — Capacity Factor 0.85
Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
5B	CO2 REMOVAL & COMPRESSION													
5B.1	CO2 Condensing Heat Exchanger	4,039	0	337	0	4,376	10%	438	0%	0	15.0%	722	5,536	10
5B.2	CO2 Compression & Drying	43,106	0	35,269	0	78,375	10%	7,838	0%	0	20.0%	17,243	103,455	188
5B.3	CO2 Pipeline											0	0	0
5B.4	CO2 Storage											0	0	0
5B.5	CO2 Monitoring											0	0	0
	SUBTOTAL 5B.	**$47,145**	**$0**	**$35,606**	**$0**	**$82,751**		**$8,275**		**$0**		**$17,965**	**$108,991**	**$198**
6	COMBUSTION TURBINE/ACCESSORIES													
6.1	Combustion Turbine Generator	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.2	Combustion Turbine Accessories	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.3	Compressed Air Piping	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
6.4	Combustion Turbine Foundations	0	0	0	0	0	10%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
7.1	Flue Gas Recycle Heat Exhchanger	39,047	0	3,260	0	42,308	10%	4,231	0%	0	15.0%	6,981	53,519	97
7.2	SCR System	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
7.3	Ductwork	11,298	0	7,259	0	18,556	9%	1,621	0%	0	15.0%	3,027	23,203	42
7.4	Stack	1,572	0	920	0	2,492	10%	238	0%	0	10.0%	273	3,004	5
7.9	HRSG, Duct & Stack Foundations	0	922	1,047	0	1,968	9%	183	0%	0	20.0%	430	2,582	5
	SUBTOTAL 7.	**$51,917**	**$922**	**$12,486**	**$0**	**$65,325**		**$6,273**		**$0**		**$10,711**	**$82,309**	**$150**
8	STEAM TURBINE GENERATOR													
8.1	Steam TG & Accessories	62,965	0	8,362	0	71,327	9.6%	6,829	0%	0	10.0%	7,816	85,972	156
8.2	Turbine Plant Auxiliaries	425	0	910	0	1,335	9.7%	130	0%	0	10.0%	146	1,611	3
8.3a	Condenser & Auxiliaries	5,003	0	3,018	0	8,021	9.5%	762	0%	0	10.0%	878	9,662	18
8.3b	Air Cooled Condenser													
8.4	Steam Piping	25,444	0	12,546	0	37,990	8.3%	3,171	0%	0	15.0%	6,174	47,334	86
8.9	TG Foundations	0	1,329	2,100	0	3,430	9.4%	323	0%	0	20.0%	750	4,503	8
	SUBTOTAL 8.	**$93,837**	**$1,329**	**$26,936**	**$0**	**$122,102**		**$11,214**		**$0**		**$15,765**	**$149,082**	**$271**
9	COOLING WATER SYSTEM													
9.1	Cooling Towers	6,408	0	1,996	0	8,404	9.5%	798	0%	0	10.0%	920	10,122	18
9.2	Circulating Water Pumps	2,101	0	200	0	2,301	8.6%	197	0%	0	10.0%	250	2,747	5
9.3	Circ. Water System Auxiliaries	589	0	79	0	668	9.4%	63	0%	0	10.0%	73	804	1
9.4	Circ. Water Piping	0	4,672	4,528	0	9,199	9.2%	847	0%	0	15.0%	1,507	11,554	21
9.5	Make-up Water System	434	0	580	0	1,014	9.5%	96	0%	0	15.0%	167	1,277	2
9.6	Component Cooling Water System	466	0	371	0	838	9.4%	79	0%	0	15.0%	137	1,054	2
9.9	Circ. Water System Foundations	0	2,768	4,397	0	7,165	9.4%	674	0%	0	20.0%	1,568	9,408	17
	SUBTOTAL 9.	**$9,999**	**$7,439**	**$12,150**	**$0**	**$29,589**		**$2,754**		**$0**		**$4,622**	**$36,965**	**$67**
10	ASH/SPENT SORBENT HANDLING SYS													
10.1	Ash Coolers	N/A	0	N/A	0	0	0%	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%	0	0	0
10.3	HGCU Ash Letdown	N/A	0	N/A	0	0	0%	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%	0	0	0
10.5	Other Ash Recovery Equipment	N/A	0	N/A	0	0	0%	0	0%	0	0.0%	0	0	0
10.6	Ash Storage Silos	1,061	0	3,269	0	4,330	10%	422	0%	0	10.0%	475	5,227	10
10.7	Ash Transport & Feed Equipment	6,869	0	7,036	0	13,905	9%	1,315	0%	0	10.0%	1,522	16,742	30
10.8	Misc. Ash Handling Equipment	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
10.9	Ash/Spent Sorbent Foundation	0	252	297	0	549	9%	51	0%	0	20.0%	120	720	1
	SUBTOTAL 10.	**$7,930**	**$252**	**$10,602**	**$0**	**$18,784**		**$1,788**		**$0**		**$2,117**	**$22,689**	**$41**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case L13F - Oxyfuel Ultra-Supercritical PC w/ CO2 Capture
Plant Size: 550.07 MW, net   Capital Charge Factor 0.175   Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT													
11.1	Generator Equipment	381	0	62	0	443	9.3%	41	0%	0	7.5%	36	520	1
11.2	Station Service Equipment	6,390	0	2,100	0	8,490	9.6%	812	0%	0	7.5%	698	10,000	18
11.3	Switchgear & Motor Control	7,347	0	1,249	0	8,596	9.3%	796	0%	0	10.0%	939	10,331	19
11.4	Conduit & Cable Tray	0	4,606	15,927	0	20,533	9.6%	1,965	0%	0	15.0%	3,375	25,873	47
11.5	Wire & Cable	0	8,692	16,778	0	25,470	8.4%	2,146	0%	0	15.0%	4,142	31,758	58
11.6	Protective Equipment	270	0	920	0	1,190	9.8%	116	0%	0	10.0%	131	1,437	3
11.7	Standby Equipment	395	0	9	0	404	9.5%	38	0%	0	10.0%	44	486	1
11.8	Main Power Transformers	918	0	29	0	946	7.6%	72	0%	0	10.0%	102	1,120	2
11.9	Electrical Foundations	0	53	129	0	182	9.5%	17	0%	0	20.0%	40	239	0
	SUBTOTAL 11.	**$15,702**	**$13,350**	**$37,202**	**$0**	**$66,254**		**$6,003**		**$0**		**$9,507**	**$81,764**	**$149**
12	INSTRUMENTATION & CONTROL													
12.1	PC Control Equipment	w/12.7	0	w/12.7	0	0	0%	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%	0	0	0
12.3	Steam Turbine Control	w/8.1	0	w/8.1	0	0	0%	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%	0	0	0
12.5	Signal Processing Equipment	W/12.7	0	w/12.7	0	0	0%	0	0%	0	0.0%	0	0	0
12.6	Control Boards, Panels & Racks	548	0	328	0	876	10%	84	0%	0	15.0%	144	1,105	2
12.7	Computer Accessories	5,534	0	967	0	6,501	10%	619	0%	0	10.0%	712	7,832	14
12.8	Instrument Wiring & Tubing	3,000	0	5,951	0	8,951	9%	762	0%	0	15.0%	1,457	11,171	20
12.9	Other I & C Equipment	1,564	0	3,548	0	5,112	10%	498	0%	0	10.0%	561	6,171	11
	SUBTOTAL 12.	**$10,645**	**$0**	**$10,795**	**$0**	**$21,440**		**$1,964**		**$0**		**$2,874**	**$26,278**	**$48**
13	IMPROVEMENTS TO SITE													
13.1	Site Preparation	0	57	1,147	0	1,204	9.9%	119	0%	0	20.0%	265	1,588	3
13.2	Site Improvements	0	1,904	2,365	0	4,269	9.8%	419	0%	0	20.0%	938	5,626	10
13.3	Site Facilities	3,412	0	3,365	0	6,777	9.8%	665	0%	0	20.0%	1,489	8,931	16
	SUBTOTAL 13.	**$3,412**	**$1,962**	**$6,877**	**$0**	**$12,251**		**$1,203**		**$0**		**$2,691**	**$16,145**	**$29**
14	BUILDINGS & STRUCTURES													
14.1	Boiler Building	0	9,859	8,670	0	18,529	9.0%	1,664	0%	0	15.0%	3,029	23,222	42
14.2	Turbine Building	0	13,027	12,141	0	25,169	9.0%	2,266	0%	0	15.0%	4,115	31,550	57
14.3	Administration Building	0	653	691	0	1,344	9.1%	122	0%	0	15.0%	220	1,685	3
14.4	Circulation Water Pumphouse	0	217	173	0	390	8.9%	35	0%	0	15.0%	64	489	1
14.5	Water Treatment Buildings	0	597	492	0	1,089	9.0%	97	0%	0	15.0%	178	1,364	2
14.6	Machine Shop	0	437	293	0	730	8.9%	65	0%	0	15.0%	119	914	2
14.7	Warehouse	0	296	297	0	593	9.0%	54	0%	0	15.0%	97	743	1
14.8	Other Buildings & Structures	0	242	206	0	448	9.0%	40	0%	0	15.0%	73	561	1
14.9	Waste Treating Building & Str.	0	443	1,343	0	1,785	9.4%	169	0%	0	15.0%	293	2,247	4
	SUBTOTAL 14.	**$0**	**$25,771**	**$24,306**	**$0**	**$50,077**		**$4,511**		**$0**		**$8,188**	**$62,776**	**$114**
	Total Cost	**$896,533**	**$58,845**	**$534,324**	**$0**	**$1,489,701**		**$141,816**		**$71,650**		**$201,116**	**$1,904,283**	**$3,462**

Exhibit 8-18 Case S13F Initial and Annual O&M Expense

INITIAL & ANNUAL O&M EXPENSES			
Case:	Case S13F - Oxyfuel Ultra-Supercritical PC w/ CO2 Capture		
Plant Size (MWe):	550.04	**Heat Rate (Btu/kWh):**	10,523
Primary/Secondary Fuel:	Montana Rosebud PRB Coal	**Fuel Cost ($/MM Btu):**	0.76
Design/Construction	4 years	**Book Life (yrs):**	20
TPC (Plant Cost) Year:	Jan 2007	**TPI Year:**	2015
Capacity Factor (%):	85	**CO_2 Captured (TPD):**	13504

OPERATING & MAINTENANCE LABOR

Operating Labor

Operating Labor Rate (base):	$33.00	$/hour
Operating Labor Burden:	30.00	% of base
Labor Overhead Charge:	25.00	% of labor

Operating Labor Requirements per Shift:	**units/mod.**	**Total Plant**
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 Operating Jobs	14.0	14.0

	$	**$/kW-net**
Annual Operating Labor Cost (calc'd)	5,261,256	9.57
Maintenance Labor Cost (calc'd)	12,090,846	21.98
Administrative & Support Labor (calc'd)	4,338,026	7.89
	21,690,128	**39.43**

VARIABLE OPERATING COSTS

	$	**$/kWh-net**
Maintenance Material Costs (calc'd)	**$18,136,269**	**0.00443**

Consumables	**Consumption Initial**	**Consumption /Day**	**Unit Cost**	**Initial Cost**	**$**	**$/kWh-net**
Water (/1000 gallons)	0	5,992	1.03	$0	$1,914,665	0.00047
Chemicals						
MU & WT Chem. (lb)	203,023	29,003	0.16	$33,458	$1,482,913	0.00036
Limestone (ton)	904	129	20.60	$18,619	$825,214	0.00020
Carbon (Hg Removal) (lb)	0	0	1.00	$0	$0	0.00000
MEA Solvent (ton)	957	0	2142.40	$2,049,232	$0	0.00000
Caustic Soda, NaOH (ton)	0	0	412.96	$0	$0	0.00000
Sulfuric acid, H_2SO_4 (ton)	0	0	132.15	$0	$0	0.00000
Corrosion Inhibitor	0	0	0.00	$0	$0	0.00000
Activated C, MEA (lb)	0	0	1.00	$0	$0	0.00000
Ammonia, 28% soln (ton)	0	0	123.60	$0	$0	0.00000
Subtotal Chemicals				**$2,101,309**	**$2,308,127**	**0.00056**
Other						
Supplemental Fuel (MMBtu)	0	0	6.75	$0	$0	0.00000
SCR Catalyst Replacement (m^3)	w/equip.	0.0000	5500.00	$0	$0	0.00000
Emission Penalties	0	0	0.00	$0	$0	0.00000
Subtotal Other				**$0**	**$0**	**0.00000**
Waste Disposal						
Spent Mercury Catalyst (lb)	0	0	0.31	$0	$0	0.00000
Flyash (ton)	0	791	15.45	$0	$3,793,735	0.00093
Bottom Ash (ton)	0	133	15.45	$0	$636,603	0.00016
Subtotal Solid Waste Disposal				**$0**	**$4,430,338**	**0.00108**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	0.00000
Sulfur (tons)	0	0	0.00	$0	$0	0.00000
Subtotal By-Products				**$0**	**$0**	**0.00000**
TOTAL VARIABLE OPERATING COSTS					**$26,789,400**	**0.00654**
Coal FUEL (tons)	**243,313**	**8,110**	**12.96**	**$3,153,334**	**$32,610,727**	**0.00796**
NATURAL GAS FUEL (Mscf)	**0**	**0**	**6.93**	**$0**	**$0**	**0.00000**

Exhibit 8-19 Case S13F Capital Investment and Operating Cost Summary

CAPITAL INVESTMENT & REVENUE REQUIREMENT SUMMARY			
Case:	Case S13F - Oxyfuel Ultra-Supercritical PC w/ CO2 Capture		
Plant Size (MWe):	550.04	**Heat Rate (Btu/kWh):**	10,523
Primary/Secondary Fuel:	Montana Rosebud PRB Coal	**Fuel Cost ($/MM Btu):**	0.76
Design/Construction	4 years	**Book Life (yrs):**	20
TPC (Plant Cost) Year:	Jan 2007	**TPI Year:**	2015
Capacity Factor (%):	85	**CO_2 Captured (TPD):**	13,504

CAPITAL INVESTMENT		**$x1000**	**$/kW**
Process Capital & Facilities		1,371,601	2,494
Engineering (incl. C.M., H.O. & Fee)		130,482	237
Process Contingency		58,453	106
Project Contingency		185,573	337.4
TOTAL PLANT COST (TPC)		**1,746,109**	**3,174.51**
OPERATING & MAINTENANCE COSTS (2007 Dollars)		**$x1000**	**$/kW**
Operating Labor		5,261	9.6
Maintenance Labor		12,091	22.0
Maintenance Material		18,136	33.0
Administrative & Support Labor		4,338	7.9
TOTAL OPERATION & MAINTENANCE		**39,826**	**72.41**
FIXED O&M			**39.43 $/kW-net**
VARIABLE O&M			**0.44 cents/kWh**
CONSUMABLE OPERATING COSTS, Less Fuel (2007 Dollars)		**$x1000**	**cents/kWh**
Water		$1,915	0.04675
Chemicals		$2,308	0.05636
Other Consumables		$0	0.00000
Waste Disposal		$4,430	0.10817
TOTAL CONSUMABLE OPERATING COSTS		**$8,653**	**0.21**
BY-PRODUCTS CREDITS (2007 Dollars)		**$0**	**0.00**
FUEL COST (2007 Dollars) Coal		**$32,611**	**0.80**
FUEL COST (2007 Dollars) Natural Gas		**$0**	**0.00**
PRODUCTION COST SUMMARY	LF	**cents/kWh**	
Fixed O & M	1.1607	0.61	
Variable O & M	1.1607	0.51	
Consumables	1.1607	0.25	
By-product Credit	1.1607	0.00	
Fuel (Coal)	1.1439	0.91	
Fuel (Natural Gas)	1.1607	0.00	
TOTAL PRODUCTION COST		**2.28**	
LEVELIZED CARRYING CHARGES (Capital)			
Fixed Charge Rate (%)	**17.5**	**7.46**	
20 YEAR LEVELIZED COST OF ELECTRICITY		**9.75**	**cents/kWh**

Exhibit 8-20 Case L13F Initial and Annual O&M Expense

INITIAL & ANNUAL O&M EXPENSES				
Case:	Case L13F - Oxyfuel Ultra-Supercritical PC w/ CO2 Capture			
Plant Size (MWe):	550.07		**Heat Rate (Btu/kWh):**	10,896
Primary/Secondary Fuel:	North Dakota Lignite Coal		**Fuel Cost ($/MM Btu):**	0.90
Design/Construction	4 years		**Book Life (yrs):**	20
TPC (Plant Cost) Year:	Jan 2007		**TPI Year:**	2015
Capacity Factor (%):	85		**CO_2 Captured (TPD):**	14297

OPERATING & MAINTENANCE LABOR						
Operating Labor						
Operating Labor Rate (base):		$33.00 $/hour				
Operating Labor Burden:		30.00 % of base				
Labor Overhead Charge:		25.00 % of labor				
Operating Labor Requirements per Shift:		**units/mod.**		**Total Plant**		
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 Operating Jobs		14.0		14.0		
					$	**$/kW-net**
Annual Operating Labor Cost (calc'd)					5,261,256	9.56
Maintenance Labor Cost (calc'd)					13,131,920	23.87
Administrative & Support Labor (calc'd)					4,598,294	8.36
					22,991,471	**41.80**

VARIABLE OPERATING COSTS						
					$	**$/kWh-net**
Maintenance Material Costs (calc'd)					**$19,697,881**	**0.00481**
Consumables	**Consumption**		**Unit**	**Initial**		
	Initial	**/Day**	**Cost**	**Cost**	**$**	**$/kWh-net**
Water (/1000 gallons)	0	5,992	1.03	$0	$1,914,665	0.00047
Chemicals						
MU & WT Chem. (lb)	203,023	29,003	0.16	$33,458	$1,482,913	0.00036
Limestone (ton)	904	129	20.60	$18,619	$825,214	0.00020
Carbon (Hg Removal) (lb)	0	0	1.00	$0	$0	0.00000
MEA Solvent (ton)	1,013	0	2142.40	$2,169,557	$0	0.00000
Caustic Soda, NaOH (ton)	0	0	412.96	$0	$0	0.00000
Sulfuric acid, H_2SO_4 (ton)	0	0	132.15	$0	$0	0.00000
Corrosion Inhibitor	0	0	0.00	$0	$0	0.00000
Activated C, MEA (lb)	0	0	1.00	$0	$0	0.00000
Ammonia, 28% soln (ton)	0	0	123.60	$0	$0	0.00000
Subtotal Chemicals				**$2,221,634**	**$2,308,127**	**0.00056**
Other						
Supplemental Fuel (MMBtu)	0	0	6.75	$0	$0	0.00000
SCR Catalyst Replacement (m^3)	w/equip.	0.0000	5500.00	$0	$0	0.00000
Emission Penalties	0	0	0.00	$0	$0	0.00000
Subtotal Other				**$0**	**$0**	**0.00000**
Waste Disposal						
Spent Mercury Catalyst (lb)	0	0	0.31	$0	$0	0.00000
Flyash (ton)	0	791	15.45	$0	$3,793,735	0.00093
Bottom Ash (ton)	0	133	15.45	$0	$636,603	0.00016
Subtotal Solid Waste Disposal				**$0**	**$4,430,338**	**0.00108**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	0.00000
Sulfur (tons)	0	0	0.00	$0	$0	0.00000
Subtotal By-Products				**$0**	**$0**	**0.00000**
TOTAL VARIABLE OPERATING COSTS					**$28,351,011**	**0.00692**
Coal FUEL (tons)	**326,080**	**10,869**	**11.97**	**$3,903,175**	**$40,365,334**	**0.00986**
NATURAL GAS FUEL (Mscf)	**0**	**0**	**6.93**	**$0**	**$0**	**0.00000**

Exhibit 8-21 Case L13F Capital Investment and Operating Cost Summary

CAPITAL INVESTMENT & REVENUE REQUIREMENT SUMMARY			
Case:	Case L13F - Oxyfuel Ultra-Supercritical PC w/ CO2 Capture		
Plant Size (MWe):	550.07	**Heat Rate (Btu/kWh):**	10,896
Primary/Secondary Fuel:	North Dakota Lignite Coal	**Fuel Cost ($/MM Btu):**	0.90
Design/Construction	4 years	**Book Life (yrs):**	20
TPC (Plant Cost) Year:	Jan 2007	**TPI Year:**	2015
Capacity Factor (%):	85	**CO_2 Captured (TPD):**	14,297

CAPITAL INVESTMENT		**$x1000**	**$/kW**
Process Capital & Facilities		1,489,701	2,708
Engineering (incl. C.M., H.O. & Fee)		141,816	258
Process Contingency		71,650	130
Project Contingency		201,116	365.6
TOTAL PLANT COST (TPC)		**1,904,283**	**3,461.89**
OPERATING & MAINTENANCE COSTS (2007 Dollars)		**$x1000**	**$/kW**
Operating Labor		5,261	9.6
Maintenance Labor		13,132	23.9
Maintenance Material		19,698	35.8
Administrative & Support Labor		4,598	8.4
TOTAL OPERATION & MAINTENANCE		**42,689**	**77.61**
FIXED O&M		**41.80**	**$/kW-net**
VARIABLE O&M		**0.48**	**cents/kWh**
CONSUMABLE OPERATING COSTS, Less Fuel (2007 Dollars)		**$x1000**	**cents/kWh**
Water		$1,915	0.04675
Chemicals		$2,308	0.05635
Other Consumables		$0	0.00000
Waste Disposal		$4,430	0.10817
TOTAL CONSUMABLE OPERATING COSTS		**$8,653**	**0.21**
BY-PRODUCTS CREDITS (2007 Dollars)		**$0**	**0.00**
FUEL COST (2007 Dollars) Coal		**$40,365**	**0.99**
FUEL COST (2007 Dollars) Natural Gas		**$0**	**0.00**
PRODUCTION COST SUMMARY	LF	**cents/kWh**	
Fixed O & M	1.1607	0.65	
Variable O & M	1.1607	0.56	
Consumables	1.1607	0.25	
By-product Credit	1.1607	0.00	
Fuel (Coal)	1.3561	1.34	
Fuel (Natural Gas)	1.1607	0.00	
TOTAL PRODUCTION COST		**2.79**	
LEVELIZED CARRYING CHARGES (Capital)			
Fixed Charge Rate (%)	**17.5**	**8.14**	
20 YEAR LEVELIZED COST OF ELECTRICITY		**10.93**	**cents/kWh**

8.4.2 Cost and Performance Summary for Cryogenic Oxycombustion Cases

A summary of plant costs and performance for all of the cryogenic oxycombustion cases is shown in Exhibit 8-22, along with the base case (air-fired without capture), S12A.

