U. S. Department of Energy

Contract: 89243319CFE000023 (Mod. 004)

Proposal: RFP 89243319RFE000015

Project Title:
Small-Scale Flexible Advanced Ultra-Supercritical Coal-Fired Power Plant with Integrated Carbon Capture

Pre-FEED Contract:
Coal-Based Power Plants of the Future – Cost Results Report, Concept 1

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Period of Performance: 4/15/2019 to 4/15/2020

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1 Concept Background

1.1 Coal-fired Power Plant Scope Description

The concept for the "Small-Scale Flexible Advanced Ultra-Supercritical Coal-Fired Power Plant" is a pulverized coal power plant with superheat (SH) temperature/reheat (RH) temperature/SH outlet pressure of 1202°F/1238°F/4800 psia (650°C/670°C/330 bar) steam conditions, capable of flexible and low-load operation, consistent with the stated goals of the Department of Energy's (DOE's) Coal FIRST (Flexible, Innovative, Resilient, Small, Transformative) initiative.

The major components of the plant include a pulverized coal-fired boiler in a close-coupled configuration; air quality control system (AQCS) consisting of an ultra-low NOx firing system, selective catalytic reduction (SCR) system for NOx control, dry scrubber/fabric filter for particulate matter (PM)/SO2/Hg/HCl control; an amine-based post combustion carbon capture system; and a synchronous steam turbine/generator. A block diagram of the overall plant (Concept 1) is shown in Figure 1. Note that the block diagram shows only the steam extractions for the carbon capture system for simplicity and clarity of the diagram. The boiler/AQCS, steam turbine and carbon capture sub-systems are discussed in more detail in the following sections.

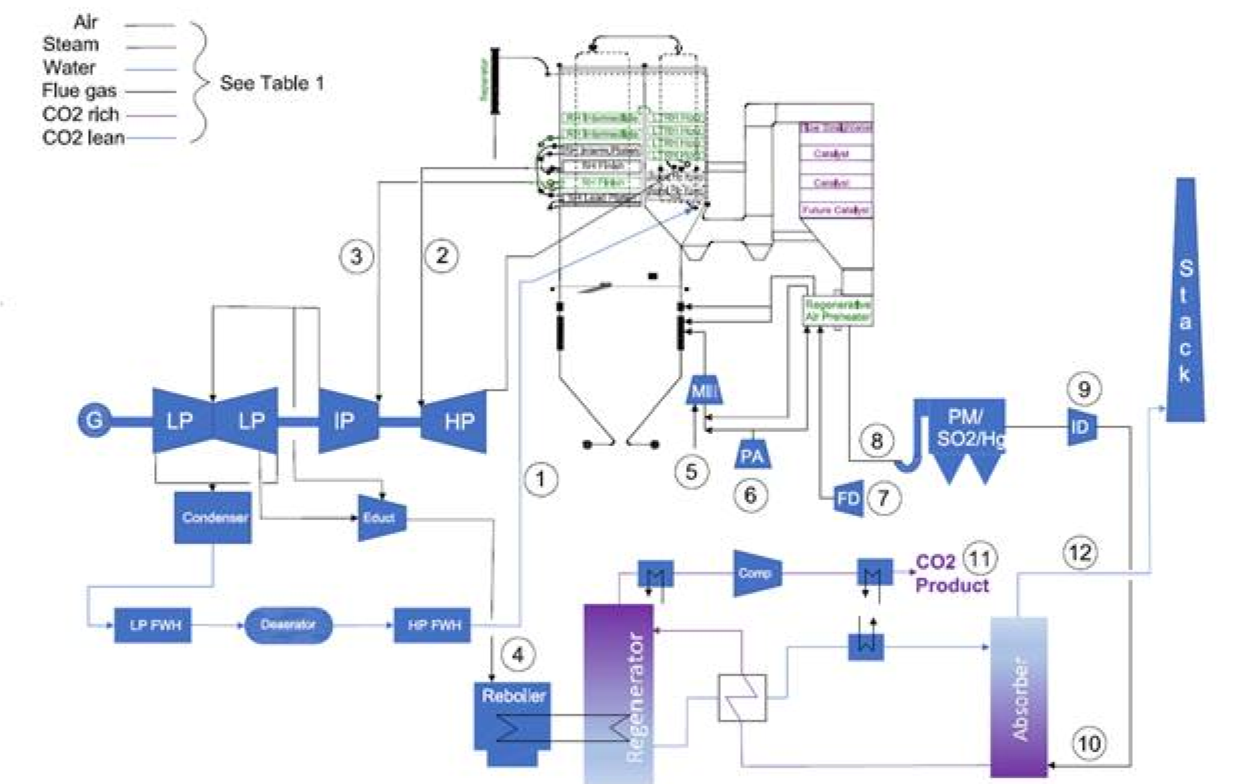


Figure 1-1 Concept 1 Block Diagram

1.2 Plant Capacity

The advanced ultra-supercritical (AUSC) coal plant steam cycle has a gross generation capacity of 300 MW in the illustrated (Concept 1) configuration. Because of the auxiliary load requirements and process steam extractions, the AUSC coal plant has a net generation capacity of 227 MW for Concept 1.

This small, flexible AUSC boiler concept was chosen because it is a reasonable compromise between the DOE goals of small plant MW capacity and high plant net efficiency. An AUSC turbine island smaller than 300 MW gross would require decreasing main steam temperature and pressure to maintain the minimum steam volumetric flow rate at the HP turbine inlet geometry required for minimum bucket lengths and nozzle carrier clearances.

Overall generation capacities of the power plant are 300 MW gross / 227 MW net for Concept 1.

1.3 Plant Location

The plant location is assumed to be a 300 acre greenfield site in the Midwestern U.S. with level topography. Coal is supplied by rail or truck delivery, and natural gas is supplied by pipeline. Fly ash and bottom ash disposal is off-site. Plant water needs are assumed to be 50% from municipal water supply and 50% from ground water.

1.3.1 Estimated Cost of Electricity of Concept 1

The cost of electricity for Concept 1 was estimated using the methodology outlined in the DOE / National Technology Laboratory (NETL) report titled “Quality Guidelines for Energy System Studies - Cost Estimation Methodology for NETL Assessments of Power Plant Performance, September 2019”. The cost of electricity for Concept 1 was compared to earlier DOE/NETL Low Rank Baseline cases both without and with CO_2 capture system (CCS). These cases included supercritical pulverized coal (SCPC) with post-combustion CO_2 capture (Case S12B) and atmospheric oxy-combustion (Case S12F). The costs for these Low Rank Baseline cases were escalated to bring them up to 2020 dollars. The cost of $2.23/MMBtu for PRB coal delivered to the mid-west plant site was taken from the DOE/NETL report titled “Quality Guidelines for Energy System Studies - Fuel Prices for Selected Feedstocks in NETL Studies, January 2019”. Table 1 summarizes the costs of electricity for all cases.

Table 1 Cost of Electricity Comparisons ($/MWh)

Case	S12A SCPC	S12B SCPC w/CCS	S12F Atm Oxy	AUSC PC	Concept 1
Capital	32.2	56.7	54.4	34.4	66.0
FOM	11.3	18.6	17.7	12.9	23.6
VOM	7.0	12.8	10.6	7.9	14.8
Fuel	19.7	28.2	24.6	18.4	22.5
CO_2 Transport & Storage	-	11.1	9.6	-	8.9
Cost of Electricity, $/MWh	70.2	127.3	116.9	73.6	135.8

It is important to note that the plant sizes for the DOE/NETL Low Rank Coal Baseline cases are 550 MW net, while the net power outputs of the AUSC PC (no carbon capture) and Concept 1 (integrated carbon capture) are 284 and 227 MW net, respectively.