Exhibit 8-22 Cost and Performance Results for Cryogenic Oxycombustion Cases

Case	S12A	S13F	L13F
Gross Power Output, MW_e	582.7	746.1	752.0
Net Power Output, MW_e	550.0	550.0	550.1
Net Plant Efficiency, % (HHV)	38.7	32.4	31.3
Net Plant Heat Rate, Btu/kWh (HHV)	8,822	10,523	10,896
Total Plant Cost, $x1000	1,018,074	1,746,109	1,904,283
Total Plant Cost, $/kW	1,851	3,175	3,462
CO_2 Capital Cost Penalty[a], $/kW	0.0	1,323.6	1,610.9
Levelized Cost of Electricity, ¢/kWh (85% Capacity Factor)	5.88	9.75	10.93
Levelized COE CO_2 Penalty[b], ¢/kWh (85% Capacity Factor)	0.00	3.86	5.05
Percent increase in COE[c], (85% Capacity Factor)	0.00%	43.63%	56.98%
Total CO_2 Emitted, lb/MWh_{net}	1,894	205	217
Cost of CO_2 Avoided[d], $/ton	--	45.8	60.2
Total CO_2 Captured, lb/MWh_{net}	0	2,046	2,166
Cost of CO_2 Captured[e], $/ton	--	37.8	46.6

a. CO_2 Capital Cost Penalty = TPC with capture – TPC case S12A air-fired without capture
b. CO_2 LCOE Cost Penalty = LCOE with capture – LCOE case S12A air-fired without capture
c. Relative to Case S12A ("Base Case")
d. CO_2 Cost Avoided = (COE with capture – COE without capture)/(Emissions without capture – Emissions with capture)
e. CO_2 Cost Captured (or Removal) = (COE with capture – COE without capture)/(CO_2 Captured)
Costs do not include CO_2 Transport, Storage, and Monitoring

9. SC CIRCULATING FLUIDIZED BED OXYCOMBUSTION CASES

Two SC, CFB, Rankine–cycle, oxycombustion power plant configurations were evaluated and are presented in this section. All plant designs employ a cryogenic distillation air separation unit to generate the oxygen. In these two cases, case S22F utilizes Montana PRB coal and case L22F utilizes North Dakota lignite.

9.1 PLANT CONFIGURATION SUMMARY

All the designs have a nominal net output of 550 MWe. All USC oxycombustion plants use a single reheat 24.1 MPa/593°C/593°C (3,500 psig/1,100°F/1,100°F) cycle. Case L22F differs from Case S22F only through the use of a different coal type (lignite instead of PRB). The following is a brief description of these two cases, which are covered in this section:

Case S22F – This case includes an SC CFB oxycombustion plant. There is no direct limestone injection into the combustor, but a back-end Alstom-based flash dryer absorber (FDA) is employed to remove SO_2 from the flue gas stream. A cryogenic distillation CPU is utilized to reduce the oxygen concentration in the CO_2 product stream to 1 ppm.

Case L22F – This case includes an SC CFB oxycombustion plant. There is no direct limestone injection into the combustor, but a back-end Alstom-based FDA is employed to remove SO_2 from the flue gas stream. A cryogenic distillation CPU is utilized to reduce the oxygen concentration in the CO_2 product stream to 1 ppm. This case is the same as Case S22F, except it uses North Dakota lignite coal as the fuel and the plant is located at a minemouth site in North Dakota.

CFB oxycombustion PC plants are assumed to be built on a greenfield site and utilize flue gas recycle for flame temperature control. Major systems for each plant (described in Section 3) include the following:

1. Oxycombustion optimized ASU
2. CFB Boiler/Steam Generator
3. FDA and Baghouse
4. CPU with Cryogenic Distillation (Specification 3b)
5. Steam Turbine/Generator

Support facilities include coal handling (receiving, crushing, storing, and drying), lime mix handling (including receiving, crushing, storing, and feeding), solid waste disposal, circulating water system with evaporative mechanical draft cooling towers, wastewater treatment, and other ancillary systems equipment necessary for an efficient, highly available, and completely operable facility.

The plant designs are based on using components suitable for a 30-year life, with provision for periodic maintenance and replacement of critical parts. All equipment is based on compliance with the latest applicable codes and standards. ASME, ANSI, IEEE, NFPA, CAA, state regulations, and OSHA codes are all adhered to in the design approach.

9.2 MODEL ASSUMPTIONS FOR SC CFB OXYCOMBUSTION CASES

The modeling assumptions used to generate the SC oxycombustion CFB case material and energy balances are summarized in Exhibit 9-1

Exhibit 9-1 Modeling Assumptions for Supercritical CFB Oxycombustion Cases Modeling Assumptions

	PRB	Lignite
	S22F	L22F
Throttle pressure, psig	3500	3500
Throttle temperature, ºF	1100	1100
Reheat temperature, ºF	1100	1100
Condenser pressure, in Hg	1.4	1.4
Cooling water to condenser, ºF	60	60
Cooling water from condenser, ºF	80	80
CO_2 Purifier Vent temperature, °F	48	48
Coal HHV (PRB and Lignite), Btu/lb	8,564	6,617
FGD efficiency, %	85	85
SOx emissions, lb/MMBtu	0.1	0.1
NOx emissions, lb/MMBtu	0.07	0.07
Baghouse efficiency, %	99.8	99.8
Particulate emissions PM/PM_{10}, lb/MMBtu	0.015	0.015
Mercury removal, %	90	90
ASU Oxygen Purity, %	95	95
CO_2 Capture Efficiency, %[a]	90.9	90.9
Product CO_2 Condition, psia/°F	2220/81	2220/81
Product CO_2 Specification[b]	3b	3b

[a] Percentage of CO_2 in flue gas

[b] Refer Section 3.6.1 for more description of product CO_2 specification.

Material and energy balance information, environmental performance and a major equipment list for the two CO_2 non-capture cases are summarized in Section 5.

9.3 PERFORMANCE RESULTS FOR CASES S22F AND L22F

A process block flow diagram for the SC CFB CO_2 capture case (with cryogenic distillation CO_2 purification option), S22F, is shown in Exhibit 9-2, and the corresponding stream tables are shown in Exhibit 9-3**.**

A process block flow diagram for the SC CFB CO_2 capture case (with cryogenic distillation CO_2 purification option), L22F, is shown in Exhibit 9-4 and the corresponding stream tables are shown in Exhibit 9-5.

Overall performance for cases S22F and L22F is summarized in Exhibit 9-6, which includes auxiliary power requirements.

9.3.1 Block Flow Diagram and Stream Table

Exhibit 9-2 Case S22F SC CFB Oxycombustion with CO_2 Cryogenic Distillation Block Flow Diagram

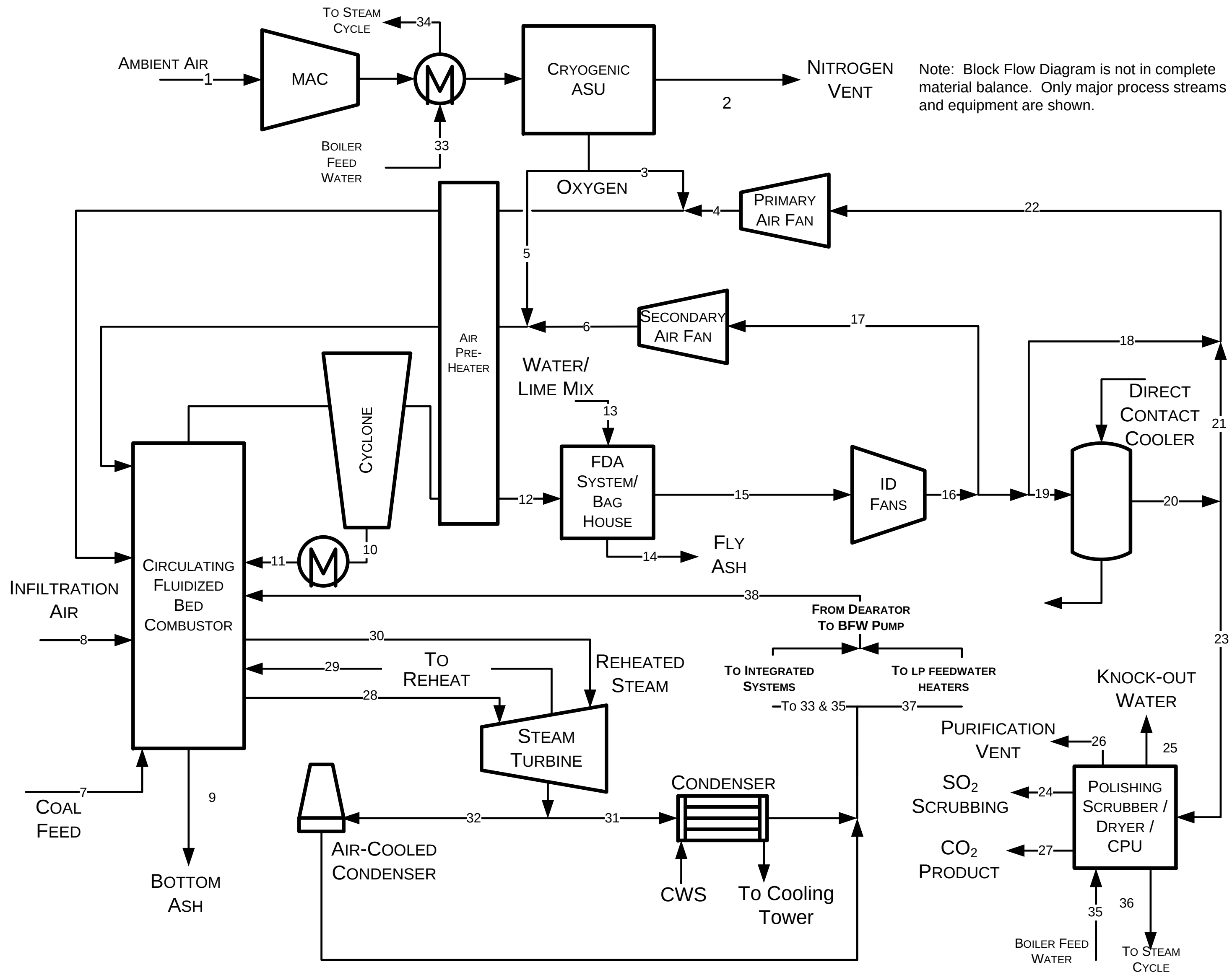


Exhibit 9-3 Case S22F SC CFB Oxycombustion with CO_2 Cryogenic Distillation Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
V-L Mole Fraction														
Ar	0.0093	0.0025	0.0000	0.0279	0.0343	0.0204	0.0000	0.0093	0.0000	0.0000	0.0000	0.0214	0.0000	0.0000
CO_2	0.0003	0.0004	0.0000	0.6586	0.0000	0.4822	0.0000	0.0003	0.0000	0.0000	0.0000	0.5060	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	0.0081	0.0000	0.2125	0.0000	0.4234	0.0000	0.0064	0.0000	0.0000	0.0000	0.3938	1.0000	0.0000
N_2	0.7759	0.9826	0.0000	0.0727	0.0162	0.0532	0.0000	0.7759	0.0000	0.0000	0.0000	0.0559	0.0000	0.0000
O_2	0.2081	0.0064	0.0000	0.0281	0.9495	0.0206	0.0000	0.2081	0.0000	0.0000	0.0000	0.0216	0.0000	0.0000
SO_2	0.0000	0.0000	0.0000	0.0002	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0014	0.0000	0.0000
Total	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000
V-L Flowrate (kg_{mol}/hr)	76,258	59,943	0	3,743	16,315	29,156	0	1,475	0	0	0	59,392	3,038	0
V-L Flowrate (kg/hr)	2,203,470	1,678,025	0	138,032	525,445	927,881	0	42,621	0	0	0	1,933,883	54,730	0
Solids Flowrate (kg/hr)	0	0	0	0	0	0	329,189	0	29,074	8,343,774	8,343,746	183	4,979	10,290
Temperature (°C)	6	17	---	120	14	115	6	6	0	871	427	147	6	87
Pressure (MPa, abs)	0.09	0.10	---	0.15	0.14	0.11	0.09	0.09	0.09	0.10	0.10	0.09	0.10	0.08
Enthalpy (kJ/kg)[A]	15.26	30.70	---	376.89	12.15	726.94	---	15.26	---	---	---	708.16	281.08	---
Density (kg/m^3)	1.1	1.2	---	1.7	1.9	1.1	---	1.1	---	---	---	0.8	1,012.1	---
V-L Molecular Weight	28.895	27.994	---	36.878	32.207	31.825	---	28.895	---	---	---	32.561	18.015	---
V-L Flowrate (lb_{mol}/hr)	168,119	132,152	0	8,252	35,968	64,277	0	3,252	0	0	0	130,936	6,698	0
V-L Flowrate (lb/hr)	4,857,819	3,699,411	0	304,309	1,158,408	2,045,628	0	93,963	0	0	0	4,263,482	120,660	0
Solids Flowrate (lb/hr)	0	0	0	0	0	0	725,737	0	64,097	18,394,872	18,394,811	404	10,978	22,686
Temperature (°F)	42	63	---	248	57	239	42	42	32	1,600	800	297	42	189
Pressure (psia)	13.0	14.7	---	22.0	20.3	15.7	13.0	13.0	13.0	14.2	14.2	12.7	15.0	12.3
Enthalpy (Btu/lb)[A]	6.6	13.2	---	162.0	5.2	312.5	---	6.6	---	---	---	304.5	120.8	---
Density (lb/ft^3)	0.070	0.073	---	0.107	0.118	0.067	---	0.070	---	---	---	0.051	63.181	---

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 9-3 Case S22F SC CFB Oxycombustion with CO_2 Cryogenic Distillation Stream Table (Continued)

	15	16	17	18	19	20	21	22	23	24	25	26	27	28
V-L Mole Fraction														
Ar	0.0204	0.0204	0.0204	0.0204	0.0204	0.0293	0.0293	0.0279	0.0293	0.0003	0.0000	0.1472	0.0002	0.0000
CO_2	0.4822	0.4822	0.4822	0.4822	0.4822	0.6921	0.6921	0.6586	0.6921	0.0067	0.0000	0.3180	0.9998	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	0.4234	0.4234	0.4234	0.4234	0.4234	0.1724	0.1724	0.2125	0.1724	0.9915	1.0000	0.0000	0.0000	1.0000
N_2	0.0532	0.0532	0.0532	0.0532	0.0532	0.0764	0.0764	0.0727	0.0764	0.0000	0.0000	0.3857	0.0000	0.0000
O_2	0.0206	0.0206	0.0206	0.0206	0.0206	0.0295	0.0295	0.0281	0.0295	0.0000	0.0000	0.1491	0.0000	0.0000
SO_2	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0015	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)	62,324	62,324	29,156	597	32,572	22,693	3,146	3,743	19,547	2,914	481	3,871	12,281	122,083
V-L Flowrate (kg/hr)	1,983,486	1,983,486	927,881	19,001	1,036,606	858,638	119,031	138,031	739,607	53,230	8,667	137,243	540,468	2,199,358
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	87	95	95	95	95	57	57	63	57	57	40	21	27	593
Pressure (MPa, abs)	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	15.31	24.23
Enthalpy (kJ/kg)[A]	695.16	704.19	704.19	704.19	704.19	258.10	258.10	319.51	258.10	147.25	65.52	17.23	-233.12	3,444.49
Density (kg/m^3)	0.9	0.9	0.9	0.9	0.9	1.2	1.2	1.2	1.2	56.0	979.3	1.5	685.0	69.7
V-L Molecular Weight	31.825	31.825	31.825	31.825	31.825	37.837	37.837	36.878	37.837	18.267	18.015	35.450	44.009	18.015
V-L Flowrate (lb_{mol}/hr)	137,402	137,402	64,277	1,316	71,809	50,030	6,936	8,252	43,095	6,424	1,061	8,535	27,075	269,147
V-L Flowrate (lb/hr)	4,372,838	4,372,838	2,045,628	41,890	2,285,325	1,892,972	262,417	304,307	1,630,555	117,351	19,108	302,568	1,191,527	4,848,755
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	189	203	203	203	203	135	135	146	135	135	103	69	81	1,100
Pressure (psia)	12.3	13.2	13.2	13.2	13.2	13.0	13.0	13.0	13.0	13.0	14.7	15.0	2,220.0	3,514.7
Enthalpy (Btu/lb)[A]	298.9	302.7	302.7	302.7	302.7	111.0	111.0	137.4	111.0	63.3	28.2	7.4	-100.2	1,480.9
Density (lb/ft^3)	0.056	0.059	0.059	0.059	0.059	0.077	0.077	0.074	0.077	3.498	61.137	0.094	42.764	4.350

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 9-3 Case S22F SC CFB Oxycombustion with CO_2 Cryogenic Distillation Stream Table (Continued)

	29	30	31	32	33	34	35	36	37	38
V-L Mole Fraction										
Ar	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.0000	0.0000	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
H_2O	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	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
Total	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)	98,442	98,442	43,547	43,547	19,503	19,503	11,455	11,455	57,357	123,304
V-L Flowrate (kg/hr)	1,773,462	1,773,462	784,515	784,515	351,347	351,347	206,372	206,372	1,033,305	2,221,352
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	340	593	35	35	52	141	52	146	52	177
Pressure (MPa, abs)	4.90	4.52	0.00	0.00	1.65	1.63	1.65	1.64	1.65	0.91
Enthalpy (kJ/kg)[A]	3,060.52	3,646.37	2,088.12	2,088.12	120.52	529.50	120.52	557.19	120.52	703.19
Density (kg/m^3)	19.4	11.6	0.0	0.0	967.4	873.6	967.4	866.9	967.4	831.4
V-L Molecular Weight	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	217,028	217,028	96,005	96,005	42,996	42,996	25,255	25,255	126,451	271,838
V-L Flowrate (lb/hr)	3,909,814	3,909,814	1,729,560	1,729,560	774,588	774,588	454,973	454,973	2,278,047	4,897,243
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	645	1,100	96	96	125	285	125	296	125	350
Pressure (psia)	710.8	655.8	0.7	0.7	240.0	237.1	240.0	238.5	240.0	132.7
Enthalpy (Btu/lb)[A]	1,315.8	1,567.7	897.7	897.7	51.8	227.6	51.8	239.5	51.8	302.3
Density (lb/ft^3)	1.209	0.725	0.003	0.003	60.394	54.535	60.394	54.122	60.394	51.902

Exhibit 9-4 Case L22F SC CFB Oxycombustion with CO_2 Cryogenic Distillation Block Flow Diagram

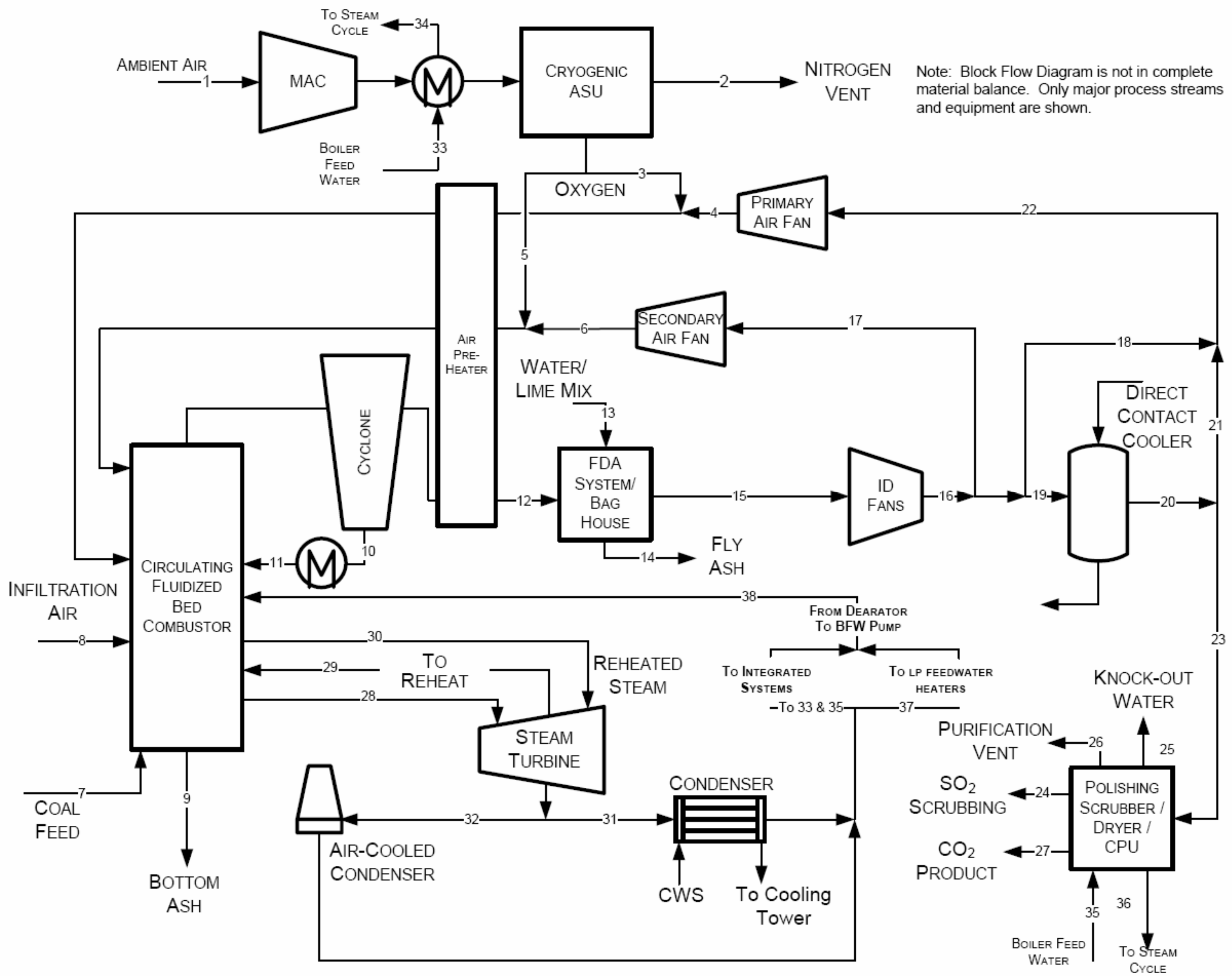


Exhibit 9-5 Case L22F SC CFB Oxycombustion with CO_2 Cryogenic Distillation Stream Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
V-L Mole Fraction														
Ar	0.0093	0.0025	0.0000	0.0275	0.0343	0.0181	0.0000	0.0093	0.0000	0.0000	0.0000	0.0190	0.0000	0.0000
CO_2	0.0003	0.0004	0.0000	0.6581	0.0000	0.4339	0.0000	0.0003	0.0000	0.0000	0.0000	0.4549	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	0.0078	0.0000	0.2167	0.0000	0.4836	0.0000	0.0062	0.0000	0.0000	0.0000	0.4575	1.0000	0.0000
N_2	0.7761	0.9829	0.0000	0.0721	0.0162	0.0475	0.0000	0.7761	0.0000	0.0000	0.0000	0.0498	0.0000	0.0000
O_2	0.2082	0.0064	0.0000	0.0253	0.9495	0.0167	0.0000	0.2082	0.0000	0.0000	0.0000	0.0175	0.0000	0.0000
SO_2	0.0000	0.0000	0.0000	0.0002	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012	0.0000	0.0000
Total	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000
V-L Flowrate (kg_{mol}/hr)	79,912	62,811	0	5,140	17,101	40,808	0	1,544	0	0	0	77,948	3,900	0
V-L Flowrate (kg/hr)	2,309,267	1,758,511	0	189,212	550,756	1,240,872	0	44,605	0	0	0	2,420,738	70,252	0
Solids Flowrate (kg/hr)	0	0	0	0	0	0	440,238	0	44,839	7,751,178	7,751,146	75	5,739	11,754
Temperature (°C)	4	17	---	119	14	108	4	4	0	871	427	147	4	87
Pressure (MPa, abs)	0.10	0.10	---	0.15	0.14	0.11	0.10	0.10	0.10	0.10	0.10	0.09	0.10	0.09
Enthalpy (kJ/kg)[A]	13.75	30.21	---	381.39	12.15	840.69	---	13.75	---	---	---	833.34	241.48	---
Density (kg/m^3)	1.2	1.2	---	1.7	1.9	1.0	---	1.2	---	---	---	0.8	1,013.1	---
V-L Molecular Weight	28.898	27.997	---	36.812	32.207	30.407	---	28.898	---	---	---	31.056	18.015	---
V-L Flowrate (lb_{mol}/hr)	176,176	138,475	0	11,332	37,700	89,967	0	3,403	0	0	0	171,845	8,597	0
V-L Flowrate (lb/hr)	5,091,062	3,876,852	0	417,141	1,214,209	2,735,655	0	98,337	0	0	0	5,336,813	154,878	0
Solids Flowrate (lb/hr)	0	0	0	0	0	0	970,559	0	98,852	17,088,423	17,088,351	164	12,653	25,914
Temperature (°F)	40	63	---	246	57	226	40	40	32	1,600	800	297	40	189
Pressure (psia)	13.8	14.7	---	22.0	20.3	15.7	13.8	13.8	13.8	14.2	14.2	13.5	15.0	13.1
Enthalpy (Btu/lb)[A]	5.9	13.0	---	164.0	5.2	361.4	---	5.9	---	---	---	358.3	103.8	---
Density (lb/ft^3)	0.074	0.073	---	0.107	0.118	0.065	---	0.074	---	---	---	0.052	63.247	---

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 9-5 (continued)
Case L22F SC CFB Oxycombustion with CO_2 Cryogenic Distillation Stream Table

	15	16	17	18	19	20	21	22	23	24	25	26	27	28
V-L Mole Fraction														
Ar	0.0181	0.0181	0.0181	0.0181	0.0181	0.0291	0.0291	0.0275	0.0291	0.0003	0.0000	0.1481	0.0002	0.0000
CO_2	0.4339	0.4339	0.4339	0.4339	0.4339	0.6954	0.6954	0.6579	0.6954	0.0067	0.0000	0.3244	0.9998	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	0.4836	0.4836	0.4836	0.4836	0.4836	0.1724	0.1724	0.2170	0.1724	0.9915	1.0000	0.0000	0.0000	1.0000
N_2	0.0475	0.0475	0.0475	0.0475	0.0475	0.0761	0.0761	0.0720	0.0761	0.0000	0.0000	0.3903	0.0000	0.0000
O_2	0.0167	0.0167	0.0167	0.0167	0.0167	0.0268	0.0268	0.0253	0.0268	0.0000	0.0000	0.1372	0.0000	0.0000
SO_2	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0015	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)	81,725	81,725	40,808	736	40,180	25,071	4,405	5,142	20,666	3,081	509	4,031	13,045	122,782
V-L Flowrate (kg/hr)	2,485,049	2,485,049	1,240,872	22,395	1,221,762	949,570	166,849	189,244	782,721	56,275	9,163	143,174	574,108	2,211,958
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	87	88	88	88	88	57	57	62	57	57	40	21	27	593
Pressure (MPa, abs)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	15.31	24.23
Enthalpy (kJ/kg)[A]	816.24	817.33	817.33	817.33	817.33	257.88	257.88	324.09	257.88	147.25	65.52	17.25	-233.12	3,444.49
Density (kg/m^3)	0.9	0.9	0.9	0.9	0.9	1.2	1.2	1.2	1.2	56.0	979.3	1.5	685.0	69.7
V-L Molecular Weight	30.407	30.407	30.407	30.407	30.407	37.875	37.875	36.805	37.875	18.266	18.015	35.517	44.009	18.015
V-L Flowrate (lb_{mol}/hr)	180,173	180,173	89,967	1,624	88,581	55,272	9,712	11,336	45,560	6,792	1,121	8,887	28,760	270,689
V-L Flowrate (lb/hr)	5,478,595	5,478,595	2,735,655	49,372	2,693,525	2,093,445	367,839	417,212	1,725,605	124,066	20,201	315,645	1,265,692	4,876,532
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	189	191	191	191	191	135	135	144	135	135	103	69	81	1,100
Pressure (psia)	13.1	13.2	13.2	13.2	13.2	13.0	13.0	13.0	13.0	13.0	14.7	15.0	2,220.0	3,514.7
Enthalpy (Btu/lb)[A]	350.9	351.4	351.4	351.4	351.4	110.9	110.9	139.3	110.9	63.3	28.2	7.4	-100.2	1,480.9
Density (lb/ft^3)	0.057	0.058	0.058	0.058	0.058	0.077	0.077	0.074	0.077	3.493	61.137	0.094	42.765	4.350

A - Reference conditions are 32.02 F & 0.089 PSIA

Exhibit 9-5 (continued)
Case L22F SC CFB Oxycombustion with CO_2 Cryogenic Distillation Stream Table

	29	30	31	32	33	34	35	36	37	38
V-L Mole Fraction										
Ar	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO_2	0.0000	0.0000	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
H_2O	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
O_2	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
Total	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)	99,011	99,011	43,782	43,782	17,197	17,197	12,168	12,168	59,427	124,010
V-L Flowrate (kg/hr)	1,783,702	1,783,702	788,748	788,748	309,810	309,810	219,210	219,210	1,070,595	2,234,077
Solids Flowrate (kg/hr)	0	0	0	0	0	0	0	0	0	0
Temperature (°C)	340	593	35	35	52	141	52	146	52	177
Pressure (MPa, abs)	4.90	4.52	0.00	0.00	1.65	1.63	1.65	1.64	1.65	0.91
Enthalpy (kJ/kg)[A]	3,060.50	3,646.37	2,081.04	2,081.04	120.52	529.50	120.52	557.19	120.52	703.19
Density (kg/m^3)	19.4	11.6	0.0	0.0	967.4	873.6	967.4	866.9	967.4	831.4
V-L Molecular Weight	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015	18.015
V-L Flowrate (lb_{mol}/hr)	218,281	218,281	96,523	96,523	37,913	37,913	26,826	26,826	131,014	273,396
V-L Flowrate (lb/hr)	3,932,391	3,932,391	1,738,891	1,738,891	683,013	683,013	483,275	483,275	2,360,259	4,925,297
Solids Flowrate (lb/hr)	0	0	0	0	0	0	0	0	0	0
Temperature (°F)	645	1,100	96	96	125	285	125	296	125	350
Pressure (psia)	710.8	655.8	0.7	0.7	240.0	237.1	240.0	238.5	240.0	132.7
Enthalpy (Btu/lb)[A]	1,315.8	1,567.7	894.7	894.7	51.8	227.6	51.8	239.5	51.8	302.3
Density (lb/ft^3)	1.209	0.725	0.003	0.003	60.394	54.535	60.394	54.122	60.394	51.902

9.3.2 Plant Power Summary

Exhibit 9-6 Case S22A and S22F Plant Power Summary
100 Percent Load

Plant Output			
	Case S22A	**Case S22F**	
Steam Turbine Power	578,400	748,700	kW_e
Total	**578,400**	**748,700**	kW_e
Auxiliary Load			
Coal Handling and Conveying	500	580	kW_e
Crushers	120	150	kW_e
Sorbent Handling & Reagent Preparation	80	160	kW_e
Ash Handling	1,300	1,070	kW_e
Primary Air Fans	4,030	5,950	kW_e
Forced Draft Fans	1,110	2,230	kW_e
Induced Draft Fans	6,860	5,060	kW_e
Main Air Compressor	N/A	94,990	kW_e
ASU Auxiliaries	N/A	1,000	kW_e
SNCR	10	N/A	kW_e
Baghouse	150	50	kW_e
FDA System	N/A	3,050	kW_e
CPU	N/A	65,620	kW_e
Miscellaneous Balance of Plant[a,b]	2,000	2,000	kW_e
Steam Turbine Auxiliaries	400	400	kW_e
Condensate Pumps	790	1,010	kW_e
Circulating Water Pumps	2,390	3,380	kW_e
Ground Water Pumps	220	330	kW_e
Cooling Tower Fans	1,560	2,040	kW_e
Air Cooled Condenser Fans	4,990	6,700	kW_e
Transformer Losses	1,810	2,780	kW_e
Total	28,320	198,550	kW_e
Plant Performance			
Net Auxiliary Load	28,320	198,550	kW_e
Net Plant Power	550,080	550,150	kW_e
Net Exported Power Efficiency (HHV)	38.9%	30.8%	
Net Plant Heat Rate (HHV)	9,246 (8,763)	11,685 (11,075)	kJ/kWhr (Btu/kWhr)
Coal Feed Flowrate	255,324 (562,894)	322,721 (711,479)	kg/hr (lb/hr)
Thermal Input[c]	1,412,786	1,785,712	kW_{th}
Condenser Duty	2,217 (2,101)	3,178 (3,012)	GJ/hr (MMBtu/hr)
Raw Water Withdrawal	9.3 (2,456)	13.9 (3,668)	m^3/min (gpm)

[a] Boiler feed pumps are turbine driven
[b] Includes plant control systems, lighting, HVAC, and miscellaneous low voltage loads
[c] HHV of as received Rosebud PRB coal is 19,920 kJ/kg (8,564 Btu/lb)

9.3.3 Energy Balance

An overall energy balance for the two plants is shown in Exhibit 9-7.

Exhibit 9-7
Cases S22F and L22F Overall Energy Balance

	HHV		Sensible + Latent		Power		Total	
	S13F	L13F	S13F	L13F	S13F	L13F	S13F	L13F
Heat In, GJ/hr (MMBtu/hr)								
Coal	6,557 (6,215)	6,776 (6,422)	3.4 (3.2)	3.9 (3.7)			6,561 (6,218)	6,780 (6,426)
Combustion/ Infiltration Air			34.3 (32.5)	32.4 (30.7)			34.3 (32.5)	32.4 (30.7)
Raw Water Makeup			25.9 (24.5)	21.5 (20.4)			25.9 (24.5)	21.5 (20.4)
Lime			0.02 (0.02)	0.02 (0.02)			0.02 (0.02)	0.02 (0.02)
Auxiliary Power					739 (700)	748 (709)	739 (700)	748 (709)
Totals	**6,557 (6,215)**	**6,776 (6,422)**	**63.5 (60.2)**	**57.8 (54.8)**	**739 (700)**	**748 (709)**	**7,360 (6,976)**	**7,582 (7,186)**
Heat Out, GJ/hr (MMBtu/hr)								
Boiler Loss			57.9 (54.9)	58.3 (55.2)			57.9 (54.9)	58.3 (55.2)
Air Heater Loss			4.4 (4.2)	5.7 (5.4)			4.4 (4.2)	5.7 (5.4)
CO_2 Cooling Duty			294.5 (279.2)	311.8 (295.6)			294.5 (279.2)	311.8 (295.6)
DCC Cooling Duty			370.0 (350.7)	601.1 (569.8)			370.0 (350.7)	601.1 (569.8)
SO_2 Polishing Scrubber Cooling Duty			156.2 (148.0)	165.1 (156.5)			156.2 (148.0)	165.1 (156.5)
ASU Cold Box Pre-Cooling			184.2 (174.6)	192.2 (182.1)			184.2 (174.6)	192.2 (182.1)
Bottom Ash			24.6 (23.3)	36.1 (34.2)			24.6 (23.3)	36.1 (34.2)
Fly Ash + FGD Ash			0.8 (0.8)	0.9 (0.9)			0.8 (0.8)	0.9 (0.9)

	HHV		Sensible + Latent		Power		Total	
	S13F	L13F	S13F	L13F	S13F	L13F	S13F	L13F
Knockout Water			27.1 (25.7)	40.9 (38.7)			27.1 (25.7)	40.9 (38.7)
Flue Gas/CPU Vent			2 (2)	2 (2)			2 (2)	2 (2)
ASU Vent Stream			52 (49)	53 (50)			52 (49)	53 (50)
Condenser			3,202 (3,035)	3,208 (3,041)			3,202 (3,035)	3,208 (3,041)
CO_2			-126 (-119)	-134 (-127)			-126 (-119)	-134 (-127)
Cooling Tower Blowdown			26.0 (24.7)	27.8 (26.3)			26.0 (24.7)	27.8 (26.3)
Process Losses[a]			299.3 (283.7)	215.0 (203.8)			299.3 (283.7)	215.0 (203.8)
ST Generator/Exhaust Losses					69 (66)	70 (66)	69 (66)	70 (66)
Power					2,715 (2,573)	2,727 (2,585)	2,715 (2,573)	2,727 (2,585)
Totals			**4,575 (4,337)**	**4,785 (4,535)**	**2,764 (2,620)**	**2,797 (2,651)**	**7,360 (6,976)**	**7,582 (7,186)**

[a] Process losses from combustion reactions and gas cooling are estimated to match the heat input to the plant.

9.3.4 Water Balance

An overall water balance for the plant is shown in Exhibit 9-8. Raw water 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 is re-used as internal recycle. Raw water makeup is the difference between water demand and internal recycle.

Exhibit 9-8
Cases S22F and L22F Water Balance

Water Use	Water Demand, m^3/min (gpm)		Internal Recycle, m^3/min (gpm)		Raw Water Withdrawl, m^3/min (gpm)		Process Water Discharge, m^3/min (gpm)		Raw Water Consumption, m^3/min (gpm)	
	S22F	L22F	S22F	L22F	S22F	L22F	S22F	L22F	S22F	L22F
FGD Makeup	0.91 (240)	1.18 (312)	0.0 (0)	0.0 (0)	0.91 (240)	1.18 (312)	0.00 (0.00)	0.00 (0.00)	0.91 (241.32)	1.17 (309.76)
BFW Makeup	0.36 (96)	0.37 (98)	0.0 (0)	0.0 (0)	0.36 (96)	0.37 (98)	0.00 (0.00)	0.00 (0.00)	0.37 (96.98)	0.37 (97.53)
Cooling Tower Makeup	12.98 (3428)	13.07 (3453)	0.4 (96)	0.4 (98)	12.61 (3332)	12.70 (3355)	4.67 (1233.66)	5.13 (1355.74)	12.61 (3331.94)	12.62 (3334.48)
Total	**14.2 (3,764)**	**14.6 (3,862)**	**0.36 (96)**	**0.37 (98)**	**13.9 (3,668)**	**14.2 (3,764)**	**4.67 (1233.66)**	**5.13 (1355.74)**	**13.89 (3670.23)**	**14.16 (3741.77)**

9.3.5 Carbon Balance

The carbon balances for the PRB air-fired CFBC and CFB oxycombustion case with cryogenic CO_2 distillation are shown in Exhibit 9-9. The carbon input to the plant consists of carbon in the air entering the primary and secondary air fans, carbon in the air entering the ASU, and the infiltration air entering the boiler, in addition to carbon in the coal. Carbon also enters the system from the injection of limestone for the air-fired case or lime into the FDA system. The carbon entering the ASU is removed before entering the boiler island. Carbon leaves the plant as CO_2 product in the oxycombustion case only. The percent of total carbon sequestered is defined as the amount of carbon product produced divided by the carbon in the coal feedstock, expressed as a percentage.