Figure 1 provides an illustrative comparison of the components of the cost of electricity for the above cases.

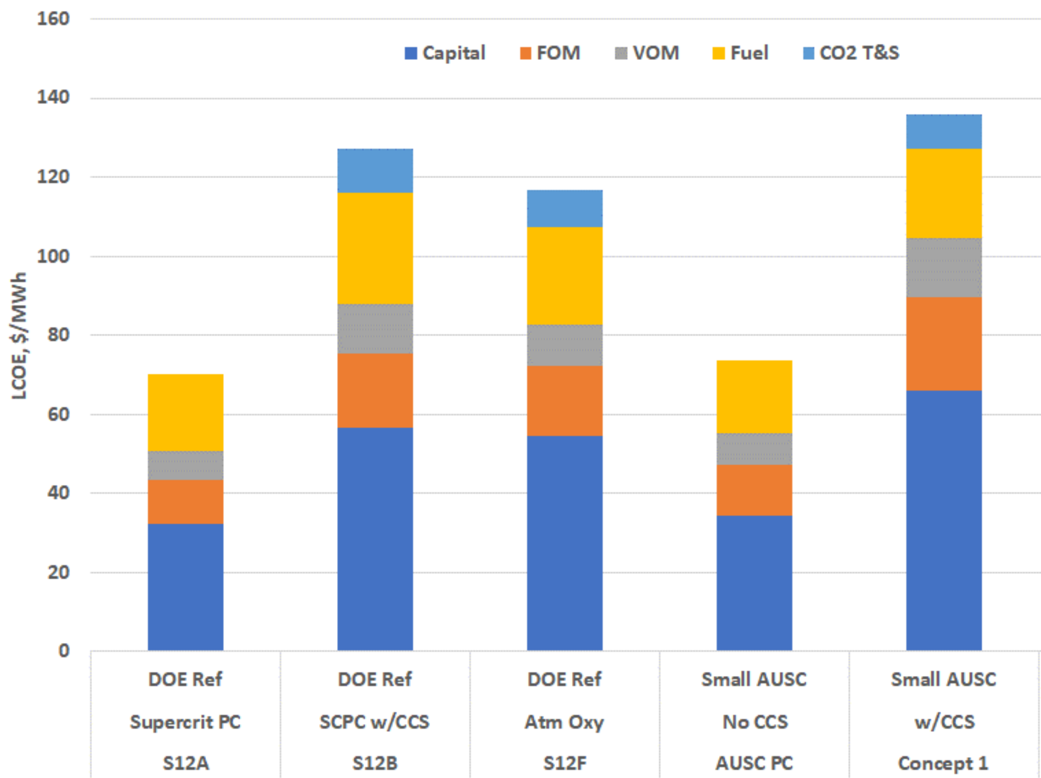


Figure 1 Cost of Electricity Comparisons

2 Plant Description

2.1 Proposed Plant Concept for the Cost Study

Concept 1 for the "Small-Scale Flexible Advanced Ultra-Supercritical Coal-Fired Power Plant" is a pulverized coal power plant with SH temperature/RH temperature/SH outlet pressure of 1202°F/1238°F/4800 psia (650°C/670°C/330 bar) steam conditions, with appropriate turbine steam extractions for carbon capture system process steam demand.

The power plant concepts being proposed provide enhanced cycling flexibility for an optimized operation regime for transient operation (i.e., faster start-up and load changes) and allow for flexible response to grid requirements, savings at start-up of initial power and thermal power consumption, and a more agile power plant that can provide more opportunities to bid in competitive power markets. These plant concepts incorporate stringent grid code compliance with dynamic cycles developed for optimal primary, secondary, and tertiary frequency support, minimum-load operation on coal or coal and auxiliary fuel at lowest cost, ability to reduce start-up times, ramp-up times to maximize dispatch times, and automatic switchover between operating modes for better dispatch.

This section lists how the small-scale flexible AUSC coal power plant concept described in this Design Basis Report meets the traits enumerated in RFP 89243319RFE000015.

- High overall plant efficiency (40%+ HHV or higher at full load, with minimal reductions in efficiency over the required generation range). The Concept 1, presented herein, achieves 33.8% net plant efficiency with integration of carbon capture, which is slightly higher than the average efficiency of the US coal fleet without CO_2 capture. As part of the present Pre-FEED study, and separately reported, a natural gas fired combined cycle plant may be used to provide a separate steam supply to the CCS (Concept 2). By supplying process steam with a gas turbine/heat recovery boiler system, Concept 2 achieves an overall 38.3% net plant efficiency with integration of carbon capture for both the AUSC coal boiler and gas turbine systems. Concept 2 achieves an AUSC coal boiler net plant efficiency of 41.3% at full load (276 MW net), while the simple cycle gas turbine and heat recovery boiler net system efficiency is 30.6% at full load (110.6 MW net).
- Modular (unit sizes of approximately 50 to 350 MW), maximizing the benefits of high-quality, low-cost shop fabrication to minimize field construction costs and project cycle time. The concept is 300 MW gross capacity and incorporates shop modularization of selected boiler convective pass, AQCS and steam turbine components.
- Near-zero emissions, with options to consider plant designs that inherently emit no or low amounts of carbon dioxide (amounts that are equal to or lower than natural gas technologies) or could be retrofitted with carbon capture without significant plant modifications. The concept includes selective catalytic reduction for NO_x control and a NID™ dry scrubber/fabric filter for particulate matter, SO_2, mercury and acid gas control. The concept also includes post-combustion capture for CO_2 control, with 90% carbon capture rate for both the AUSC coal boiler and the gas turbine/heat recovery boiler.
- The overall plant must be capable of high ramp rates and achieve minimum loads commensurate with estimates of renewable market penetration by 2050. The conceptual boiler design for Concept 1 includes use of nickel-based superalloys for selected thick walled components to minimize thermal stress during load cycling, and digital solutions to help achieve the target ramp rates. GE is developing digital technologies to assist existing units in achieving reduced minimum load of 20% (60 MW gross for Concept 1) or lower. One western US utility has achieved 15-18% minimum load with use of a digital product Digital Boiler + that is under active development.
- Minimized water consumption. This is addressed by use of GE's NID™ technology for flue gas desulfurization. Various waste water stream integration techniques are also used.
- Reduced design, construction, and commissioning schedules from conventional norms by leveraging techniques including but not limited to advanced process engineering and parametric design methods. This is addressed by modular shop fabrication concepts for selected boiler convective pass assemblies, the NID™ system, and steam turbine modules.
- Enhanced maintenance features including technology advances with monitoring and diagnostics to reduce maintenance and minimize forced outages. This is addressed by including GE's digital tools for condition monitoring and asset management.

- Integration with coal upgrading, or other plant value streams (e.g., co-production). This is not addressed by the present concept.
- Capable of natural gas co-firing. This concept includes side horn gas ignitors for up to 10% natural gas cofiring of the AUSC coal boiler on a heat input basis.

The carbon capture plant (CCP) would have flexibility in terms of flue gas flow capacity (operating range) and with regards to different fuels for the AUSC coal power plant, as long as the flue gas CO_2 concentration to the CCP is close to the design case. The typical standard operating range for the CCP is approximately 50-60% of design capacity, while the best operating performance is typically at 100% capacity (at highest efficiency). Therefore, turndown is often combined with operation below the highest efficiency point. Lower turndown operation (< 50 %) may require additional design features, such as:

- Specific recycle arrangements for compressor and pump systems
- Multiple parallel equipment arrangement (for one service), so that partial stream flow capacity can be turned off, while the remaining equipment remains in operation
- Disproportional turndown strategy for the core absorption/regeneration cycle (this means turndown of solvent circulation lower than capacity reduction of the flue gas feed to the CCP).