% Captured = (Carbon in Product for Sequestration) / (Carbon in the Coal) * 100

or

(323,295)/356,888 * 100= 90.6% (Case S22F)

Exhibit 9-9
Cases S22F and L22F Carbon Balance

Carbon In, kg/hr (lb/hr)			Carbon Out, kg/hr (lb/hr)		
	S22F	**L22F**		**S22F**	**L22F**
Coal	164,819 (363,363)	174,130 (383,892)	**ASU Vent**	300 (662)	315 (694)
Air (CO_2)	306 (675)	321 (707)	**Flue Gas / CPU Vent**	14,785 (32,594)	15,705 (34,623)
			Ash	2,305 (5,082)	1,503 (3,313)
Lime	0 (0)	0 (0)	**CO_2 Product**	147,473 (325,123)	156,653 (345,361)
			SO_2 Scrubber	233 (514)	248 (546)
			DCC Discharge	1 (3)	2 (5)
			Convergence Tolerance[a]	27 (59)	26 (58)
Total	165,125 (364,038)	174,451 (384,599)	**Total**	165,125 (364,038)	174,451 (384,599)

[a] By difference

9.3.6 Sulfur Balance

Exhibit 9-10 shows the sulfur balances for the PRB air-fired CFBC and CFB oxycombustion case with cryogenic CO_2 distillation. Sulfur input comes solely from the sulfur in the coal. Sulfur output is the sulfur combined with lime in the ash, the discharge from the DCC and polishing scrubber, and the sulfur sequestered in the CO_2 product stream, where applicable. The total sulfur capture is represented by the following fraction:

(Sulfur in Ash + Sulfur in waste discharge streams)/Sulfur in the coal or
(4,960 + 319)/ 5,279*100 = 100% (S22F)
(4,747 + 332)/ 6,080*100 = 100% (L22F)

Exhibit 9-10
Cases S22A and S22F Sulfur Balance

Sulfur In, kg/hr (lb/hr)			Sulfur Out, kg/hr (lb/hr)		
	S22F	**L22F**		**S22F**	**L22F**
Coal	2,395 (5,279)	2,758 (6,080)	**Ash**	2,250 (4,960)	2,607 (5,747)
			SO_2 Polishing Scrubber	145 (319)	151 (332)
			Flue Gas / CPU Vent	0 (0)	0 (0)
			CO_2 Product	0 (0)	0 (0)
			DCC Discharge	0 (0)	0 (0)
			Convergence Tolerance	0 (0)	0 (0)
Total	2,395 (5,279)	2,758 (6,080)	**Total**	2,395 (5,279)	2,758 (6,080)

9.3.7 Air Emissions

For the oxycombustion case, all particulates are assumed to be removed from the process stream after the baghouse, by either the direct contact cooler or the SO_2 polishing scrubber, with no particulate matter being vented to the atmosphere. Mercury was assumed to be absorbed in the desiccant dryer, removed with the condensed water in CO_2 compression train, and co-sequestered with the CO_2 product stream. Eighty percent of the NO_x generated in the combustor is assumed to be vented from the CPU, with the remaining NO_x co-sequestered in the form of NO_2.

Exhibit 9-11
Cases S22F and L22F Estimated Air Emissions

	kg/GJ ($lb/10^6$ Btu)		Tonne/year (ton/year) 85% capacity factor		kg/MWh (lb/MWh)	
	S22F	**L22F**	**S22F**	**L22F**	**S22F**	**L22F**
SO_2	0.000 (0.000)	0.000 (0.000)	0 (0)	0 (0)	0.000 (0.00)	0.000 (0.00)
NO_X	0.024 (0.056)	0.024 (0.056)	1,152 (1,270)	1,204 (1,327)	0.207 (0.456)	0.214 (0.471)
Particulates	0.0000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000))	0.000 (0.000)	0.000 (0.000)
Hg	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.00 (0.00)	0.0 (0.0)	0.00 (0.00)
CO_2	8.4 (19.5)	8.4 (19.5)	401,101 (442,138)	428,319 (472,141)	72 (159)	76 (168)
CO_2[a]					98 (216)	105 (231)

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

9.3.8 Heat and Mass Balance Diagrams

Heat and mass balance diagrams are shown for the following subsystems in Exhibit 9-13 through Exhibit 9-15:

- Boiler and flue gas cleanup
- Steam and feedwater

Exhibit 9-12 Case S22F Heat and Mass Balance, Ultra-Supercritical PC Boiler and Gas Cleanup Systems

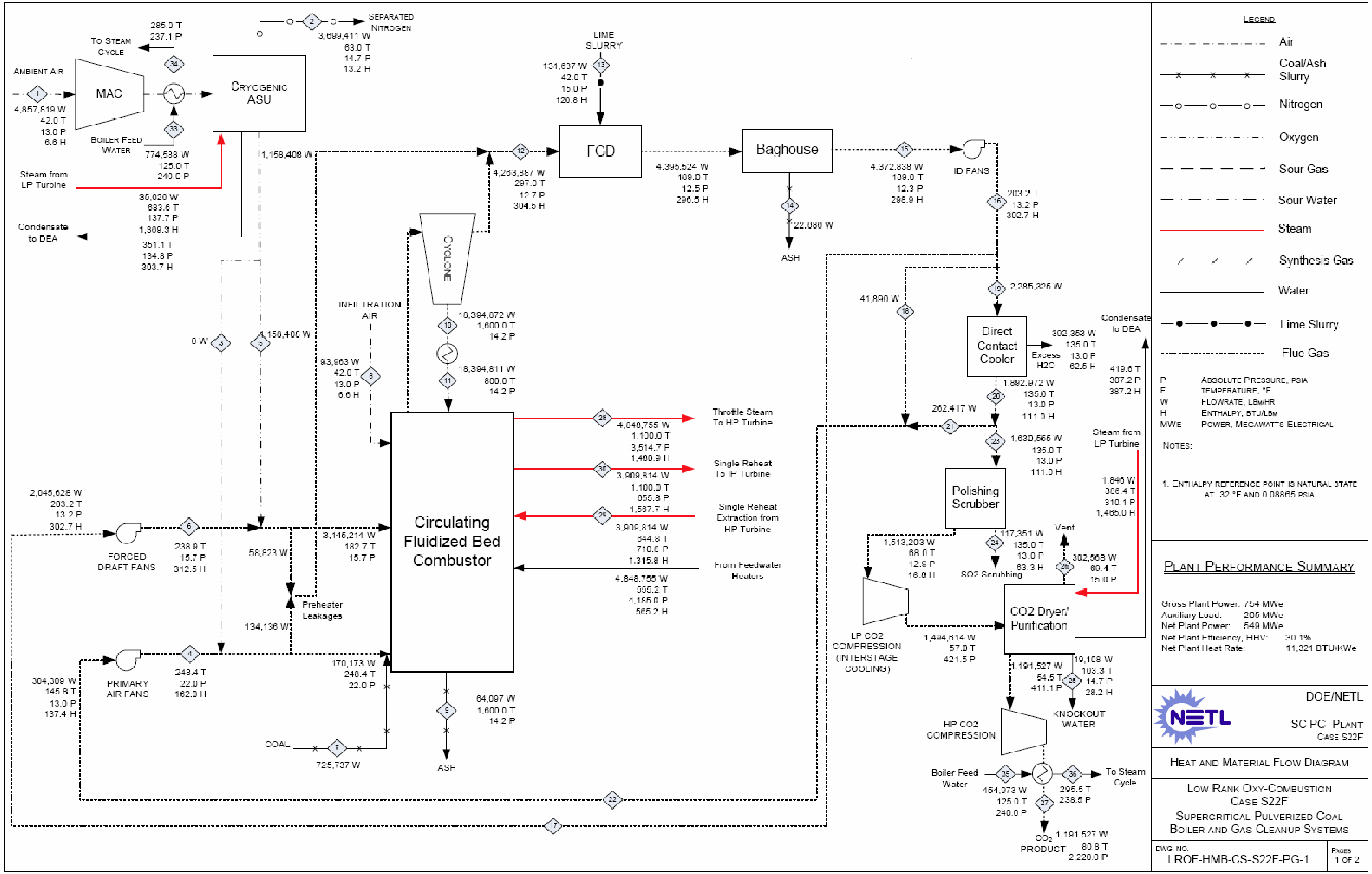


Exhibit 9-13 Case S22F Heat and Mass Balance, Power Block Systems

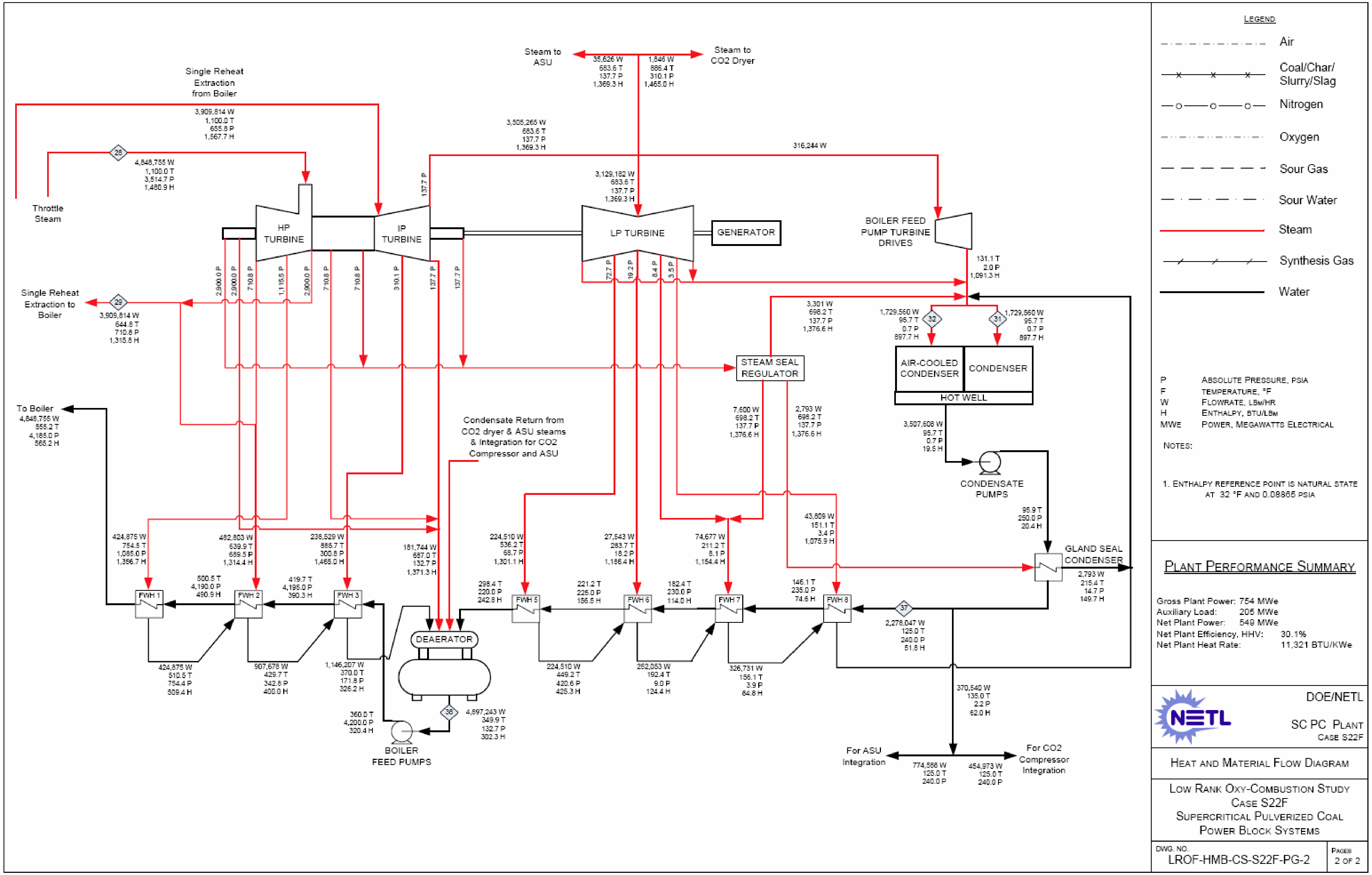


Exhibit 9-14 Case L22F Heat and Mass Balance, Ultra-Supercritical PC Boiler and Gas Cleanup Systems

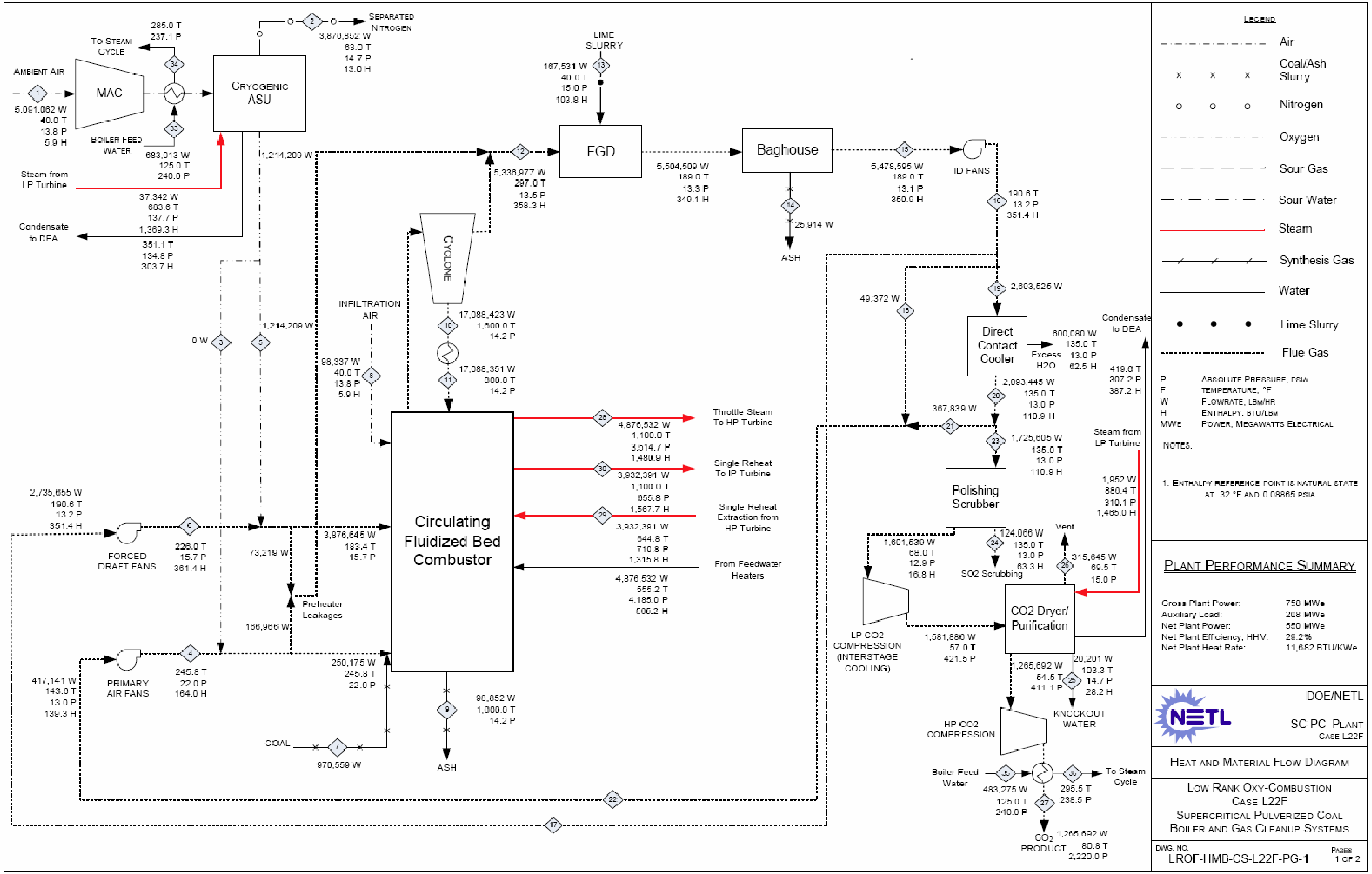
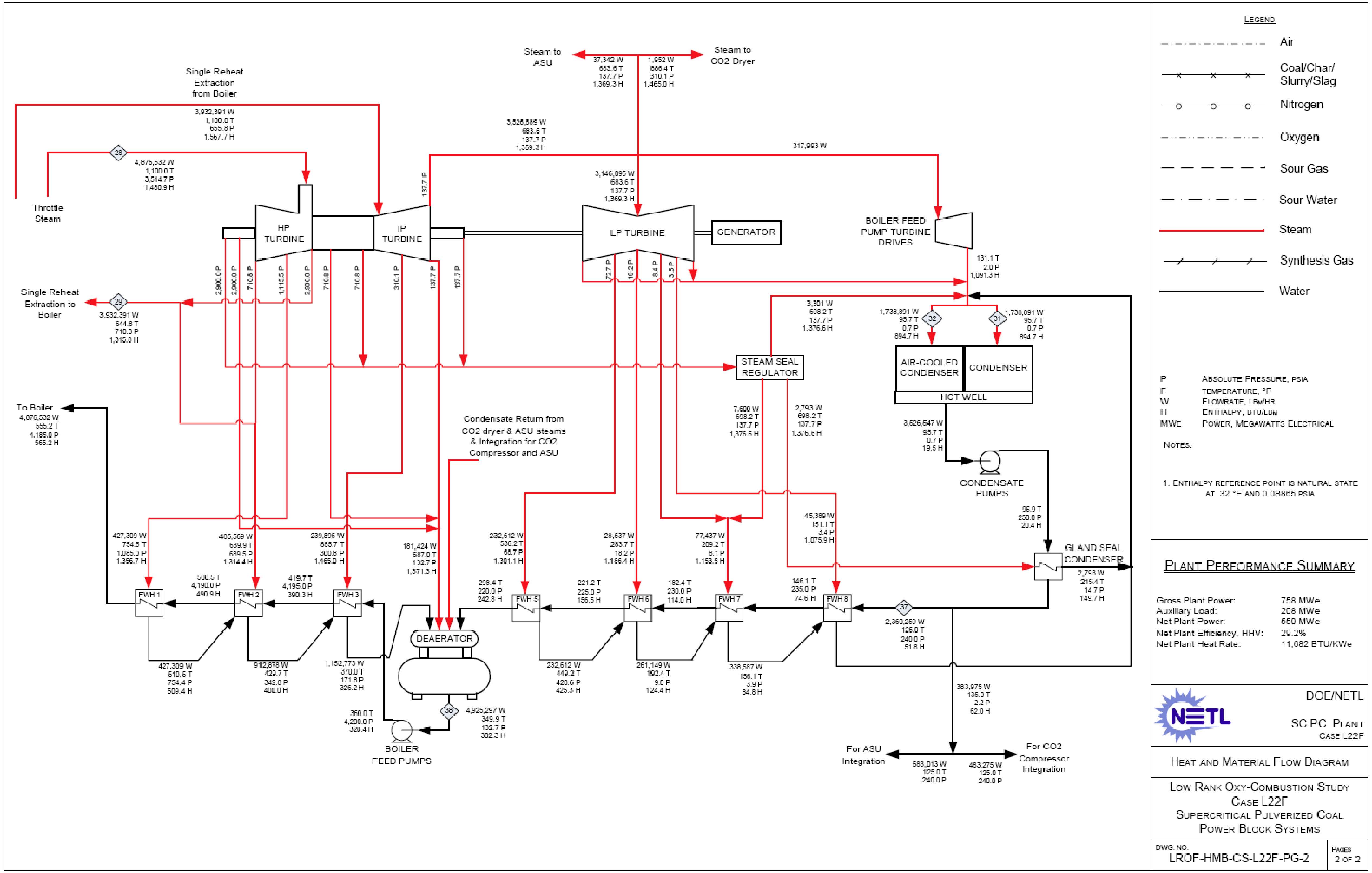


Exhibit 9-15 Case L22F Heat and Mass Balance, Power Block Systems



9.3.9 Major Equipment List for Cases S22F and L22F

Major equipment items for these cases are shown in the following tables. The accounts used in the equipment list correspond to the account numbers used in the cost estimates in **Section 8.4**. 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	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
1	Bottom Trestle Dumper and Receiving Hoppers	N/A	181 tonne (200 ton)	181 tonne (200 ton)	2 (0)
2	Feeder	Belt	572 tonne/hr (630 tph)	572 tonne/hr (630 tph)	2 (0)
3	Conveyor No. 1	Belt	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	2 (0)
4	Transfer Tower No. 1	Enclosed	N/A	N/A	1 (0)
5	Conveyor No. 2	Belt	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1 (0)
6	As-Received Coal Sampling System	Two-stage	N/A	N/A	1 (0)
7	Stacker/Reclaimer	Traveling, linear	1,134 tonne/hr (1,250 tph)	1,134 tonne/hr (1,250 tph)	1 (0)
8	Reclaim Hopper	N/A	73 tonne (80 ton)	91 tonne (100 ton)	1 (0)
9	Feeder	Vibratory	272 tonne/hr (300 tph)	363 tonne/hr (400 tph)	2 (1)
10	Conveyor No. 3	Belt w/ tripper	544 tonne/hr (600 tph)	726 tonne/hr (800 tph)	2 (1)
11	Crusher Tower	N/A	N/A	N/A	1 (0)
12	Coal Surge Bin w/ Vent Filter	Dual outlet	272 tonne (300 ton)	363 tonne (400 ton)	1 (0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
13	Crusher	Impactor reduction	8 cm x 0 - 3 cm x 0 (3 in x 0 - 3/4 in x 0)	8 cm x 0 - 3 cm x 0 (3 in x 0 - 3/4 in x 0)	2 (0)
14	As-Fired Coal Sampling System	Swing hammer	N/A	N/A	2 (0)
15	Conveyor No. 4	Belt w/tripper	544 tonne/hr (600 tph)	726 tonne/hr (800 tph)	1 (1)
16	Transfer Tower No. 2	Enclosed	N/A	N/A	1 (0)
17	Conveyor No. 5	Belt w/ tripper	544 tonne/hr (600 tph)	726 tonne/hr (800 tph)	1 (0)
18	Coal Silo w/ Vent Filter and Slide Gates	Field erected	1,179 tonne (1,300 ton)	1,633 tonne (1,800 ton)	1 (0)
19	Limestone Truck Unloading Hopper	N/A	36 tonne (40 ton)	36 tonne (40 ton)	3 (0)
20	Limestone Feeder	Belt	18 tonne/hr (20 tph)	27 tonne/hr (30 tph)	1 (0)
21	Limestone Conveyor No. L1	Belt	18 tonne/hr (20 tph)	27 tonne/hr (30 tph)	1 (0)
22	Limestone Reclaim Hopper	N/A	0 tonne (0 ton)	9 tonne (10 ton)	1 (0)
23	Limestone Reclaim Feeder	Belt	18 tonne/hr (20 tph)	18 tonne/hr (20 tph)	1 (0)
24	Limestone Conveyor No. L2	Belt	18 tonne/hr (20 tph)	18 tonne/hr (20 tph)	1 (0)
25	Limestone Day Bin	w/ actuator	64 tonne (70 ton)	73 tonne (80 ton)	1 (0)

ACCOUNT 2 COAL AND SORBENT PREPARATION AND FEED

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
1	Coal Feeder	Gravimetric	64 tonne/hr (70 tph)	82 tonne/hr (90 tph)	6 (0)
2	Limestone Bin Activator	0	5 tonne/hr (6 tph)	6 tonne/hr (7 tph)	1 (1)
3	Limestone Weigh Feeder	Gravimetric	5 tonne/hr (6 tph)	6 tonne/hr (7 tph)	1 (1)
4	Limestone Rod Mill - Top size 1/16"	Rotary	5 tonne/hr (6 tph)	6 tonne/hr (7 tph)	1 (1)
5	Blower	Roots	10 m^3/min @ 0.2 MPa (370 scfm @ 24 psi)	12 m^3/min @ 0.2 MPa (420 scfm @ 24 psi)	1 (1)

ACCOUNT 3 FEEDWATER AND MISCELLANEOUS SYSTEMS AND EQUIPMENT

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
1	Demineralized Water Storage Tank	Vertical, cylindrical, outdoor	1,453,598 liters (384,000 gal)	1,461,169 liters (386,000 gal)	2 (0)
2	Condensate Pumps	Vertical canned	29,526 lpm @ 213 m H_2O (7,800 gpm @ 700 ft H_2O)	29,526 lpm @ 213 m H_2O (7,800 gpm @ 700 ft H_2O)	1 (1)
3	Deaerator and Storage Tank	Horizontal spray type	2,419,462 kg/hr (5,334,000 lb/hr), 5 min. tank	2,433,069 kg/hr (5,364,000 lb/hr), 5 min. tank	1 (0)
4	Boiler Feed Pump/Turbine	Barrel type, multi-stage, centrifugal	40,504 lpm @ 3,475 m H_2O (10,700 gpm @ 11,400 ft H_2O)	40,882 lpm @ 3,475 m H_2O (10,800 gpm @ 11,400 ft H_2O)	1 (1)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
5	Startup Boiler Feed Pump, Electric Motor Driven	Barrel type, multi-stage, centrifugal	12,113 lpm @ 3,475 m H_2O (3,200 gpm @ 11,400 ft H_2O)	12,113 lpm @ 3,475 m H_2O (3,200 gpm @ 11,400 ft H_2O)	1 (0)
6	LP Feedwater Heater 1A/1B	Horizontal U-tube	875,433 kg/hr (1,930,000 lb/hr)	879,969 kg/hr (1,940,000 lb/hr)	2 (0)
7	LP Feedwater Heater 2A/2B	Horizontal U-tube	875,433 kg/hr (1,930,000 lb/hr)	879,969 kg/hr (1,940,000 lb/hr)	2 (0)
8	LP Feedwater Heater 3A/3B	Horizontal U-tube	875,433 kg/hr (1,930,000 lb/hr)	879,969 kg/hr (1,940,000 lb/hr)	2 (0)
9	LP Feedwater Heater 4A/4B	Horizontal U-tube	875,433 kg/hr (1,930,000 lb/hr)	879,969 kg/hr (1,940,000 lb/hr)	2 (0)
10	HP Feedwater Heater 6	Horizontal U-tube	2,417,647 kg/hr (5,330,000 lb/hr)	2,431,255 kg/hr (5,360,000 lb/hr)	1 (0)
11	HP Feedwater Heater 7	Horizontal U-tube	2,417,647 kg/hr (5,330,000 lb/hr)	2,431,255 kg/hr (5,360,000 lb/hr)	1 (0)
12	HP Feedwater heater 8	Horizontal U-tube	2,417,647 kg/hr (5,330,000 lb/hr)	2,431,255 kg/hr (5,360,000 lb/hr)	1 (0)
13	Auxiliary Boiler	Shop fabricated, water tube	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)	1 (0)
14	Fuel Oil System	No. 2 fuel oil for light off	1,135,624 liter (300,000 gal)	1,135,624 liter (300,000 gal)	1 (0)
15	Service Air Compressors	Flooded Screw	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	28 m^3/min @ 0.7 MPa (1,000 scfm @ 100 psig)	2 (1)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
16	Instrument Air Dryers	Duplex, regenerative	28 m^3/min (1,000 scfm)	28 m^3/min (1,000 scfm)	2 (1)
17	Closed Cycle Cooling Heat Exchangers	Shell and tube	53 GJ/hr (50 MMBtu/hr) each	53 GJ/hr (50 MMBtu/hr) each	2 (0)
18	Closed Cycle Cooling Water Pumps	Horizontal centrifugal	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)	2 (1)
19	Engine-Driven Fire Pump	Vertical turbine, diesel engine	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)	1 (1)
20	Fire Service Booster Pump	Two-stage horizontal centrifugal	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)	1 (1)
21	Raw Water Pumps	Stainless steel, single suction	5,867 lpm @ 18 m H_2O (1,550 gpm @ 60 ft H_2O)	6,397 lpm @ 18 m H_2O (1,690 gpm @ 60 ft H_2O)	2 (1)
22	Ground Water Pumps	Stainless steel, single suction	2,915 lpm @ 268 m H_2O (770 gpm @ 880 ft H_2O)	2,574 lpm @ 268 m H_2O (680 gpm @ 880 ft H_2O)	5 (1)
23	Filtered Water Pumps	Stainless steel, single suction	492 lpm @ 49 m H_2O (130 gpm @ 160 ft H_2O)	492 lpm @ 49 m H_2O (130 gpm @ 160 ft H_2O)	2 (1)
24	Filtered Water Tank	Vertical, cylindrical	458,035 liter (121,000 gal)	458,035 liter (121,000 gal)	1 (0)
25	Makeup Water Demineralizer	Multi-media filter, cartridge filter, RO membrane assembly, electrodeionization unit	946 lpm (250 gpm)	984 lpm (260 gpm)	1 (1)
26	Liquid Waste Treatment System	--	10 years, 24-hour storm	10 years, 24-hour storm	1 (0)

ACCOUNT 4 BOILER AND ACCESSORIES

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
1	Boiler	Atm. Pressure CFBC, Once-thru Supercritical Boiler with Air Heater	2,417,647 kg/hr steam @ 25.5 MPa/602°C/602°C (5,330,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)	2,431,255 kg/hr steam @ 25.5 MPa/602°C/602°C (5,360,000 lb/hr steam @ 3,700 psig/1,115°F/1,115°F)	1 (0)
2	Primary Air Fan	Centrifugal	#N/A	#N/A	2 (0)
3	Forced Draft Fan	Centrifugal	#N/A	#N/A	2 (0)
4	Induced Draft Fan	Centrifugal	#N/A	#N/A	2 (0)
5	SNCR Lance		22 lpm (6 gpm)	23 lpm (6 gpm)	1 (1)
6	Dilution Air Blower	Centrifugal	51 m^3/min @ 108 cm WG (1,800 acfm @ 42 in. WG)	54 m^3/min @ 108 cm WG (1,900 acfm @ 42 in. WG)	2 (1)
7	Ammonia Storage	Horizontal tank	56,781 liter (15,000 gal)	60,567 liter (16,000 gal)	5 (0)
8	Ammonia Feed Pump	Centrifugal	11 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)	11 lpm @ 91 m H_2O (3 gpm @ 300 ft H_2O)	2 (1)

ACCOUNT 5 FLUE GAS CLEANUP

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
1	Fabric Filter	Single stage, high-ratio with pulse-jet online cleaning system, air-to-cloth ratio - 3.5 ft/min	1,090,890 kg/hr (2,405,000 lb/hr) 99.91% efficiency	1,366,674 kg/hr (3,013,000 lb/hr) 99.92% efficiency	2 (0)

ACCOUNT 6 COMBUSTION TURBINE/ACCESSORIES

N/A

ACCOUNT 7 DUCTING AND STACK

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
1	Stack	CS plate, type 409SS liner	#N/A	#N/A	1 (0)

ACCOUNT 8 STEAM TURBINE GENERATOR

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
1	Steam Turbine	Commercially available	794 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)	797 MW 24.1 MPa/593°C/593°C (3500 psig/ 1100°F/1100°F)	1(0)
2	Steam Turbine Generator	Hydrogen cooled, static excitation	880 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	890 MVA @ 0.9 p.f., 24 kV, 60 Hz, 3-phase	1(0)
3	Surface Condenser	Single pass, divided waterbox including vacuum pumps	1,760 GJ/hr (1,670 MMBtu/hr), Condensing temperature 35°C (96°F), Inlet water temperature 9°C (48°F), Water temperature rise 11°C (20°F)	1,760 GJ/hr (1,670 MMBtu/hr), Condensing temperature 35°C (96°F), Inlet water temperature 8°C (47°F), Water temperature rise 11°C (20°F)	1(0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
4	Air-cooled Condenser	---	1,760 GJ/hr (1,670 MMBtu/hr), Condensing temperature 35°C (96°F), Ambient temperature 6°C (42°F)	1,760 GJ/hr (1,670 MMBtu/hr), Condensing temperature 35°C (96°F), Ambient temperature 4°C (40°F)	1(0)

ACCOUNT 9 COOLING WATER SYSTEM

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
1	Circulating Water Pumps	Vertical, wet pit	533,700 lpm @ 30 m (141,000 gpm @ 100 ft)	586,700 lpm @ 30 m (155,000 gpm @ 100 ft)	2 (1)
2	Cooling Tower	Evaporative, mechanical draft, multi-cell	3°C (37°F) wet bulb / 9°C (48°F) CWT / 20°C (68°F) HWT / 2986 GJ/hr (2830 MMBtu/hr) heat duty	2°C (36°F) wet bulb / 8°C (47°F) CWT / 19°C (67°F) HWT / 3281 GJ/hr (3110 MMBtu/hr) heat duty	1 (0)

ACCOUNT 10 ASH/SPENT SORBENT RECOVERY AND HANDLING

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
1	Economizer Hopper (part of boiler scope of supply)	--	--	--	4 (0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
2	Bottom Ash Hopper (part of boiler scope of supply)	--	--	--	2 (0)
3	Clinker Grinder	--	#N/A	#N/A	1 (1)
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	#N/A	#N/A	1 (1)
8	Ash Seal Water Pumps	Vertical, wet pit	7,571 lpm @ 9 m H_2O (2000 gpm @ 28 ft H_2O)	7,571 lpm @ 9 m H_2O (2000 gpm @ 28 ft H_2O)	1 (1)
9	Hydrobins	--	#N/A	#N/A	1 (1)
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	--	10 m^3/min @ 0.2 MPa (370 scfm @ 24 psi)	12 m^3/min @ 0.2 MPa (420 scfm @ 24 psi)	1 (1)
13	Fly Ash Silo	Reinforced concrete	318 tonne (700 ton)	408 tonne (900 ton)	2 (0)
14	Slide Gate Valves	--	--	--	2 (0)
15	Unloader	--	--	--	1 (0)

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
16	Telescoping Unloading Chute	--	64 tonne/hr (70 tph)	73 tonne/hr (80 tph)	1 (0)

ACCOUNT 11 ACCESSORY ELECTRIC PLANT

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
1	STG Transformer	Oil-filled	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	24 kV/345 kV, 650 MVA, 3-ph, 60 Hz	1 (0)
2	Auxiliary Transformer	Oil-filled	24 kV/4.16 kV, 225 MVA, 3-ph, 60 Hz	24 kV/4.16 kV, 228 MVA, 3-ph, 60 Hz	1 (1)
3	Low Voltage Transformer	Dry ventilated	4.16 kV/480 V, 34 MVA, 3-ph, 60 Hz	4.16 kV/480 V, 34 MVA, 3-ph, 60 Hz	1 (1)
4	STG Isolated Phase Bus Duct and Tap Bus	Aluminum, self-cooled	24 kV, 3-ph, 60 Hz	24 kV, 3-ph, 60 Hz	1 (0)
5	Medium Voltage Switchgear	Metal clad	4.16 kV, 3-ph, 60 Hz	4.16 kV, 3-ph, 60 Hz	1 (1)
6	Low Voltage Switchgear	Metal enclosed	480 V, 3-ph, 60 Hz	480 V, 3-ph, 60 Hz	1 (1)
7	Emergency Diesel Generator	Sized for emergency shutdown	750 kW, 480 V, 3-ph, 60 Hz	750 kW, 480 V, 3-ph, 60 Hz	1 (0)

ACCOUNT 12 INSTRUMENTATION AND CONTROL

Equipment No.	Description	Type	Design Condition		Opr Qty. (Spares)
			Case S22F	Case L22F	
1	DCS - Main Control	Monitor/keyboard; Operator printer (laser color); Engineering printer (laser B&W)	Operator stations/printers and engineering stations/printers	Operator stations/printers and engineering stations/printers	1 (0)
2	DCS - Processor	Microprocessor with redundant input/output	N/A	N/A	1 (0)
3	DCS - Data Highway	Fiber optic	Fully redundant, 25% spare	Fully redundant, 25% spare	1 (0)

9.4 ECONOMIC ANALYSIS FOR ULTRA-SUPERCRITICAL OXYCOMBUSTION CASES

Capital and operating costs for the SC CFB oxycombustion cases are presented in Section 9.4.1. A cost and performance summary table for all six cases is given in Section 9.4.2, and additional cost detail sheets for all cases are contained in Section 2.7

9.4.1 Cost Results for Cases S22F and L22F

The capital and operating costs for Cases S22F and L22F are shown in Exhibit 9-16 through Exhibit 9-21. Capital and operating cost estimating methodology is explained Section 2.7.