Thus, the required turndown for the power plant with its full environmental compliance of 5:1, means an operational range for the CCP of 20% to design capacity is expected to be achievable.

The required start-up time for the power plant from cold conditions is 4 hours and from warm conditions is 2 hours, respectively. The CCP design allows for transient operating flue gas flow changes, e.g. during start-up or shut-down of power plant. Previous test runs performed by GE at pilot-scale showed a fast response of the CCP design as proposed to changes in load.

For the CCP a bypass for the flue gas feed to the stack is recommended, which would allow the power plant to ramp up/down at a different ramp rate or with different cold/warm start duration than the CCP. Also, the reduction of steam flow from the power plant to the CCP Regenerator Reboiler is an option to generate more electrical power during transient operations, with resulting reduced CO_2 capture rate.

The proposed steam turbine concept combines the existing capabilities of the GE USC modular steam turbine product platform with the use of high temperature materials, scaled to a plant size normally associated with much lower steam conditions.

A schematic of the water steam cycle for the AUSC steam turbine with no steam extractions is shown in Figure 2.1.

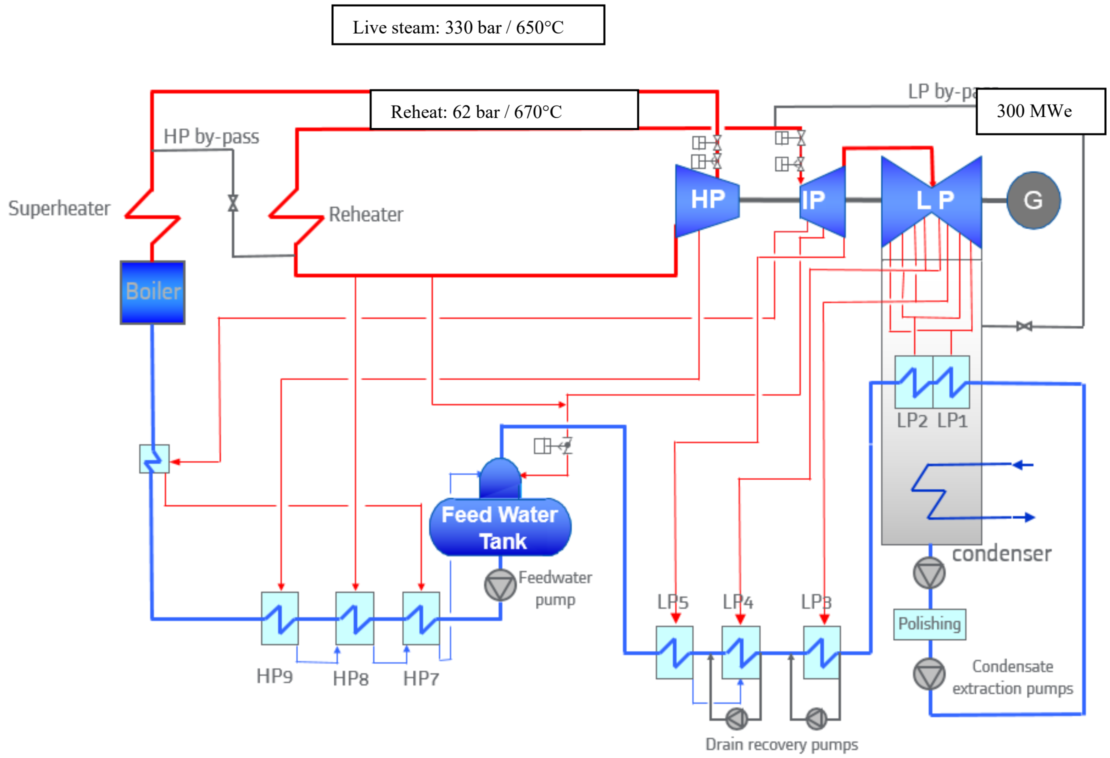
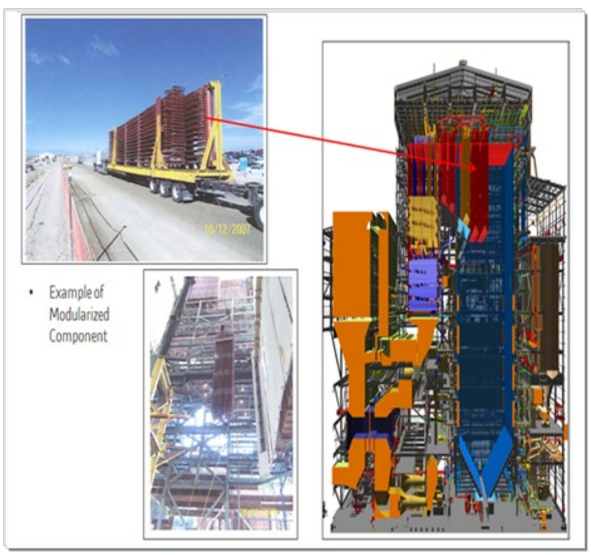


Figure 2-1 Water Steam Cycle Schematic



The boiler will use pressure part designs that are modularized, an example of which is shown in Figure 2-2. Fabrication of pressure part modules in the shop has several benefits. It reduces tube welds in on site, more difficult welds are performed more easily in the shop, and header girth welds can be done in the shop with automated machines while achieving a 0% rejection rate.

Figure 2-2 Example of Pressure Part Modularization

Ground modularization on site during construction of components that would be too large to ship effectively if they were shop modularized will be utilized, an example of which is shown in Figure 2-3. Ground modularization reduces the total number of pressure part lifts thus reducing schedule and allows more difficult welds to be performed more easily. Utilizing standard design modules for piping skids and instrument racks increases the flexibility schedule for design releases, fabrication releases, and erection sequencing. This allows for early turnover to electrical trades to complete and start the cold commissioning process.

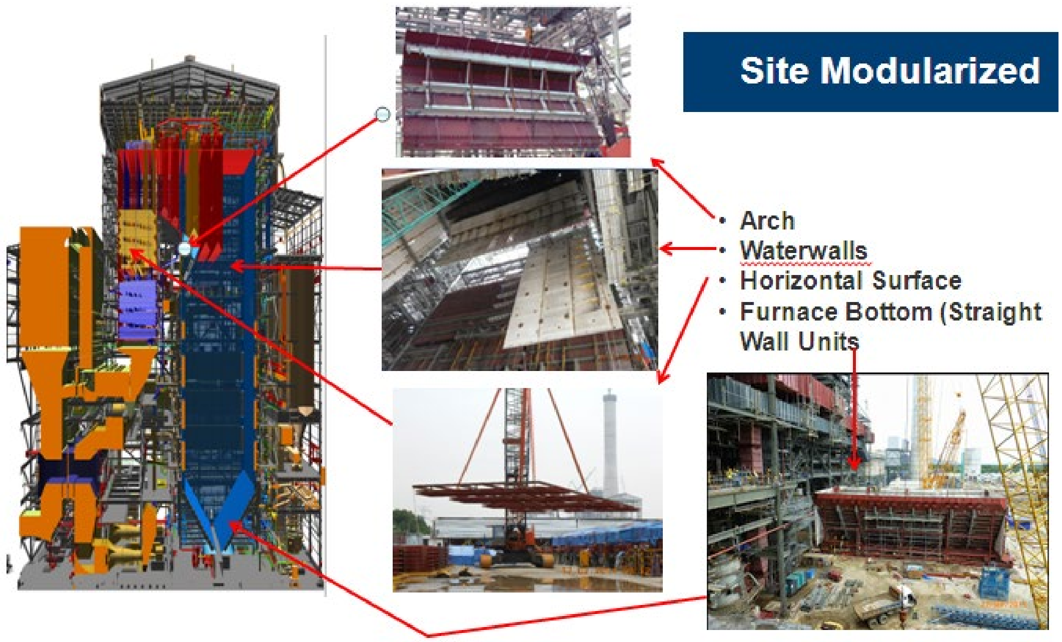


Figure 2-3 Examples of Ground Modularization

The proven modular steam turbine platform combines many design features supporting the evolution to more advanced and efficient steam cycles. Some of the features are unique to GE steam turbines and represent the best design practices developed over decades. These can be summarised as follows:

- Separated high pressure and intermediate pressure turbine modules using multiple shell casing design, with inner and outer casings cascading high temperature differences over several shells.
- Disk-type welded turbine rotors to apply new materials to the hottest and most exposed rotor sections. The optimised composition of materials in each rotor supports high operational flexibility combined with competitive product life time.
- Robust, multiple stage reaction type blading is used to moderate the pressure/ temperature drop per stage. Best suited steel alloys are available to off-set the stage specific stress levels.
- A consequent compact steam turbine and turbo-generator design in combination with the proven single bearing concept (single bearings between adjacent modules) minimises the overall shaft length.
- GE's pre-engineered and efficient low pressure steam turbine platform also offers sideways or downward exhausting steam designs to support optimised arrangement concepts and turbine hall layouts. (see Figure 2-4 and Figure 2-5)

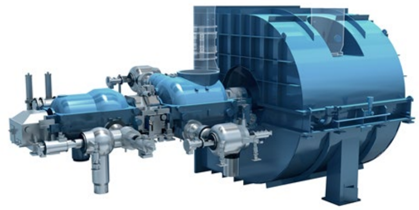


Figure 2-4 Steam Turbine Train (side exhaust option)

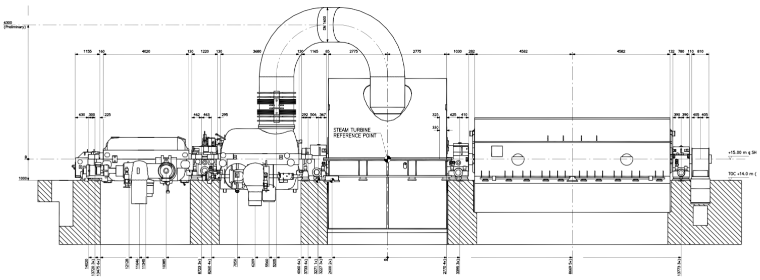


Figure 2-5 Steam Turbine Train Including Generator (downwards exhaust option)

Representative small USC HP and IP turbine modules are shown in Figure 2-6 and figure 2-7. These modules are shop assembled and transported to site as modular units.

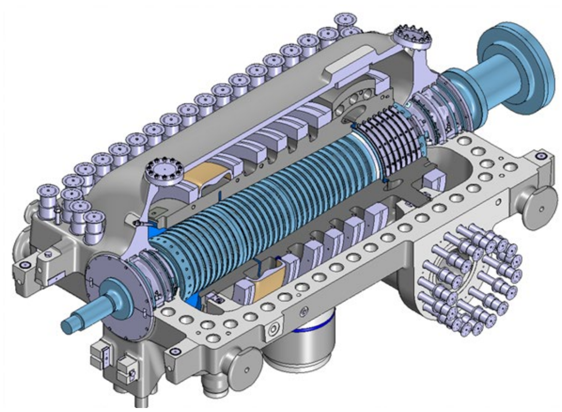


Figure 2-6 Small USC HP Turbine Module

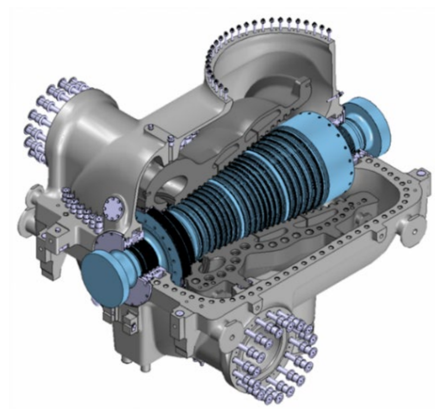


Figure 2-7 Small USC IP Turbine Module

A representative small USC LP turbine module is shown in Figure 2-8. These modules are shop assembled and transported to site as modular units.

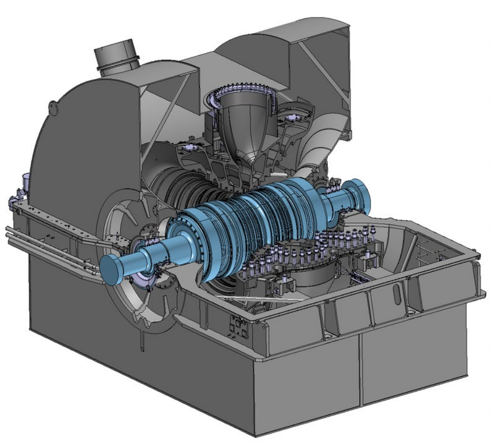


Figure 2-8 Representative LP Turbine Module (downwards exhaust option)

3 AECOM Cost Estimate for the EPC

3.1 Purpose

Electric Power Research Institute (EPRI) has contracted AECOM to prepare Engineering, Procurement and Construction (EPC) cost estimates for concept power plants. One estimate would be for a 309 MW Advanced Ultra-Supercritical Coal-Fired (AUSC) Power Plant and the other estimate would be for a 278 MW AUSC power plant with an integrated carbon capture system (CCS). The estimates have been developed to a Class 4 accuracy as defined by the Association for the Advancement of Cost Engineering (AACE), with an accuracy range of -30% to +40%. The AACE estimate accuracy graph is shown in Figure 3.1.