Exhibit 9-16 Case S22F Total Plant Costs

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case L22F - Oxy-Fuel Super-Critical CFB w/ CO2 Capture
Plant Size: 549.73 MW, net — Capital Charge Factor 0.175 — Capacity Factor 0.85
Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
	SUBTOTAL 1.	**$26,169**	**$8,754**	**$15,730**	**$0**	**$50,653**		**$4,552**		**$0**		**$8,281**	**$63,485**	**$115**
2	COAL & SORBENT PREP & FEED													
	SUBTOTAL 2.	**$12,034**	**$70,532**	**$61,753**	**$0**	**$144,320**		**$13,298**		**$0**		**$23,643**	**$181,261**	**$330**
3	FEEDWATER & MISC. BOP SYSTEMS													
	SUBTOTAL 3.	**$109,265**	**$0**	**$52,053**	**$0**	**$161,319**		**$14,897**		**$0**		**$29,115**	**$205,331**	**$374**
4	CFB BOILER													
	SUBTOTAL 4.	**$539,783**	**$0**	**$274,265**	**$0**	**$814,049**		**$50,528**		**$78,097**		**$64,927**	**$1,007,601**	**$1,833**
5A	FLUE GAS CLEANUP						*							
	SUBTOTAL 5A.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
5B	CO2 REMOVAL & COMPRESSION													
	SUBTOTAL 5B.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
6	COMBUSTION TURBINE/ACCESSORIES													
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
	SUBTOTAL 7.	**$67,621**	**$0**	**$8,902**	**$0**	**$76,524**		**$2,179**		**$0**		**$3,984**	**$82,687**	**$150**
8	STEAM TURBINE GENERATOR													
	SUBTOTAL 8.	**$94,452**	**$1,329**	**$27,285**	**$0**	**$123,065**		**$11,342**		**$0**		**$15,897**	**$150,304**	**$273**
9	COOLING WATER SYSTEM													
	SUBTOTAL 9.	**$11,621**	**$8,035**	**$13,409**	**$0**	**$33,065**		**$3,106**		**$0**		**$5,122**	**$41,293**	**$75**
10	ASH/SPENT SORBENT HANDLING SYS													
	SUBTOTAL 10.	**$3,470**	**$110**	**$4,640**	**$0**	**$8,220**		**$790**		**$0**		**$927**	**$9,938**	**$18**
11	ACCESSORY ELECTRIC PLANT													
	SUBTOTAL 11.	**$55,909**	**$15,348**	**$45,853**	**$0**	**$117,110**		**$10,080**		**$0**		**$17,846**	**$145,037**	**$264**
12	INSTRUMENTATION & CONTROL													
	SUBTOTAL 12.	**$3,825**	**$3,276**	**$9,634**	**$0**	**$16,734**		**$1,530**		**$0**		**$2,213**	**$20,478**	**$37**
13	IMPROVEMENTS TO SITE													
	SUBTOTAL 13.	**$3,467**	**$1,993**	**$6,987**	**$0**	**$12,447**		**$1,228**		**$0**		**$2,735**	**$16,410**	**$30**
14	BUILDINGS & STRUCTURES													
	SUBTOTAL 14.	**$0**	**$25,955**	**$24,475**	**$0**	**$50,430**		**$4,548**		**$0**		**$8,247**	**$63,224**	**$115**
	Total Cost	**$927,617**	**$135,331**	**$544,987**	**$0**	**$1,607,935**		**$118,079**		**$78,097**		**$182,937**	**$1,987,048**	**$3,615**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S22F - Oxy-Fuel Super-Critical CFB w/ CO2 Capture
Plant Size: 549.01 MW, net Capital Charge Factor 0.175 Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
1.1	Coal Receive & Unload	4,763	0	2,176	0	6,939	8.9%	620	0%	0	15.0%	1,134	8,693	16
1.2	Coal Stackout & Reclaim	6,156	0	1,395	0	7,551	8.7%	661	0%	0	15.0%	1,232	9,443	17
1.3	Coal Conveyors	5,724	0	1,380	0	7,104	8.8%	622	0%	0	15.0%	1,159	8,885	16
1.4	Other Coal Handling	1,497	0	319	0	1,817	8.7%	159	0%	0	15.0%	296	2,272	4
1.5	Sorbent Receive & Unload	58	0	17	0	76	8.8%	7	0%	0	15.0%	12	95	0
1.6	Sorbent Stackout & Reclaim	940	0	350	0	1,290	8.7%	113	0%	0	15.0%	210	1,614	3
1.7	Sorbent Conveyors	336	976	82	0	1,393	8.6%	120	0%	0	15.0%	227	1,741	3
1.8	Other Sorbent Handling	2,726	639	106	0	3,471	8.8%	307	0%	0	15.0%	567	4,344	8
1.9	Coal & Sorbent Hnd.Foundations	0	5,840	7,368	0	13,208	9.4%	1,241	0%	0	15.0%	2,167	16,616	30
	SUBTOTAL 1.	**$22,201**	**$7,456**	**$13,192**	**$0**	**$42,849**		**$3,849**		**$0**		**$7,005**	**$53,703**	**$98**
2	COAL & SORBENT PREP & FEED													
2.1	Coal Crushing & Drying	2,790	0	544	0	3,334	8.7%	291	0%	0	15.0%	544	4,168	8
2.2	Coal Conveyor to Storage	7,144	0	1,559	0	8,703	8.7%	761	0%	0	15.0%	1,420	10,883	20
2.3	Coal Injection System	0	0	0	0	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	0.0%	0	0	0
2.5	Sorbent Prep Equipment	0	0	0	0	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	0.0%	0	0	0
2.7	Sorbent Injection System	0	0	0	0	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	0.0%	0	0	0
2.9	Coal & Sorbent Feed Foundation	0	58,683	49,259	0	107,942	9.3%	10,004	0%	0	15.0%	17,692	135,638	247
	SUBTOTAL 2.	**$9,934**	**$58,683**	**$51,362**	**$0**	**$119,978**		**$11,056**		**$0**		**$19,655**	**$150,689**	**$274**
3	FEEDWATER & MISC. BOP SYSTEMS													
3.1	FeedwaterSystem	37,438	0	12,093	0	49,532	8.7%	4,328	0%	0	15.0%	8,079	61,939	113
3.2	Water Makeup & Pretreating	4,168	0	1,342	0	5,510	9.5%	521	0%	0	20.0%	1,206	7,237	13
3.3	Other Feedwater Subsystems	11,462	0	4,844	0	16,305	9.0%	1,461	0%	0	15.0%	2,665	20,431	37
3.4	Service Water Systems	817	0	445	0	1,262	9.4%	119	0%	0	20.0%	276	1,656	3
3.5	Other Boiler Plant Systems	19,767	0	19,516	0	39,283	9.5%	3,731	0%	0	15.0%	6,452	49,467	90
3.6	FO Supply Sys & Nat Gas	2,817	0	3,522	0	6,339	9.4%	598	0%	0	15.0%	1,041	7,978	15
3.7	Waste Treatment Equipment	0	0	0	0	0	9.7%	0	0%	0	20.0%	0	0	0
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	29,912	0	9,138	0	39,049	9.6%	3,755	0%	0	20.0%	8,561	51,365	94
	SUBTOTAL 3.	**$106,381**	**$0**	**$50,899**	**$0**	**$157,280**		**$14,512**		**$0**		**$28,280**	**$200,072**	**$364**
4	CFB BOILER													
4.1	CFB Boiler & Accesories	311,204	0	116,973	0	428,177	9.7%	41,554	15%	64,227	10.0%	53,396	587,354	1,070
4.2	ASU/Oxidant Compression	161,370	0	132,030	0	293,400	0.0%	0	0%	0	0.0%	0	293,400	534
4.3	Open	0	0	0	0	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	0.0%	0	0	0
4.5	Primary Air System	w/4.1	0	w/4.1	0	0	0.0%	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	0.0%	0	0	0
4.7	Major Component Rigging	0	w/4.1	w/4.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
4.8	CFB Foundations	0	w/14.1	w/14.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 4.	**$472,574**	**$0**	**$249,003**	**$0**	**$721,577**		**$41,554**		**$64,227**		**$53,396**	**$880,754**	**$1,604**
5A	FLUE GAS CLEANUP						*							
5.1	Absorber Vessels & Accessories	0	0	0	0	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	0.0%	0	0	0
5.3	Bag House & Accessories (Incl. w/ 4.1)	0	0	0	0	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	0.0%	0	0	0
5.5	Gypsum Dewatering System	0	0	0	0	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	0.0%	0	0	0
5.9	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 5A.	0	0	0	0	0		0		0		0	0	0
5B	CO2 REMOVAL & COMPRESSION													
5B.1	**CO2 Removal System**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S22F - Oxy-Fuel Super-Critical CFB w/ CO2 Capture
Plant Size: 549.01 MW, net — Capital Charge Factor 0.175 — Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
5B.2	CO2 Compression & Drying						0							
	SUBTOTAL 5B.	**$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%	0	0	0
6.2	Combustion Turbine Accessories	0	0	0	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%	0	0	0
6.4	Combustion Turbine Foundations	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
7.1	Heat Recovery Steam Generator	47,740	0	3,986	0	51,726	0%	0	0%	0	0.0%	0	51,726	94
7.2	HRSG Accessories	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
7.3	Ductwork	15,615	0	2,077	0	17,692	9%	1,543	0%	0	15.0%	2,885	22,120	40
7.4	Stack	759	0	1,626	0	2,385	10%	230	0%	0	10.0%	262	2,877	5
7.9	Duct & Stack Foundations	1,328	0	751	0	2,079	9%	195	0%	0	20.0%	455	2,728	5
	SUBTOTAL 7.	**$65,442**	**$0**	**$8,440**	**$0**	**$73,882**		**$1,967**		**$0**		**$3,601**	**$79,451**	**$145**
8	STEAM TURBINE GENERATOR													
8.1	Steam TG & Accessories	62,747	0	8,333	0	71,080	9.6%	6,812	0%	0	10.0%	7,789	85,682	156
8.2	Turbine Plant Auxiliaries	423	0	907	0	1,330	9.8%	130	0%	0	10.0%	146	1,606	3
8.3a	Condenser & Auxiliaries	5,361	0	3,234	0	8,594	9.6%	827	0%	0	10.0%	942	10,364	19
8.3b	Air Cooled Condenser						10.0%		0%		20.0%			
8.4	Steam Piping	25,609	0	12,627	0	38,236	8.4%	3,213	0%	0	15.0%	6,217	47,666	87
8.9	TG Foundations	0	1,325	2,093	0	3,418	9.5%	323	0%	0	20.0%	748	4,490	8
	SUBTOTAL 8.	**$94,140**	**$1,325**	**$27,194**	**$0**	**$122,659**		**$11,305**		**$0**		**$15,843**	**$149,807**	**$273**
9	COOLING WATER SYSTEM													
9.1	Cooling Towers	7,675	0	2,390	0	10,066	9.6%	963	0%	0	10.0%	1,103	12,131	22
9.2	Circulating Water Pumps	2,147	0	205	0	2,351	8.5%	199	0%	0	10.0%	255	2,806	5
9.3	Circ.Water System Auxiliaries	601	0	80	0	681	9.5%	65	0%	0	10.0%	75	821	1
9.4	Circ.Water Piping	0	4,765	4,618	0	9,383	9.4%	878	0%	0	15.0%	1,539	11,801	21
9.5	Make-up Water System	491	0	656	0	1,146	9.6%	110	0%	0	15.0%	188	1,445	3
9.6	Component Cooling Water Sys	475	0	378	0	854	9.5%	81	0%	0	15.0%	140	1,075	2
9.9	Circ.Water System Foundations& Structures	0	2,827	4,492	0	7,319	9.5%	692	0%	0	20.0%	1,602	9,613	18
	SUBTOTAL 9.	**$11,389**	**$7,592**	**$12,818**	**$0**	**$31,800**		**$2,988**		**$0**		**$4,903**	**$39,691**	**$72**
10	ASH/SPENT SORBENT HANDLING SYS													
10.1	Ash Coolers	N/A	0	N/A	0	0	0%	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%	0	0	0
10.3	HGCU Ash Letdown	N/A	0	N/A	0	0	0%	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%	0	0	0
10.5	Other Ash Recovery Equipment	N/A	0	N/A	0	0	0%	0	0%	0	0.0%	0	0	0
10.6	Ash Storage Silos	431	0	1,328	0	1,760	10%	173	0%	0	10.0%	193	2,126	4
10.7	Ash Transport & Feed Equipment	2,791	0	2,859	0	5,650	10%	540	0%	0	10.0%	619	6,809	12
10.8	Misc. Ash Handling Equipment	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
10.9	Ash/Spent Sorbent Foundation	0	102	121	0	223	9%	21	0%	0	20.0%	49	293	1
	SUBTOTAL 10.	**$3,222**	**$102**	**$4,308**	**$0**	**$7,633**		**$734**		**$0**		**$861**	**$9,228**	**$17**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case S22F - Oxy-Fuel Super-Critical CFB w/ CO2 Capture
Plant Size: 549.01 MW, net   Capital Charge Factor 0.175   Capacity Factor 0.85

Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

		Equipment		Labor		Bare Erected	Eng'g CM H.O. &		Process Cont.		Project Cont.		TOTAL PLANT COST	
Acct No.	**Item/Description**	**Cost**	**Material Cost**	**Direct**	**Indirect**	**Cost $**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**$**	**$/kW**
11	ACCESSORY ELECTRIC PLANT													
11.1	Generator Equipment	294	0	1,001	0	1,295	9.3%	120	0%	0	7.5%	106	1,521	3
11.2	Station Service Equipment	3,002	0	68	0	3,070	9.3%	287	0%	0	7.5%	252	3,609	7
11.3	Switchgear & Motor Control	14,364	0	406	0	14,770	9.3%	1,369	0%	0	10.0%	1,614	17,752	32
11.4	Conduit & Cable Tray	0	731	1,792	0	2,523	9.7%	244	0%	0	15.0%	415	3,182	6
11.5	Wire & Cable	35,614	14,169	41,388	0	91,171	8.4%	7,681	0%	0	15.0%	14,828	113,680	207
11.6	Protective Equipment	0	0	0	0	0	9.8%	0	0%	0	10.0%	0	0	0
11.7	Standby Equipment	1,413	0	32	0	1,445	9.2%	133	0%	0	10.0%	158	1,736	3
11.8	Main Power Transformers	948	0	27	0	975	7.6%	74	0%	0	10.0%	105	1,154	2
11.9	Electrical Foundations	0	363	889	0	1,252	9.6%	120	0%	0	20.0%	274	1,646	3
	SUBTOTAL 11.	**$55,636**	**$15,263**	**$45,603**	**$0**	**$116,501**		**$10,028**		**$0**		**$17,752**	**$144,280**	**$263**
12	INSTRUMENTATION & CONTROL													
12.1	PC Control Equipment	w/12.7	0	w/12.7	0	0	0%	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%	0	0	0
12.3	Steam Turbine Control	w/8.1	0	w/8.1	0	0	0%	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%	0	0	0
12.5	Signal Processing Equipment	W/12.7	0	w/12.7	0	0	0%	0	0%	0	0.0%	0	0	0
12.6	Control Boards,Panels & Racks	0	0	0	0	0	9%	0	0%	0	15.0%	0	0	0
12.7	Distributed Control System Equipment	0	96	1,910	0	2,006	9%	186	0%	0	10.0%	219	2,411	4
12.8	Instrument Wiring & Tubing	0	3,174	3,943	0	7,117	9%	607	0%	0	15.0%	1,159	8,882	16
12.9	Other I & C Equipment	3,818	0	3,765	0	7,584	10%	735	0%	0	10.0%	832	9,151	17
	SUBTOTAL 12.	**$3,818**	**$3,270**	**$9,618**	**$0**	**$16,706**		**$1,528**		**$0**		**$2,210**	**$20,444**	**$37**
13	IMPROVEMENTS TO SITE													
13.1	Site Preparation	0	57	1,144	0	1,202	9.9%	119	0%	0	20.0%	264	1,585	3
13.2	Site Improvements	0	1,900	2,359	0	4,259	9.9%	420	0%	0	20.0%	936	5,615	10
13.3	Site Facilities	3,404	0	3,357	0	6,762	9.9%	666	0%	0	20.0%	1,486	8,914	16
	SUBTOTAL 13.	**$3,404**	**$1,957**	**$6,861**	**$0**	**$12,223**		**$1,206**		**$0**		**$2,686**	**$16,114**	**$29**
14	BUILDINGS & STRUCTURES													
14.1	Boiler Building	0	9,853	8,665	0	18,518	9.0%	1,664	0%	0	15.0%	3,027	23,210	42
14.2	Turbine Building	0	13,015	12,130	0	25,145	9.0%	2,266	0%	0	15.0%	4,112	31,523	57
14.3	Administration Building	0	652	690	0	1,342	9.1%	122	0%	0	15.0%	220	1,683	3
14.4	Circulation Water Pumphouse	0	215	171	0	385	8.9%	34	0%	0	15.0%	63	483	1
14.5	Water Treatment Buildings	0	617	508	0	1,125	9.0%	101	0%	0	15.0%	184	1,410	3
14.6	Machine Shop	0	436	293	0	729	8.9%	65	0%	0	15.0%	119	913	2
14.7	Warehouse	0	296	297	0	592	9.0%	54	0%	0	15.0%	97	743	1
14.8	Other Buildings & Structures	0	242	206	0	447	9.0%	40	0%	0	15.0%	73	560	1
14.9	Waste Treating Building & Str.	0	444	1,348	0	1,792	9.5%	170	0%	0	15.0%	294	2,256	4
	SUBTOTAL 14.	**$0**	**$25,770**	**$24,307**	**$0**	**$50,077**		**$4,516**		**$0**		**$8,189**	**$62,782**	**$114**
	Total Cost	**$848,142**	**$121,418**	**$503,606**	**$0**	**$1,473,166**		**$105,243**		**$64,227**		**$164,379**	**$1,807,015**	**$3,291**

Exhibit 9-17 Case L22F Total Plant Costs

Department:	NETL Office of Systems Analysis and Planning
Project:	Oxy-Fuel Combustion Systems Analysis
Case:	Case L22F - Oxy-Fuel Super-Critical CFB w/ CO2 Capture
Plant Size:	549.73 MW, net
Capital Charge Factor	0.175
Capacity Factor	0.85
Cost Base:	Jan 2007
Prepared:	19-Sep-09
	x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor		Bare Erected Cost $	Eng'g CM H.O. &		Process Cont.		Project Cont.		TOTAL PLANT COST	
				Direct	Indirect		%	Total	%	Total	%	Total	$	$/kW
1	COAL HANDLING SYSTEM													
	SUBTOTAL 1.	**$26,169**	**$8,754**	**$15,730**	**$0**	**$50,653**		**$4,552**		**$0**		**$8,281**	**$63,485**	**$115**
2	COAL & SORBENT PREP & FEED													
	SUBTOTAL 2.	**$12,034**	**$70,532**	**$61,753**	**$0**	**$144,320**		**$13,298**		**$0**		**$23,643**	**$181,261**	**$330**
3	FEEDWATER & MISC. BOP SYSTEMS													
	SUBTOTAL 3.	**$109,265**	**$0**	**$52,053**	**$0**	**$161,319**		**$14,897**		**$0**		**$29,115**	**$205,331**	**$374**
4	CFB BOILER													
	SUBTOTAL 4.	**$539,783**	**$0**	**$274,265**	**$0**	**$814,049**		**$50,528**		**$78,097**		**$64,927**	**$1,007,601**	**$1,833**
5A	FLUE GAS CLEANUP						*							
	SUBTOTAL 5A.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
5B	CO2 REMOVAL & COMPRESSION													
	SUBTOTAL 5B.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
6	COMBUSTION TURBINE/ACCESSORIES													
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
	SUBTOTAL 7.	**$67,621**	**$0**	**$8,902**	**$0**	**$76,524**		**$2,179**		**$0**		**$3,984**	**$82,687**	**$150**
8	STEAM TURBINE GENERATOR													
	SUBTOTAL 8.	**$94,452**	**$1,329**	**$27,285**	**$0**	**$123,065**		**$11,342**		**$0**		**$15,897**	**$150,304**	**$273**
9	COOLING WATER SYSTEM													
	SUBTOTAL 9.	**$11,621**	**$8,035**	**$13,409**	**$0**	**$33,065**		**$3,106**		**$0**		**$5,122**	**$41,293**	**$75**
10	ASH/SPENT SORBENT HANDLING SYS													
	SUBTOTAL 10.	**$3,470**	**$110**	**$4,640**	**$0**	**$8,220**		**$790**		**$0**		**$927**	**$9,938**	**$18**
11	ACCESSORY ELECTRIC PLANT													
	SUBTOTAL 11.	**$55,909**	**$15,348**	**$45,853**	**$0**	**$117,110**		**$10,080**		**$0**		**$17,846**	**$145,037**	**$264**
12	INSTRUMENTATION & CONTROL													
	SUBTOTAL 12.	**$3,825**	**$3,276**	**$9,634**	**$0**	**$16,734**		**$1,530**		**$0**		**$2,213**	**$20,478**	**$37**
13	IMPROVEMENTS TO SITE													
	SUBTOTAL 13.	**$3,467**	**$1,993**	**$6,987**	**$0**	**$12,447**		**$1,228**		**$0**		**$2,735**	**$16,410**	**$30**
14	BUILDINGS & STRUCTURES													
	SUBTOTAL 14.	**$0**	**$25,955**	**$24,475**	**$0**	**$50,430**		**$4,548**		**$0**		**$8,247**	**$63,224**	**$115**
	Total Cost	**$927,617**	**$135,331**	**$544,987**	**$0**	**$1,607,935**		**$118,079**		**$78,097**		**$182,937**	**$1,987,048**	**$3,615**

Department:	NETL Office of Systems Analysis and Planning	**Cost Base:**	Jan 2007
Project:	Oxy-Fuel Combustion Systems Analysis	**Prepared:**	19-Sep-09
Case:	Case L22F - Oxy-Fuel Super-Critical CFB w/ CO2 Capture		**x $1, 000**
Plant Size:	549.73 MW, net Capital Charge Factor 0.175 Capacity Factor 0.85		