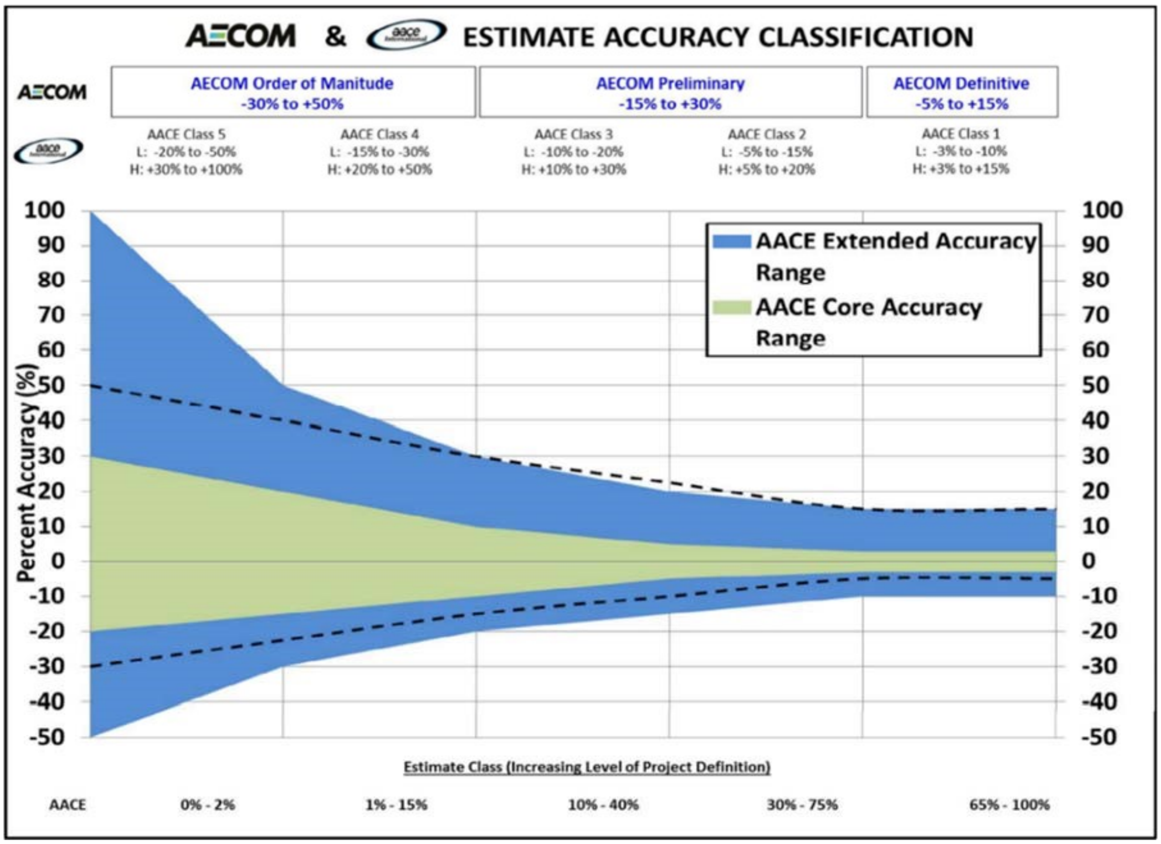


Figure 3.1 AACE Estimate Accuracy Classification

3.2 Basis

The Class 4 estimates include Engineering, Procurement, Construction (EPC) plus scope and costs by others to represent an EPC Total Installed Cost (TIC) estimate through start-up and commissioning. The estimates are based on preliminary engineering deliverables.

The cost estimates have been prepared for the following cases:

1. 309 MW gross / 284 MW net Advanced Ultra-supercritical Coal-Fired (AUSC) power plant, without CCS.
2. 278 MW gross / 227 MW net Advanced Ultra-supercritical Coal-Fired (AUSC) power plant, with integrated CCS.

The plant location for each case is assumed to be in the midwestern United States.

The main sources used to develop the Class 4 estimates include the following:

1. Recently published data from the National Energy Technology Laboratory (NETL)
2. Recently published data from the U.S. Energy Information Administration (EIA)
3. Recommended Practices from AACE organization
4. AECOM's experience in the power industry
5. Equipment information provided by General Electric (GE)

The guidelines established by NETL and EIA for cost estimation and scaling were used as the basis for the estimates. The final estimates were adjusted using information provided from previous similar AECOM power projects.

The 309 and 278 MW gross plants estimated were scaled down using the plant data presented in the NETL guidelines. In addition, the EIA published information was also used and compared to the NETL guidelines. The results were very similar. NETL guidelines included a 685 MW gross (650 MW net) supercritical (SC) coal-fired power plant and a 776 MW gross (650 MW net) SC coal-fired power plant with CCS. The EIA information included a 735 MW gross (650 MW net) Ultra-Supercritical (USC) coal-fired power plant and an 831 MW gross (650 MW net) USC coal-fired power plant with CCS.

The NETL information was based on a midwestern United States location. No location factoring was required for the Class 4 estimates. The EIA information was for an average greenfield site across the United States. The EIA data included location factors for 64 cities. Cincinnati, Ohio was chosen as a midwestern city using the EIA data for comparison.

A "Capacity Factored" estimating method was used, following the recommendations of the AACE International Recommended Practices. Pricing was then reviewed an adjusted to reflect data from previous AECOM power plant work. The summary estimates include pricing for equipment, material and labor for the published plants. Also, cost scaling for each of the cost breakdown categories was used per the formula below.

$$\text{Plant/Equipment Cost}_A = \text{Plant/Equipment Cost}_B \text{ X } (\text{Capacity}_A / \text{Capacity}_B)^{exp}$$

The plant/equipment costs and exponents used were initially those established by the NETL guidelines. To better represent the AUSC power plants and AECOM experience some of the capacities and exponents were revised.

The NETL data was based on a SC Coal-Fired Power Plants. The EIA data was based on USC Coal-Fired Power Plants. The Class 4 estimates were for AUSC Power Plants. The AUSC plant may require a higher grade of steam piping. This detail will be determined in a detail estimate where the design is further along. The steam piping material difference between the 3 plants was considered well within the Class 4 margins of accuracy.

The Summary Estimates included the information provided by GE for the Owner Furnished Equipment (OFE) costs.

The following information was provided by GE for the plant equipment cost.

1 Boiler and AQCS $225,000,000

2 Turbine $15,000,000

3 CCS $254,000,000

The equipment used in the capacity factored estimate was replaced with the above GE provide equipment. Labor to install the GE equipment was included in the Class 4 estimates. GE's AQCS equipment included a Novel Integrated Desulfurization (NID) System (dry scrubber). The NETL data included a Wet Flue Gas Desulfurization (WFGD) Unit. Dry scrubbing eliminated the need for labor, equipment and materials for the following equipment; sorbent receiving, sorbent unloading, sorbent preparation, WFGD absorber vessel, gypsum dewatering and spray dryer evaporator.

3.3 Estimate Detail

An estimate breakout for direct construction labor, plant equipment, material, construction equipment, indirect construction labor, expenses, construction management, engineering, startup, insurance, G&A and Fee was developed based on AECOM previous similar power projects.

Total Project Cost

The total project cost includes the following

1. Total Installed Cost
    a. Direct Field Cost
    b. Indirect Field Cost
    c. Home Office Cost
2. Insurance

3. G&A
4. Fee

Each item is detailed below.

Direct Field Cost

The direct field cost portion of the estimate includes following cost breakdown for labor and materials.

1. Site Development
2. Concrete
3. Structures
4. Balance of Plant (BOP) Equipment & Owner Furnished Equipment (OFE) Equipment Labor
5. Piping
6. Electrical
7. Instrumentation and Controls
8. Buildings

Indirect Field Cost & Home Office

The indirect field cost portion of the estimate includes the following.

1. Field Indirect Labor and Materials (including Facilities)
2. Construction Equipment

Home Office Cost

The home office cost includes the following,

1. Construction Management Staff & Services
2. Engineering
3. Startup and Commissioning

Insurance

Insurance is primarily the AECOM domestic package for field work and home office work. AECOM construction labor rates include workers compensation rates.

G&A

A percentage of 5% was set as the G&A rate.

Fee

A percentage of 8% was set as the Fee rate.

Reference Documents and Resources:

The following documents and resources were used to develop the estimate summary and estimate detail.

1. U.S. Department of Energy, National Energy Technology Laboratory, "Cost and Performance for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity", September 24, 2019
2. U.S. Department of Energy, National Energy Technology Laboratory, "Quality Guidelines for Energy System Studies, Capital Cost Scaling Methodology: Revision 4 Report", October 2019
3. U.S. Department of Energy, National Energy Technology Laboratory, "Quality Guidelines for Energy Systems Studies Cost Estimation Methodology for NETL Assessments of Power Plant Performance", September 6, 2019
4. U.S. Energy Information Administration, "Capital Cost and Performance Characteristic Estimates for Utility Scale Electric Power Generating Technologies", February 2020
5. AACE International, "Recommended Practice 58R-10, Escalation Estimating Principles and Methods Using Indices", May 25, 2011
6. AACE International, "Recommended Practice 59R-10, Development of Factored Cost Estimates – As Applied in Engineering, Procurement, and Construction for the Process Industries", June 18, 2011
7. U.S. Department of Labor, "Bureau of Labor Statistics, Consumer Price Index", January 2020

Please note that the cost estimates provided herein are dependent upon the various underlying assumptions, inclusions, and exclusions utilized in developing them. Actual project costs will differ, and can be significantly affected by factors such as changes in the external environment, the manner in which the project is implemented, and other factors which impact the estimate basis or otherwise affect the project. Estimate accuracy ranges are only projections based upon cost estimating methods and are not a guarantee of actual project costs.

Estimate Detail Breakout

A further breakout for direct construction labor, material, construction equipment,

Expenses and Subcontracts was developed using the AACE International

Recommended Practices for Estimating. Each power plant type (AUSC and AUSC with CCS) was estimated separately which added two additional estimates to the Summary estimate which included both plants.

3.4 Civil / Structural / Architectural (C/S/A)

The C/S/A portion of the estimate was broken down using the AACE International Recommend Practices and AECOM's power industry experience. The cost of labor and materials was developed for each of the following:

1. Site Development
2. Concrete
3. Structures
4. Buildings
5. Painting

3.5 Mechanical

The Mechanical portion of the estimate was broken down using the information supplied by GE for owner furnished equipment (OFE), AACE International Recommend Practices and AECOM's power industry experience. The cost of labor and materials was developed for each of the following:

1. Owner Furnished Equipment
    a. GE Boiler & AQCS equipment
    b. Turbine
    c. CCS
2. Balance of Plant (BOP) Mechanical
    a. BOP Equipment
    b. Piping
    c. Insulation

3.6 Electrical / Instrumentation & Controls (I&C)

The Electrical / I&C portion of the estimate was broken down using the AACE International Recommend Practices and AECOM's power industry experience. The cost of labor and materials was developed for each of the following:

1. Main Power System
2. Auxiliary Power System
3. BOP Electrical
4. Instrumentation
5. Substation & Switchyard

4 Project Indirect Cost

The Indirect Project Cost portion of the estimate was broken down using the AACE International Recommend Practices and AECOM's power industry experience. The breakout included the cost of labor, materials, construction equipment and expense.

The project indirect costs include the following:

1. Craft Support Labor, Materials and Facilities
2. Construction Equipment
3. Consumables
4. Construction Management (Field Staff)
5. Home Office Engineering
6. Home Office Start-up Support and Training
7. Start-up Craft Labor Support
8. Miscellaneous Expenses (i.e. Insurance, Warranty, Taxes, etc.)

CLIENT:	Electric Power Resource Institute (EPRI)	DATE:	26-Mar-20
PROJECT:	AUSC - 309 MW gross / 284 MW net	PREPARED BY:	CY
LOCATION:	Midwestern United States	FIELD L FAC:	
JOB NO.:		FIELD L RATE:	
REV NO.:	13.1		

AECOM

TOTAL PROJECT

ACCT	DESCRIPTION	KEY QUANTITIES	FIELD WORKHOURS	FIELD LABOR	MATERIAL	SUBCONTRACTS SUB HOURS	SUBCONTRACTS SUB COST	TOTAL BASE BID
03	SITE DEVELOPMENT		-	$ 10,785,183	$ 3,710,548	-	$ -	$ 14,495,731
04	CONCRETE	-	-	$ 2,086,668	$ 1,521,140	-	$ -	$ 3,607,808
05	STRUCTURES	-	-	$ 13,216,686	$ 13,273,283	-	$ -	$ 26,489,969
06	EQUIPMENT & BOP PIPING (OFE EQUIP BY GE BELOW)		-	$ 113,319,508	$ 62,680,295	-	$ -	$ 175,999,803
11	STEAM PIPING			$ 7,530,111	$ 18,577,751		$ -	$ 26,107,862
12	ELECTRICAL		-	$ 7,209,440	$ 14,735,746	-	$ -	$ 21,945,186
13	INSTRUMENTATION		-	$ 3,657,511	$ 8,471,931	-	$ -	$ 12,129,442
14	PAINTING (INCLUDED WITH BOP)		-	$ -	$ -	-	$ -	$ -
15	INSULATION (INCLUDED WITH BOP)		-	$ -	$ -	-	$ -	$ -
16	BUILDINGS		-	$ 1,524,399	$ 1,603,175	-	$ -	$ 3,127,573
	DIRECT FIELD COST		-	**$ 159,329,505**	**$ 124,573,867**	-	**$ -**	**$ 283,903,372**
31	SUPPORT STAFF AND SERVICES		-	$ -	$ -	-	$ -	$ -
32	CONST SUPPLIES / CONSUMABLES		-	$ -	$ -	-	$ -	$ -
33	TEMPORARY FACILITIES		-	$ -	$ -	-	$ -	$ -
33	FIELD OFFICE EXPENSES		-	$ -	$ -	-	$ -	$ -
	FIELD INDIRECT LABOR & EXPENSES (INCL FACILITES)		-	$ 28,390,337	$ -	-	$ -	$ 28,390,337
41	CONSTRUCTION EQUIPMENT (INCLUDES FUEL)		-	$ -	$ 11,356,135	-	$ -	$ 11,356,135
22	HEAVY HAUL/LIFT		-	$ -	$ -	-	$ -	$ -
42	SMALL TOOLS AND COMSUMABLES		-	$ -	$ -	-	$ -	$ -
	CASUAL OVERTIME		-	$ -	$ -	-	$ -	$ -
50	VENDOR STARTUP ASSISTANCE (Include w/ Equip Supply)		-	$ -	$ -	-	$ -	$ -
51	CRAFT SUPPORT - COMMISSIONING		-	$ -	$ -	-	$ -	$ -
21	COMMISSIONING SPARES		-	$ -	$ -	-	$ -	$ -
21	FIRST FILLS AND CHEMICALS		-	$ -	$ -	-	$ -	$ -
	INDIRECT FIELD COST		-	**$ 28,390,337**	**$ 11,356,135**	-	**$ -**	**$ 39,746,472**
	TOTAL FIELD COST		-	**$ 187,719,842**	**$ 135,930,002**	-	**$ -**	**$ 323,649,844**
31A	CONST. MANAGEMENT STAFF & SERVICES			$ 19,873,236				$ 19,873,236
61	HOME OFFICE SERVICES			$ 22,712,270				$ 22,712,270
	START UP AND COMMISSIONING SERVICES			$ 4,258,551				$ 4,258,551
	TOTAL FIELD AND HOME OFFICE	-	-	**$ 234,563,898**	**$ 135,930,002**	-	**$ -**	**$ 370,493,900**
71	BONDING/BAR (INCLUDED BELOW)							$ -
71	AUTO INSURANCE, TAXES, BONDS, WARRANTY				$ -			$ -
	Total Other Cost			**$ -**	**$ -**	-	**$ -**	**$ -**
94	ESCALATION	0.00%		$ -				$ -
	Total Escalated Cost		0	**$ 234,563,898**	**$ 135,930,002**	-	**$ -**	**$ 370,493,900**
92	CONTINGENCY	15.00%		$ 35,184,585	$ 20,389,500		$ -	**$ 55,574,085**
	TOTAL INSTALLED COST		-	**$ 269,748,483**	**$ 156,319,503**	-	**$ -**	**$ 426,067,985**
99	G&A	5.00%		$ 13,487,424	$ 7,815,975		$ -	$ 18,524,695
	SUBTOTAL			**$ 283,235,907**	**$ 164,135,478**	-	**$ -**	**$ 447,371,385**
	FEE	8.00%		$ 22,658,873	$ 13,130,838		$ -	$ 35,789,711
	SUBTOTAL			**$ 305,894,779**	**$ 177,266,316**	-	**$ -**	**$ 483,161,095**
71	INSURANCE						$ 1,196,943	$ 1,196,943
	GRAND TOTAL			**$ 305,894,779**	**$ 177,266,316**		**$ 1,196,943**	**$ 484,358,038**
	GE BOILER & AQCS SUPPLY				$ 225,000,000			$ 225,000,000
	GE TURBINE SUPPLY				$ 15,000,000			$ 15,000,000
	TOTAL PROJECT COST		-	**$ 305,894,779**	**$ 417,266,316**	-	**$ 1,196,943**	**$ 724,358,000**