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
1	COAL HANDLING SYSTEM													
1.1	Coal Receive & Unload	5,704	0	2,605	0	8,309	8.9%	743	0%	0	15.0%	1,358	10,410	19
1.2	Coal Stackout & Reclaim	7,372	0	1,670	0	9,042	8.7%	791	0%	0	15.0%	1,475	11,308	21
1.3	Coal Conveyors	6,854	0	1,653	0	8,506	8.8%	745	0%	0	15.0%	1,388	10,640	19
1.4	Other Coal Handling	1,793	0	382	0	2,176	8.7%	190	0%	0	15.0%	355	2,720	5
1.5	Sorbent Receive & Unload	64	0	19	0	83	8.8%	7	0%	0	15.0%	14	104	0
1.6	Sorbent Stackout & Reclaim	1,030	0	383	0	1,413	8.7%	123	0%	0	15.0%	230	1,767	3
1.7	Sorbent Conveyors	367	1,069	89	0	1,526	8.6%	132	0%	0	15.0%	249	1,907	3
1.8	Other Sorbent Handling	2,986	700	116	0	3,801	8.8%	336	0%	0	15.0%	621	4,758	9
1.9	Coal & Sorbent Hnd.Foundations	0	6,985	8,812	0	15,797	9.4%	1,484	0%	0	15.0%	2,592	19,872	36
	SUBTOTAL 1.	**$26,169**	**$8,754**	**$15,730**	**$0**	**$50,653**		**$4,552**		**$0**		**$8,281**	**$63,485**	**$115**
2	COAL & SORBENT PREP & FEED													
2.1	Coal Crushing & Drying	3,380	0	659	0	4,039	8.7%	352	0%	0	15.0%	659	5,049	9
2.2	Coal Conveyor to Storage	8,654	0	1,889	0	10,543	8.7%	922	0%	0	15.0%	1,720	13,184	24
2.3	Coal Injection System	0	0	0	0	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	0.0%	0	0	0
2.5	Sorbent Prep Equipment	0	0	0	0	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	0.0%	0	0	0
2.7	Sorbent Injection System	0	0	0	0	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	0.0%	0	0	0
2.9	Coal & Sorbent Feed Foundation	0	70,532	59,206	0	129,738	9.3%	12,025	0%	0	15.0%	21,264	163,027	297
	SUBTOTAL 2.	**$12,034**	**$70,532**	**$61,753**	**$0**	**$144,320**		**$13,298**		**$0**		**$23,643**	**$181,261**	**$330**
3	FEEDWATER & MISC. BOP SYSTEMS													
3.1	FeedwaterSystem	37,586	0	12,141	0	49,727	8.7%	4,345	0%	0	15.0%	8,111	62,183	113
3.2	Water Makeup & Pretreating	4,284	0	1,379	0	5,663	9.5%	536	0%	0	20.0%	1,240	7,439	14
3.3	Other Feedwater Subsystems	11,507	0	4,863	0	16,370	9.0%	1,466	0%	0	15.0%	2,675	20,512	37
3.4	Service Water Systems	840	0	457	0	1,297	9.4%	122	0%	0	20.0%	284	1,702	3
3.5	Other Boiler Plant Systems	19,852	0	19,600	0	39,452	9.5%	3,747	0%	0	15.0%	6,480	49,679	90
3.6	FO Supply Sys & Nat Gas	3,030	0	3,787	0	6,817	9.4%	643	0%	0	15.0%	1,119	8,579	16
3.7	Waste Treatment Equipment	0	0	0	0	0	9.7%	0	0%	0	20.0%	0	0	0
3.8	Misc. Equip.(cranes,AirComp.,Comm.)	32,166	0	9,826	0	41,993	9.6%	4,038	0%	0	20.0%	9,206	55,236	100
	SUBTOTAL 3.	**$109,265**	**$0**	**$52,053**	**$0**	**$161,319**		**$14,897**		**$0**		**$29,115**	**$205,331**	**$374**
4	CFB BOILER													
4.1	CFB Boiler & Accesories	378,413	0	142,235	0	520,649	9.7%	50,528	15%	78,097	10.0%	64,927	714,201	1,299
4.2	ASU/Oxidant Compression	161,370	0	132,030	0	293,400	0.0%	0	0%	0	0.0%	0	293,400	534
4.3	Open	0	0	0	0	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	0.0%	0	0	0
4.5	Primary Air System	w/4.1	0	w/4.1	0	0	0.0%	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	0.0%	0	0	0
4.7	Major Component Rigging	0	w/4.1	w/4.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
4.8	CFB Foundations	0	w/14.1	w/14.1	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 4.	**$539,783**	**$0**	**$274,265**	**$0**	**$814,049**		**$50,528**		**$78,097**		**$64,927**	**$1,007,601**	**$1,833**
5A	FLUE GAS CLEANUP						*							
5.1	Absorber Vessels & Accessories	0	0	0	0	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	0.0%	0	0	0
5.3	Bag House & Accessories (Incl. w/ 4.1)	0	0	0	0	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	0.0%	0	0	0
5.5	Gypsum Dewatering System	0	0	0	0	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	0.0%	0	0	0
5.7	Open													
5.8	Open													
5.9	Open	0	0	0	0	0	0.0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 5A.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case L22F - Oxy-Fuel Super-Critical CFB w/ CO2 Capture
Plant Size: 549.73 MW, net Capital Charge Factor 0.175 Capacity Factor 0.85
Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & Fee %	Eng'g CM H.O. & Fee Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
5B	CO2 REMOVAL & COMPRESSION													
5B.1	CO2 Removal System	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
5B.2	CO2 Compression & Drying	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
5B.3	CO2 Pipeline													
5B.4	CO2 Storage													
5B.5	CO2 Monitoring													
	SUBTOTAL 5B.	**$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%	0	0	0
6.2	Combustion Turbine Accessories	0	0	0	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%	0	0	0
6.4	Combustion Turbine Foundations	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
	SUBTOTAL 6.	**$0**	**$0**	**$0**	**$0**	**$0**		**$0**		**$0**		**$0**	**$0**	**$0**
7	HRSG, DUCTING & STACK													
7.1	Heat Recovery Steam Generator	47,962	0	4,005	0	51,966	0%	0	0%	0	0.0%	0	51,966	95
7.2	HRSG Accessories	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
7.3	Ductwork	17,440	0	2,319	0	19,759	9%	1,723	0%	0	15.0%	3,222	24,704	45
7.4	Stack	839	0	1,797	0	2,636	10%	254	0%	0	10.0%	289	3,179	6
7.9	Duct & Stack Foundations	1,381	0	781	0	2,162	9%	202	0%	0	20.0%	473	2,838	5
	SUBTOTAL 7.	**$67,621**	**$0**	**$8,902**	**$0**	**$76,524**		**$2,179**		**$0**		**$3,984**	**$82,687**	**$150**
8	STEAM TURBINE GENERATOR													
8.1	Steam TG & Accessories	62,948	0	8,360	0	71,307	9.6%	6,834	0%	0	10.0%	7,814	85,956	156
8.2	Turbine Plant Auxiliaries	425	0	910	0	1,334	9.8%	131	0%	0	10.0%	146	1,611	3
8.3a	Condenser & Auxiliaries	5,367	0	3,238	0	8,605	9.6%	828	0%	0	10.0%	943	10,377	19
8.3b	Air Cooled Condenser						10.0%		0%		20.0%			
8.4	Steam Piping	25,712	0	12,678	0	38,390	8.4%	3,225	0%	0	15.0%	6,242	47,857	87
8.9	TG Foundations	0	1,329	2,100	0	3,429	9.5%	324	0%	0	20.0%	751	4,504	8
	SUBTOTAL 8.	**$94,452**	**$1,329**	**$27,285**	**$0**	**$123,065**		**$11,342**		**$0**		**$15,897**	**$150,304**	**$273**
9	COOLING WATER SYSTEM													
9.1	Cooling Towers	7,684	0	2,393	0	10,077	9.6%	964	0%	0	10.0%	1,104	12,145	22
9.2	Circulating Water Pumps	2,294	0	219	0	2,513	8.5%	213	0%	0	10.0%	273	2,998	5
9.3	Circ.Water System Auxiliaries	636	0	85	0	721	9.5%	69	0%	0	10.0%	79	868	2
9.4	Circ.Water Piping	0	5,043	4,888	0	9,931	9.4%	930	0%	0	15.0%	1,629	12,490	23
9.5	Make-up Water System	503	0	672	0	1,175	9.6%	113	0%	0	15.0%	193	1,481	3
9.6	Component Cooling Water Sys	503	0	400	0	903	9.5%	86	0%	0	15.0%	148	1,138	2
9.9	Circ.Water System Foundations& Structure	0	2,991	4,753	0	7,744	9.5%	733	0%	0	20.0%	1,695	10,172	19
	SUBTOTAL 9.	**$11,621**	**$8,035**	**$13,409**	**$0**	**$33,065**		**$3,106**		**$0**		**$5,122**	**$41,293**	**$75**
10	ASH/SPENT SORBENT HANDLING SYS													
10.1	Ash Coolers	N/A	0	N/A	0	0	0%	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%	0	0	0
10.3	HGCU Ash Letdown	N/A	0	N/A	0	0	0%	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%	0	0	0
10.5	Other Ash Recovery Equipment	N/A	0	N/A	0	0	0%	0	0%	0	0.0%	0	0	0
10.6	Ash Storage Silos	464	0	1,431	0	1,895	10%	186	0%	0	10.0%	208	2,289	4
10.7	Ash Transport & Feed Equipment	3,006	0	3,079	0	6,085	10%	582	0%	0	10.0%	667	7,333	13
10.8	Misc. Ash Handling Equipment	0	0	0	0	0	0%	0	0%	0	0.0%	0	0	0
10.9	Ash/Spent Sorbent Foundation	0	110	130	0	240	9%	23	0%	0	20.0%	53	315	1
	SUBTOTAL 10.	**$3,470**	**$110**	**$4,640**	**$0**	**$8,220**		**$790**		**$0**		**$927**	**$9,938**	**$18**

Department: NETL Office of Systems Analysis and Planning
Project: Oxy-Fuel Combustion Systems Analysis
Case: Case L22F - Oxy-Fuel Super-Critical CFB w/ CO2 Capture
Plant Size: 549.73 MW, net Capital Charge Factor 0.175 Capacity Factor 0.85
Cost Base: Jan 2007
Prepared: 19-Sep-09
x $1, 000

Acct No.	Item/Description	Equipment Cost	Material Cost	Labor Direct	Labor Indirect	Bare Erected Cost $	Eng'g CM H.O. & %	Eng'g CM H.O. & Total	Process Cont. %	Process Cont. Total	Project Cont. %	Project Cont. Total	TOTAL PLANT COST $	TOTAL PLANT COST $/kW
11	ACCESSORY ELECTRIC PLANT													
11.1	Generator Equipment	295	0	1,003	0	1,298	9.3%	120	0%	0	7.5%	106	1,525	3
11.2	Station Service Equipment	3,018	0	69	0	3,087	9.3%	289	0%	0	7.5%	253	3,629	7
11.3	Switchgear & Motor Control	14,445	0	408	0	14,853	9.3%	1,377	0%	0	10.0%	1,623	17,852	32
11.4	Conduit & Cable Tray	0	735	1,802	0	2,537	9.7%	246	0%	0	15.0%	417	3,200	6
11.5	Wire & Cable	35,815	14,249	41,621	0	91,684	8.4%	7,724	0%	0	15.0%	14,911	114,320	208
11.6	Protective Equipment	0	0	0	0	0	9.8%	0	0%	0	10.0%	0	0	0
11.7	Standby Equipment	1,416	0	32	0	1,448	9.2%	133	0%	0	10.0%	158	1,739	3
11.8	Main Power Transformers	920	0	26	0	946	7.6%	72	0%	0	10.0%	102	1,120	2
11.9	Electrical Foundations	0	364	892	0	1,256	9.6%	120	0%	0	20.0%	275	1,651	3
	SUBTOTAL 11.	**$55,909**	**$15,348**	**$45,853**	**$0**	**$117,110**		**$10,080**		**$0**		**$17,846**	**$145,037**	**$264**
12	INSTRUMENTATION & CONTROL													
12.1	PC Control Equipment	w/12.7	0	w/12.7	0	0	0%	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%	0	0	0
12.3	Steam Turbine Control	w/8.1	0	w/8.1	0	0	0%	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%	0	0	0
12.5	Signal Processing Equipment	W/12.7	0	w/12.7	0	0	0%	0	0%	0	0.0%	0	0	0
12.6	Control Boards,Panels & Racks	0	0	0	0	0	9%	0	0%	0	15.0%	0	0	0
12.7	Distributed Control System Equipment	0	96	1,913	0	2,009	9%	186	0%	0	10.0%	220	2,415	4
12.8	Instrument Wiring & Tubing	0	3,180	3,949	0	7,129	9%	608	0%	0	15.0%	1,160	8,897	16
12.9	Other I & C Equipment	3,825	0	3,772	0	7,596	10%	737	0%	0	10.0%	833	9,166	17
	SUBTOTAL 12.	**$3,825**	**$3,276**	**$9,634**	**$0**	**$16,734**		**$1,530**		**$0**		**$2,213**	**$20,478**	**$37**
13	IMPROVEMENTS TO SITE													
13.1	Site Preparation	0	58	1,165	0	1,224	9.9%	121	0%	0	20.0%	269	1,614	3
13.2	Site Improvements	0	1,935	2,403	0	4,337	9.9%	428	0%	0	20.0%	953	5,718	10
13.3	Site Facilities	3,467	0	3,419	0	6,886	9.9%	679	0%	0	20.0%	1,513	9,077	17
	SUBTOTAL 13.	**$3,467**	**$1,993**	**$6,987**	**$0**	**$12,447**		**$1,228**		**$0**		**$2,735**	**$16,410**	**$30**
14	BUILDINGS & STRUCTURES													
14.1	Boiler Building	0	9,898	8,705	0	18,603	9.0%	1,672	0%	0	15.0%	3,041	23,316	42
14.2	Turbine Building	0	13,110	12,219	0	25,329	9.0%	2,283	0%	0	15.0%	4,142	31,753	58
14.3	Administration Building	0	658	696	0	1,354	9.1%	123	0%	0	15.0%	222	1,699	3
14.4	Circulation Water Pumphouse	0	227	181	0	408	8.9%	36	0%	0	15.0%	67	511	1
14.5	Water Treatment Buildings	0	633	521	0	1,154	9.0%	103	0%	0	15.0%	189	1,447	3
14.6	Machine Shop	0	440	296	0	736	8.9%	65	0%	0	15.0%	120	922	2
14.7	Warehouse	0	298	299	0	598	9.0%	54	0%	0	15.0%	98	749	1
14.8	Other Buildings & Structures	0	244	208	0	451	9.0%	40	0%	0	15.0%	74	566	1
14.9	Waste Treating Building & Str.	0	445	1,351	0	1,797	9.5%	171	0%	0	15.0%	295	2,262	4
	SUBTOTAL 14.	**$0**	**$25,955**	**$24,475**	**$0**	**$50,430**		**$4,548**		**$0**		**$8,247**	**$63,224**	**$115**
	Total Cost	**$927,617**	**$135,331**	**$544,987**	**$0**	**$1,607,935**		**$118,079**		**$78,097**		**$182,937**	**$1,987,048**	**$3,615**

Exhibit 9-18 Case S22F Initial and Annual O&M Expense

INITIAL & ANNUAL O&M EXPENSES						
Case:	Case S22F - Oxy-Fuel Super-Critical CFB w/ CO2 Capture					
Plant Size (MWe):	549.01			**Heat Rate (Btu/kWh):**		11,321
Primary/Secondary Fuel:	Montana Rosebud PRB Coal			**Fuel Cost ($/MM Btu):**		0.76
Design/Construction	4 years			**Book Life (yrs):**		20
TPC (Plant Cost) Year:	Jan 2007			**TPI Year:**		2015
Capacity Factor (%):	85			**CO_2 Captured (TPD):**		0

OPERATING & MAINTENANCE LABOR						
Operating Labor						
Operating Labor Rate (base):		$33.00 $/hour				
Operating Labor Burden:		30.00 % of base				
Labor Overhead Charge:		25.00 % of labor				
Operating Labor Requirements per Shift:		**units/mod.**		**Total Plant**		
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 Operating Jobs		14.0		14.0		
					$	**$/kW-net**
Annual Operating Labor Cost (calc'd)					5,261,256	9.58
Maintenance Labor Cost (calc'd)					12,986,158	23.65
Administrative & Support Labor (calc'd)					4,561,853	8.31
					22,809,267	**41.55**

VARIABLE OPERATING COSTS						
					$	**$/kWh-net**
Maintenance Material Costs (calc'd)					**$19,479,237**	**0.00477**
Consumables	**Consumption**		**Unit**	**Initial**		
	Initial	**/Day**	**Cost**	**Cost**	**$**	**$/kWh-net**
Water (/1000 gallons)	0	5,992	1.03	$0	$1,914,665	0.00047
Chemicals						
MU & WT Chem. (lb)	203,023	29,003	0.16	$33,458	$1,482,913	0.00036
Limestone (ton)	904	129	20.60	$18,619	$825,214	0.00020
Carbon (Hg Removal) (lb)	0	0	1.00	$0	$0	0.00000
MEA Solvent (ton)	0	0	2142.40	$0	$0	0.00000
Caustic Soda, NaOH (ton)	0	0	412.96	$0	$0	0.00000
Sulfuric acid, H_2SO_4 (ton)	0	0	132.15	$0	$0	0.00000
Corrosion Inhibitor	0	0	0.00	$0	$0	0.00000
Activated C, MEA (lb)	0	0	1.00	$0	$0	0.00000
Ammonia, 28% soln (ton)	0	0	123.60	$0	$0	0.00000
Subtotal Chemicals				**$52,077**	**$2,308,127**	**0.00056**
Other						
Supplemental Fuel (MMBtu)	0	0	6.75	$0	$0	0.00000
SCR Catalyst Replacement (m^3)	w/equip.	0.0000	5500.00	$0	$0	0.00000
Emission Penalties	0	0	0.00	$0	$0	0.00000
Subtotal Other				**$0**	**$0**	**0.00000**
Waste Disposal						
Spent Mercury Catalyst (lb)	0	0	0.31	$0	$0	0.00000
Flyash (ton)	0	791	15.45	$0	$3,793,735	0.00093
Bottom Ash (ton)	0	133	15.45	$0	$636,603	0.00016
Subtotal Solid Waste Disposal				**$0**	**$4,430,338**	**0.00108**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	0.00000
Sulfur (tons)	0	0	0.00	$0	$0	0.00000
Subtotal By-Products				**$0**	**$0**	**0.00000**
TOTAL VARIABLE OPERATING COSTS					**$28,132,367**	**0.00688**
Coal FUEL (tons)	**261,265**	**8,709**	**12.96**	**$3,386,000**	**$35,016,881**	**0.00857**
NATURAL GAS FUEL (Mscf)	**0**	**0**	**6.93**	**$0**	**$0**	**0.00000**

Exhibit 9-19 Case S22F Capital Investment and Operating Cost Summary

CAPITAL INVESTMENT & REVENUE REQUIREMENT SUMMARY			
Case:	Case S22F - Oxy-Fuel Super-Critical CFB w/ CO2 Capture		
Plant Size (MWe):	549.01	**Heat Rate (Btu/kWh):**	11,321
Primary/Secondary Fuel:	Montana Rosebud PRB Coal	**Fuel Cost ($/MM Btu):**	0.76
Design/Construction	4 years	**Book Life (yrs):**	20
TPC (Plant Cost) Year:	Jan 2007	**TPI Year:**	2015
Capacity Factor (%):	85	**CO_2 Captured (TPD):**	0

CAPITAL INVESTMENT		**$x1000**		**$/kW**
Process Capital & Facilities		1,473,166		2,683
Engineering (incl. C.M., H.O. & Fee)		105,243		192
Process Contingency		64,227		117
Project Contingency		164,379		299.4
TOTAL PLANT COST (TPC)		**1,807,015**		**3,291.41**
OPERATING & MAINTENANCE COSTS (2007 Dollars)		**$x1000**		**$/kW**
Operating Labor		5,261		9.6
Maintenance Labor		12,986		23.7
Maintenance Material		19,479		35.5
Administrative & Support Labor		4,562		8.3
TOTAL OPERATION & MAINTENANCE		**42,289**		**77.03**
FIXED O&M			**41.55**	**$/kW-net**
VARIABLE O&M			**0.48**	**cents/kWh**
CONSUMABLE OPERATING COSTS, Less Fuel (2007 Dollars)		**$x1000**		**cents/kWh**
Water		$1,915		0.04684
Chemicals		$2,308		0.05646
Other Consumables		$0		0.00000
Waste Disposal		$4,430		0.10838
TOTAL CONSUMABLE OPERATING COSTS		**$8,653**		**0.21**
BY-PRODUCTS CREDITS (2007 Dollars)		**$0**		**0.00**
FUEL COST (2007 Dollars) Coal		**$35,017**		**0.86**
FUEL COST (2007 Dollars) Natural Gas		**$0**		**0.00**
PRODUCTION COST SUMMARY	LF		**cents/kWh**	
Fixed O & M	1.1607		0.65	
Variable O & M	1.1607		0.55	
Consumables	1.1607		0.25	
By-product Credit	1.1607		0.00	
Fuel (Coal)	1.1439		0.98	
Fuel (Natural Gas)	1.1607		0.00	
TOTAL PRODUCTION COST			**2.43**	
LEVELIZED CARRYING CHARGES (Capital)				
Fixed Charge Rate (%)	**17.5**		**7.74**	
20 YEAR LEVELIZED COST OF ELECTRICITY			**10.16**	**cents/kWh**