CLIENT:	Electric Power Resource Institute (EPRI)	DATE:	13-Mar-20
PROJECT:	AUSC - 309 MW gross / 284 MW net (excluding contingency)	PREPARED BY:	CY
LOCATION:	Midwestern United States	FIELD L FAC:	
JOB NO.:		FIELD L RATE:	
REV NO.:	13.1		

AECOM

TOTAL PROJECT

ACCT	DESCRIPTION	KEY QUANTITIES	FIELD WORKHOURS	AECOM FIELD LABOR	MATERIAL	SUBCONTRACTS SUB HOURS	SUB COST	TOTAL BASE BID
03	SITE DEVELOPMENT		-	$ 10,785,183	$ 3,710,548	-	$ -	$ 14,495,731
04	CONCRETE	-	-	$ 2,086,668	$ 1,521,140	-	$ -	$ 3,607,808
05	STRUCTURES	-	-	$ 13,216,686	$ 13,273,283	-	$ -	$ 26,489,969
06	EQUIPMENT & BOP PIPING (OFE EQUIP BY GE BELOW)		-	$ 113,319,508	$ 62,680,295	-	$ -	$ 175,999,803
11	STEAM PIPING			$ 7,530,111	$ 18,577,751		$ -	$ 26,107,862
12	ELECTRICAL		-	$ 7,209,440	$ 14,735,745	-	$ -	$ 21,945,186
13	INSTRUMENTATION		-	$ 3,657,511	$ 8,471,931	-	$ -	$ 12,129,442
14	PAINTING (INCLUDED WITH BOP)		-	$ -	$ -	-	$ -	$ -
15	INSULATION (INCLUDED WITH BOP)		-	$ -	$ -	-	$ -	$ -
16	BUILDINGS		-	$ 1,524,399	$ 1,603,175	-	$ -	$ 3,127,573
	DIRECT FIELD COST		-	**$ 159,329,505**	**$ 124,573,867**	-	**$ -**	**$ 283,903,372**
31	SUPPORT STAFF AND SERVICES		-	$ -	$ -	-	$ -	$ -
32	CONST SUPPLIES / CONSUMABLES		-	$ -	$ -	-	$ -	$ -
33	TEMPORARY FACILITIES		-	$ -	$ -	-	$ -	$ -
33	FIELD OFFICE EXPENSES		-	$ -	$ -	-	$ -	$ -
	FIELD INDIRECT LABOR & EXPENSES (INCL FACILITES)		-	$ 28,390,337	$ -	-	$ -	$ 28,390,337
41	CONSTRUCTION EQUIPMENT (INCLUDES FUEL)		-	$ -	$ 11,356,135	-	$ -	$ 11,356,135
22	HEAVY HAUL/LIFT		-	$ -	$ -	-	$ -	$ -
42	SMALL TOOLS AND COMSUMABLES		-	$ -	$ -	-	$ -	$ -
	CASUAL OVERTIME		-	$ -	$ -	-	$ -	$ -
50	VENDOR STARTUP ASSISTANCE (Include w/ Equip Supply)		-	$ -	$ -	-	$ -	$ -
51	CRAFT SUPPORT - COMMISSIONING		-	$ -	$ -	-	$ -	$ -
21	COMMISSIONING SPARES		-	$ -	$ -	-	$ -	$ -
21	FIRST FILLS AND CHEMICALS		-	$ -	$ -	-	$ -	$ -
	INDIRECT FIELD COST		-	**$ 28,390,337**	**$ 11,356,135**	-	**$ -**	**$ 39,746,472**
	TOTAL FIELD COST		-	**$ 187,719,842**	**$ 135,930,002**	-	**$ -**	**$ 323,649,844**
31A	CONST. MANAGEMENT STAFF & SERVICES			$ 19,873,236				$ 19,873,236
61	HOME OFFICE SERVICES			$ 22,712,270				$ 22,712,270
	START UP AND COMMISSIONING SERVICES			$ 4,258,551				$ 4,258,551
	TOTAL FIELD AND HOME OFFICE	-	-	**$ 234,563,898**	**$ 135,930,002**	-	**$ -**	**$ 370,493,900**
71	BONDING/BAR (INCLUDED BELOW)							$ -
71	AUTO INSURANCE, TAXES, BONDS, WARRANTY				$ -			$ -
	Total Other Cost			**$ -**	**$ -**	-	**$ -**	**$ -**
94	ESCALATION	0.00%		$ -				$ -
	Total Escalated Cost		0	**$ 234,563,898**	**$ 135,930,002**	-	**$ -**	**$ 370,493,900**
92	CONTINGENCY	0.00%		$ -	$ -		$ -	$ -
	TOTAL INSTALLED COST		-	**$ 234,563,898**	**$ 135,930,002**	-	**$ -**	**$ 370,493,900**
99	G&A	5.00%		$ -	$ 18,524,695		$ -	$ 18,524,695
	SUBTOTAL			**$ 234,563,898**	**$ 154,454,697**	-	**$ -**	**$ 389,018,595**
	FEE	8.00%			$ 31,121,488		$ -	$ 31,121,488
	SUBTOTAL			**$ 234,563,898**	**$ 185,576,185**	-	**$ -**	**$ 420,140,083**
71	INSURANCE						$ 1,040,819	$ 1,040,819
	GRAND TOTAL			**$ 234,563,898**	**$ 185,576,185**		**$ 1,040,819**	**$ 421,180,902**
	GE BOILER & AQCS SUPPLY				$ 225,000,000			$ 225,000,000
	GE TURBINE SUPPLY				$ 15,000,000			$ 15,000,000
	TOTAL PROJECT COST		-	**$ 234,563,898**	**$ 425,576,185**	-	**$ 1,040,819**	**$ 661,181,000**

CLIENT:	Electric Power Resource Institute (EPRI)	DATE:	26-Mar-20
PROJECT:	AUSC with CCS - 278 MW gross / 227 MW net	PREPARED BY:	CY
LOCATION:	Midwestern United States	FIELD L FAC:	
JOB NO.:		FIELD L RATE:	
REV NO.:	13.1		