Exhibit 9-20 Case L22F Initial and Annual O&M Expense

INITIAL & ANNUAL O&M EXPENSES			
Case:	Case L22F - Oxy-Fuel Super-Critical CFB w/ CO2 Capture		
Plant Size (MWe):	549.73	**Heat Rate (Btu/kWh):**	11,682
Primary/Secondary Fuel:	North Dakota Lignite Coal	**Fuel Cost ($/MM Btu):**	0.90
Design/Construction	4 years	**Book Life (yrs):**	20
TPC (Plant Cost) Year:	Jan 2007	**TPI Year:**	2015
Capacity Factor (%):	85	**CO_2 Captured (TPD):**	15185

OPERATING & MAINTENANCE LABOR

Operating Labor

Operating Labor Rate (base):	$33.00	$/hour
Operating Labor Burden:	30.00	% of base
Labor Overhead Charge:	25.00	% of labor

Operating Labor Requirements per Shift:	units/mod.	Total Plant
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 Operating Jobs	14.0	14.0

	$	$/kW-net
Annual Operating Labor Cost (calc'd)	5,261,256	9.57
Maintenance Labor Cost (calc'd)	14,174,163	25.78
Administrative & Support Labor (calc'd)	4,858,855	8.84
	24,294,274	**44.19**

VARIABLE OPERATING COSTS

	$	$/kWh-net
Maintenance Material Costs (calc'd)	**$21,261,245**	**0.00519**

Consumables	**Consumption Initial**	**/Day**	**Unit Cost**	**Initial Cost**	**$**	**$/kWh-net**
Water (/1000 gallons)	0	5,992	1.03	$0	$1,914,665	0.00047
Chemicals						
MU & WT Chem. (lb)	203,023	29,003	0.16	$33,458	$1,482,913	0.00036
Limestone (ton)	904	129	20.60	$18,619	$825,214	0.00020
Carbon (Hg Removal) (lb)	0	0	1.00	$0	$0	0.00000
MEA Solvent (ton)	1,076	0	2142.40	$2,304,335	$0	0.00000
Caustic Soda, NaOH (ton)	0	0	412.96	$0	$0	0.00000
Sulfuric acid, H_2SO_4 (ton)	0	0	132.15	$0	$0	0.00000
Corrosion Inhibitor	0	0	0.00	$0	$0	0.00000
Activated C, MEA (lb)	0	0	1.00	$0	$0	0.00000
Ammonia, 28% soln (ton)	0	0	123.60	$0	$0	0.00000
Subtotal Chemicals				**$2,356,412**	**$2,308,127**	**0.00056**
Other						
Supplemental Fuel (MMBtu)	0	0	6.75	$0	$0	0.00000
SCR Catalyst Replacement (m^3)	w/equip.	0.0000	5500.00	$0	$0	0.00000
Emission Penalties	0	0	0.00	$0	$0	0.00000
Subtotal Other				**$0**	**$0**	**0.00000**
Waste Disposal						
Spent Mercury Catalyst (lb)	0	0	0.31	$0	$0	0.00000
Flyash (ton)	0	791	15.45	$0	$3,793,735	0.00093
Bottom Ash (ton)	0	133	15.45	$0	$636,603	0.00016
Subtotal Solid Waste Disposal				**$0**	**$4,430,338**	**0.00108**
By-products & Emissions						
Gypsum (tons)	0	0	0.00	$0	$0	0.00000
Sulfur (tons)	0	0	0.00	$0	$0	0.00000
Subtotal By-Products				**$0**	**$0**	**0.00000**
TOTAL VARIABLE OPERATING COSTS					**$29,914,375**	**0.00731**
Coal FUEL (tons)	**349,401**	**11,647**	**11.97**	**$4,182,333**	**$43,252,293**	**0.01057**
NATURAL GAS FUEL (Mscf)	**0**	**0**	**6.93**	**$0**	**$0**	**0.00000**

Exhibit 9-21 Case L22F Capital Investment and Operating Cost Summary

CAPITAL INVESTMENT & REVENUE REQUIREMENT SUMMARY			
Case:	Case L22F - Oxy-Fuel Super-Critical CFB w/ CO2 Capture		
Plant Size (MWe):	549.73	Heat Rate (Btu/kWh):	11,682
Primary/Secondary Fuel:	North Dakota Lignite Coal	Fuel Cost ($/MM Btu):	0.90
Design/Construction	4 years	Book Life (yrs):	20
TPC (Plant Cost) Year:	Jan 2007	TPI Year:	2015
Capacity Factor (%):	85	CO_2 **Captured (TPD):**	15,185

CAPITAL INVESTMENT	**$x1000**	**$/kW**
Process Capital & Facilities	1,607,935	2,925
Engineering (incl. C.M., H.O. & Fee)	118,079	215
Process Contingency	78,097	142
Project Contingency	182,937	332.8
TOTAL PLANT COST (TPC)	**1,987,048**	**3,614.59**

OPERATING & MAINTENANCE COSTS (2007 Dollars)	**$x1000**	**$/kW**
Operating Labor	5,261	9.6
Maintenance Labor	14,174	25.8
Maintenance Material	21,261	38.7
Administrative & Support Labor	4,859	8.8
TOTAL OPERATION & MAINTENANCE	**45,556**	**82.87**
FIXED O&M		**44.19 $/kW-net**
VARIABLE O&M		**0.52 cents/kWh**

CONSUMABLE OPERATING COSTS, Less Fuel (2007 Dollars)	**$x1000**	**cents/kWh**
Water	$1,915	0.04678
Chemicals	$2,308	0.05639
Other Consumables	$0	0.00000
Waste Disposal	$4,430	0.10823
TOTAL CONSUMABLE OPERATING COSTS	**$8,653**	**0.21**
BY-PRODUCTS CREDITS (2007 Dollars)	**$0**	**0.00**
FUEL COST (2007 Dollars) Coal	**$43,252**	**1.06**
FUEL COST (2007 Dollars) Natural Gas	**$0**	**0.00**

PRODUCTION COST SUMMARY	LF	**cents/kWh**	
Fixed O & M	1.1607	0.69	
Variable O & M	1.1607	0.60	
Consumables	1.1607	0.25	
By-product Credit	1.1607	0.00	
Fuel (Coal)	1.3561	1.43	
Fuel (Natural Gas)	1.1607	0.00	
TOTAL PRODUCTION COST		**2.97**	
LEVELIZED CARRYING CHARGES (Capital)			
Fixed Charge Rate (%)	**17.5**	**8.50**	
20 YEAR LEVELIZED COST OF ELECTRICITY		**11.47**	**cents/kWh**

9.4.2 Cost Estimate and Performance Summary for CFB Oxycombustion Cases

A summary of plant costs and performance for all of the cryogenic oxycombustion cases is shown in Exhibit 9-22, along with the base case (air-fired without capture), S12A.

Exhibit 9-22 Cost and Performance Results for Cryogenic Oxycombustion Cases

Case	S12A	S22F	L22F
Gross Power Output, MW_e	582.7	754.2	757.6
Net Power Output, MW_e	550.0	549.0	549.7
Net Plant Efficiency, % (HHV)	38.7	30.1	29.2
Net Plant Heat Rate, Btu/kWh (HHV)	8,822	11,321	11,682
Total Plant Cost, $x1000	1,018,074	1,916,379	2,100,531
Total Plant Cost, $/kW	1,851	3,491	3,821
CO_2 Capital Cost Penalty[a], $/kW	0.0	1,639.7	1,970.1
Levelized Cost of Electricity, ¢/kWh (85% Capacity Factor)	5.88	10.69	12.01
Levelized COE CO_2 Penalty[b], ¢/kWh (85% Capacity Factor)	0.00	4.81	6.13
Percent increase in COE[c], (85% Capacity Factor)	0.00%	54.27%	69.20%
Total CO_2 Emitted, lb/MWh_{net}	1,894	218	231
Cost of CO_2 Avoided[d], $/ton	--	57.3	73.7
Total CO_2 Captured, lb/MWh_{net}	0	2,170	2,302
Cost of CO_2 Captured[e], $/ton	--	44.3	53.2

a. CO_2 Capital Cost Penalty = TPC with capture – TPC case S12A air-fired without capture
b. CO_2 LCOE Cost Penalty = LCOE with capture – LCOE case S12A air-fired without capture
c. Relative to Case S12A ("Base Case")
d. CO_2 Cost Avoided = (COE with capture – COE without capture)/(Emissions without capture – Emissions with capture)
e. CO_2 Cost Captured (or Removal) = (COE with capture – COE without capture)/(CO_2 Captured)
Costs do not include CO_2 Transport, Storage, and Monitoring

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10. CONCLUSIONS

A techno-economic analysis of seventeen different plant designs was conducted to determine the technical and economic feasibility of various oxycombustion technologies. The key results of this analysis are as follows:

- Oxycombustion as a means of capturing and sequestering CO_2 significantly increases the cost of power production. The 20-year LCOE for oxycombustion cases is 58 to 78% higher than its equivalent air-fired case without CO_2 controls.
- Total plant capital (TPC) cost is the parameter that has the largest impact on LCOE. The TPC is 69 to 75% of the LCOE for all cases. For USC and SC cases, the TPC is 58 to 67% higher in the oxycombustion cases. For the CFBC, the TPC is 80 to 87% higher. The higher cost differential in the CFBC cases is attributable to higher process contingencies which are applied to account for the fact that SC CFBC has never been demonstrated at any size near commercial scale. If all contingencies are removed, the cost differential is reduced to 18 to 25% for USC and SC cases and 43-70% for CFBC cases. This cost differential is primarily the cost of capturing and compressing the CO_2 by adding an ASU, oxycombustor and CPU to the conventional air-fired unit design.
- The amount of energy consumed per unit of power produced is significantly higher in the oxycombustion cases. On average for all cases, adding CO_2 capture decreases plant energy efficiency by 7 to 9 absolute percentage points or ~21 percent on a relative basis as compared to an air-fired plant. For comparison, the energy efficiency penalty for CO_2 capture on an air-fired plant using an amine scrubbing system (post-combustion capture) is ~ 11 absolute percentage points or ~27 percent relative. Decreased energy efficiency increases the LCOE.
- Oxycombustion is a developing power technology; no oxycombustion plants have been built at commercial scale. Since CO_2 capture and sequestration increases the cost of power production regardless of plant design, the oxycombustion cost penalty shown here should not deter further research and development of oxycombustion technology. In particular, oxycombustion combined with co-sequestration of CO_2 and combustion products offers the potential to be less costly than alternative methods of CO_2 capture.
- Further oxycombustion research and development programs are recommended. These programs should focus on demonstrating oxycombustion at larger scale, on developing advanced boiler construction materials, on advanced systems to control flue gas recycle, and on overcoming obstacles to co-sequestration. Also recommended are programs to improve the performance and reduce the cost of ASU and CPU systems.

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11. REFERENCES

1. Ciferno, J.P., 5th Annual Conference on Carbon Caption & Sequestration (2006): "Market-Based Advanced Coal Power Systems
Comparison Study—CO_2 Capture Cases", Alexandria, WV.

2 Ciferno, J., "Pulverized Coal Oxycombustion Power Plants, Volume 1: Bituminous Coal to Electricity", DOE/NETL-2007/1291, (2008).

3. Karl, T.R., Trenberth, K.E. (2003). Modern Global Climate Change, Science, Vol 302, December 5, 2 003, pp. 1719-1723.

4. Houghton et al. {Eds} (2001). Climate Change 2001: The Scientific Basis, Cambridge University Press.

5. Greenhouse Gas Emissions Control by Oxygen Firing in Circulating Fluidized Bed Boilers, Phase 1-A Preliminary Systems Evaluation, ALSTOM Power Inc., Windsor, CT, US DOE NETL, Pittsburgh PA, May 2003.

6. Advanced Low/Zero Emission Boiler Design and Operation, Task 3 – Techno-Economic Study, American Air Liquide, Countryside Il, US DOE – NETL, Pittsburgh PA, November 2004, DE-FC26-02NT41586.

7. Oxy Combustion Processes for CO_2 Capture from Power Plants, IEA Greenhouse Gas R&D Programme, Prepared by MitsuiBabcock, Report 2005/0, July 2005.

8. Moritis, G., (2003). CO_2 Sequestration Adds New Dimension to Oil, Gas Production, Oil and Gas Journal, Vol. 101.9, March 3, 2003. 39-44.

9. Impact of Impurities on CO_2 Capture, Transport and Storage, IEA Greenhouse Gas R&D Programme, Prepared by SNC-Lavalin, Inc., Report Number PH4/32, August 2004.

10. Coal Specifications for Quality Guidelines, Revision 0, May 31, 2005.

11. "Annual Energy Outlook 2007 with Projections to 2030," AEO Reference Case Table 19, EIA, February 2007.

12. Personal Communication between John Wimer (NETL) and Diane Kearney (EIA), AEO 2007 Reference Case NEMS model forecasted average costs of delivering (transport cost only) to electric utilities in 2010, as shown in the AEO 2007 data provided by the EIA to NETL on March 30, 2007. (Source: aeo2007.d112106a).

13. 1999 Environmental Protection Agency Information Collection Request Database with Coal Compositions for Over 37,000 Samples.

14. "Protection of Environment." Code of Federal Regulations Title 40, PART 60—Standards of Performance for New Stationary Sources, Subpart Da—Standards of Performance for Electric Utility Steam Generating Units for Which Construction is Commenced After September 18, 1978; Source: 72 FR 32722, June 13, 2007; http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=5239e4e3a1684997ba0d06797c26b6ae&rgn=div6&view=text&node=40:6.0.1.1.1.10&idno=40.

15. US EPA Green Book Nonattainment Area Map, http://www.epa.gov/oar/oaqps/greenbk/mapnpoll.html.

16. Energy Information Administration, The Demonstrated Reserve Base, U.S. Coal Reserves: 1997, Update, February 1999, Figure 1,
http://www.eia.doe.gov/cneaf/coal/reserves/chapter1.html#chapter1a.html.

17. Montana Annual Precipitation, U.S. Department of Agriculture, Natural Resources Conservation Service, http://www.ncgc.nrcs.usda.gov/products/datasets/images/climate/maps/mt.jpg.

18. Documentation for EPA Base Case 2006 (V.3.0) Using the Integrated Planning Model, EPA, November 2006.

19. www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/PRBunit.html.

20. www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/pubs/42775/Q123106.pdf.

21. Pearson, Thomas E. and John C. Buschmann, "90's for the 90's: High Efficiency Dry Flue Gas Desulfurization", Power-GEN '95, Anaheim, CA, December 1995.

22. NETL Coal Plant Database, http://www.netl.doe.gov/energy-analyses/pubs/NETLCoalPowerPlantDatabase-PublicRelease100606.xls.

23. Texas Commission of Environmental Quality, An Order Denying the Application of Oak Grove Management Co., LLC for Proposed Air Permit No. 76474 and PSD-TX-1056, Docket No. 2006-0195-AIR, SOAH Docket No. 582-06-1502.

24. "State Agency Approves Permit for TXU Coal Plant," http://ktvt.iewatershed.com/index.php?pagename=news_070617_plant.

25. Kitto, J.B. and Stultz, S.C., Steam: Its Generation and Use, Edition 41, Baberton, OH, 2005.

26. Standalone Documentation for EPA Base Case 2004 (V.2.1.9) Using the Integrated Planning Model, EPA 430-R-05-011, September 2005.

27. www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/PRBunit.html.

28. www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/pubs/42775/Q123106.pdf.

29. Future CO_2 Capture Technology Options for the Canadian Market. Canadian Department for Business Enterprise & Regulation Reform, Report No. COAL R309 BERR/Pub URN 07/1251. March 2007.

30. Buhre, B.J.P., et. al., "Oxy-fuel combustion technology for coal-fired power generation," Progress in Energy and Combustion Science 2005, 31, 283-307.

31 "Impact of Impurities on CO_2 Capture, Transport and Storage", IEA Greenhouse Gas R&D Programme Report PH_4/32, August 2004.

32. Final Technical Report for the JEA Large-Scale CFB Combustion Demonstration Project, Prepared by Black & Veatch, DOE Cooperative Agreement Number DE-FC21-90MC27403, June 2005.

33. Venäläinen, Ilkka and Psik, Rafal, "460 MWe Supercritical CFB Boiler Design for Lagisza Power Plant".

34. Module 6: Air Pollutants and Control Techniques, (SNCR Control Efficiency) http://www.epa.gov/eogapti1/module6/nitrogen/control/control.htm.

35. North American Electric Reliability Council website, http://www.nerc.com/~gads/.

36. Cooling Tower Fundamentals, ed. John C. Hensley, 2nd Edition, The Marley Cooling Tower Company, Mission, Kansas, 1985.

37. Personal Correspondence with Frank Ortega, Product Manager – Dry Cooling, Thermal Engineering / GEA Power Cooling, Inc., September 2008.

38. "EPA Technical Development Document for the Final Regulations Addressing Cooling Water Intake Structures for New Facilities, EPA-821-R-01-036, November 2001.

39. Herzog, Howard J., "The Economics of CO_2 Separation and Capture," MIT Energy Laboratory.

40. Quality Guidelines for Energy System Studies, prepared by DOE NETL Office of Systems and Policy Support, June 4, 2003.

41. Association for the Advancement of Cost Engineering International, AACEI (1997). "Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries," AACE International Recommended Practice No. 18R-97 (revised June 15, 1998). http://www.aacei.org/technical/rps/18r-97.pdf.

42. Smith, Lawrence A., Gupta, Neeraj, Sass, Bruce M. and Bubenik, Thomas A., "Engineering and Economic Assessment of Carbon Dioxide Sequestration in Saline Formations," Battelle Memorial Institute, 2001.

43. Ciferno, Jared P. and McIlvried, Howard, "CO_2 Flow Modeling and Pipe Diameter Determination," February, 2003.

44. Economic Evaluation of CO2 Storage and Sink Enhancement Options, Tennessee Valley Authority, NETL and EPRI, December 2002.

45. "Overview of Monitoring Requirements for Geologic Storage Projects," International Energy Agency Greenhouse Gas R&D Programme, Report Number PH4/29, November 2004.

46. Power Systems Financial Model Version 5.0, September 2006.

47. Peter Wieslanger, Fabric Filters for Power Applications, ALSTOM Power Environmental Systems AB, 2000, www.power.alstom.com.

48. Sargent & Lundy LLC. "Dry Flue Gas Desulfurization Technology Evaluation" prepared for National Lime Association, September 2002.

49. Memorandum from William H. Maxwell (Energy Strategies Group, Office of Air Quality Planning and Standards, EPA) to Robert Wayland (Group Leader, Energy Strategies Group, Office of Quality Planning and Standards, EPA), "Revised New Source Performance Standards (NSPS) Statistical Analysis for Mercury Emissions," May 31, 2006.

50. Technical Specification and Cost Estimates, ALPC Reference No. 30258, Revision 1, American Air Liquide, Oxy-combustion Technology for CO_2 Capture in Pulverized Coal-Fired Boilers – DOE Project task 7, 13,745 MT/D Air Separation Unit, February 10, 2006.

51. Technical Specification and Cost Estimates, Revision 4, American Air Liquide, Pulverized Coal Oxy-Fuel System Analysis – DOE Project task 7, CO_2 Compression and Purification Unit, November 14, 2008.

52. Klaus M. Retzlaff, W. Anthony Ruegger, Steam Turbines for Ultrasupercritical Power Plants, GER-3 954A, GE Power Generation, 8/96.

53. "Oxyfuel Project Steam Conditions", NETL e-mail message dated 09/22/2005.

54. R.D. Hottenstine, N.A. Phillips, and R.L. Dail, Development Plan for Advanced Fossil Fuel Plants, prepared by Gilbert Associates, Inc. for EPRI, EPRI CS-4029, Final report, May 1985.

55. J. Hoffmann, Cost and Performance Baseline for Low Rank Coal Fossil Energy Plants Combustion Process Power Plants with and without CO_2 Capture, DOE/NETL-401/110409, November, 2009.

56. Jared Ciferno, Pulverized Coal Oxycombustion Power Plants, DOE/NETL-2007/1291, August, 2008.