AECOM

TOTAL PROJECT

ACCT	DESCRIPTION	KEY QUANTITIES	FIELD WORKHOURS	AECOM FIELD LABOR	AECOM MATERIAL	SUBCONTRACTS SUB HOURS	SUBCONTRACTS SUB COST	TOTAL BASE BID
03	SITE DEVELOPMENT		-	$ 11,164,529	$ 3,842,036	-	$ -	$ 15,006,565
04	CONCRETE	-	-	$ 1,869,930	$ 1,424,388	-	$ -	$ 3,294,318
05	STRUCTURES	-	-	$ 11,005,477	$ 10,851,732	-	$ -	$ 21,857,210
06	EQUIPMENT & BOP PIPING (OFE EQUIP BY GE BELOW)		-	$ 194,979,490.52	$ 66,768,957.53	-	$ -	$ 261,748,448
11	STEAM PIPING			$ 7,452,050	$ 18,386,752		$ -	$ 25,838,802
12	ELECTRICAL		-	$ 9,638,168	$ 18,670,587	-	$ -	$ 28,308,756
13	INSTRUMENTATION		-	$ 3,956,833	$ 9,160,145	-	$ -	$ 13,116,978
15	INSULATION		-	$ -	$ -	-	$ -	$ -
16	BUILDINGS		-	$ 1,403,361	$ 1,467,546	-	$ -	$ 2,870,906
	DIRECT FIELD COST		-	**$ 241,469,839**	**$ 130,572,144**	-	**$ -**	**$ 372,041,983**
31	SUPPORT STAFF AND SERVICES		-	$ -	$ -	-	$ -	$ -
32	CONST SUPPLIES / CONSUMABLES		-	$ -	$ -	-	$ -	$ -
33	TEMPORARY FACILITIES		-	$ -	$ -	-	$ -	$ -
33	FIELD OFFICE EXPENSES		-	$ -	$ -	-	$ -	$ -
	FIELD INDIRECT LABOR & EXPENSES (INCL FACILITES)		-	$ 29,391,317	$ -	-	$ -	$ 29,391,317
41	CONSTRUCTION EQUIPMENT (INCLUDES FUEL)		-	$ -	$ 11,719,322	-	$ -	$ 11,719,322
22	HEAVY HAUL/LIFT		-	$ -	$ -	-	$ -	$ -
42	SMALL TOOLS AND COMSUMABLES		-	$ -	$ -	-	$ -	$ -
	CASUAL OVERTIME		-	$ -	$ -	-	$ -	$ -
50	VENDOR STARTUP ASSISTANCE (Include w/ Equip Supply)		-	$ -	$ -	-	$ -	$ -
51	CRAFT SUPPORT - COMMISSIONING		-	$ -	$ -	-	$ -	$ -
21	COMMISSIONING SPARES		-	$ -	$ -	-	$ -	$ -
21	FIRST FILLS AND CHEMICALS		-	$ -	$ -	-	$ -	$ -
	INDIRECT FIELD COST		-	**$ 29,391,317**	**$ 11,719,322**	-	**$ -**	**$ 41,110,639**
	TOTAL FIELD COST		-	**$ 270,861,156**	**$ 142,291,467**	-	**$ -**	**$ 413,152,622**
31A	CONST. MANAGEMENT STAFF & SERVICES			$ 20,648,330				$ 20,648,330
61	HOME OFFICE SERVICES			$ 24,182,729				$ 24,182,729
	START UP AND COMMISSIONING SERVICES			$ 4,464,504				$ 4,464,504
	TOTAL FIELD AND HOME OFFICE	-	-	**$ 320,156,718**	**$ 142,291,467**	-	**$ -**	**$ 462,448,185**
71	BONDING/BAR (INCLUDED BELOW)							$ -
71	AUTO INSURANCE, TAXES, BONDS, WARRANTY				$ -			$ -
	Total Other Cost			**$ -**	**$ -**	-	**$ -**	**$ -**
94	ESCALATION	0.00%		$ -				$ -
	Total Escalated Cost		0	**$ 320,156,718**	**$ 142,291,467**	-	**$ -**	**$ 462,448,185**
92	CONTINGENCY	17.43%		$ 55,803,316	$ 24,801,403		$ -	**$ 80,604,719**
	TOTAL INSTALLED COST		-	**$ 375,960,034**	**$ 167,092,869**	-	**$ -**	**$ 543,052,904**
99	G&A	5.00%		$ 18,798,002	$ 8,354,643		$ -	$ 27,152,645
	SUBTOTAL			**$ 394,758,036**	**$ 175,447,513**	-	**$ -**	**$ 570,205,549**
	FEE	8.00%		$ 31,580,643	$ 14,035,801		$ -	$ 45,616,444
	SUBTOTAL			**$ 426,338,679**	**$ 189,483,314**	-	**$ -**	**$ 615,821,993**
71	INSURANCE						$ 1,485,563	$ 1,485,563
	GRAND TOTAL			**$ 426,338,679**	**$ 189,483,314**		**$ 1,485,563**	**$ 617,307,556**
	GE BOILER & AQCS SUPPLY				$ 225,000,000			$ 225,000,000
	GE TURBINE SUPPLY				$ 15,000,000			$ 15,000,000
	GE CCS				$ 254,000,000			$ 254,000,000
	TOTAL PROJECT COST		-	**$ 426,338,679**	**$ 683,483,314**	-	**$ 1,485,563**	**$ 1,111,308,000**

CLIENT:	Electric Power Resource Institute (EPRI)	DATE:	13-Mar-20
PROJECT:	AUSC with CCS - 278 MW gross / 227 MW net (excluding contingency)	PREPARED BY:	CY
LOCATION:	Midwestern United States	FIELD L FAC:	
JOB NO.:		FIELD L RATE:	
REV NO.:	13.1		

AECOM

TOTAL PROJECT

ACCT	DESCRIPTION	KEY QUANTITIES	FIELD WORKHOURS (AECOM)	FIELD LABOR (AECOM)	MATERIAL (AECOM)	SUBCONTRACTS SUB HOURS	SUBCONTRACTS SUB COST	TOTAL BASE BID
03	SITE DEVELOPMENT		-	$ 11,164,529	$ 3,842,036	-	$ -	$ 15,006,565
04	CONCRETE	-	-	$ 1,869,930	$ 1,424,388	-	$ -	$ 3,294,318
05	STRUCTURES	-	-	$ 11,005,477	$ 10,851,732	-	$ -	$ 21,857,210
06	EQUIPMENT & BOP PIPING (OFE EQUIP BY GE BELOW)		-	$ 194,979,490.52	$ 66,768,957.53	-	$ -	$ 261,748,448
11	STEAM PIPING			$ 7,452,050	$ 18,386,752			$ 25,838,802
12	ELECTRICAL		-	$ 9,638,168	$ 18,670,587	-	$ -	$ 28,308,756
13	INSTRUMENTATION		-	$ 3,956,833	$ 9,160,145	-	$ -	$ 13,116,978
15	INSULATION		-	$ -	$ -	-	$ -	$ -
16	BUILDINGS		-	$ 1,403,361	$ 1,467,546	-	$ -	$ 2,870,906
	DIRECT FIELD COST		-	**$ 241,469,839**	**$ 130,572,144**	-	**$ -**	**$ 372,041,983**
31	SUPPORT STAFF AND SERVICES		-	$ -	$ -	-	$ -	$ -
32	CONST SUPPLIES / CONSUMABLES		-	$ -	$ -	-	$ -	$ -
33	TEMPORARY FACILITIES		-	$ -	$ -	-	$ -	$ -
33	FIELD OFFICE EXPENSES		-	$ -	$ -	-	$ -	$ -
	FIELD INDIRECT LABOR & EXPENSES (INCL FACILITES)		-	$ 29,391,317	$ -	-	$ -	$ 29,391,317
41	CONSTRUCTION EQUIPMENT (INCLUDES FUEL)		-	$ -	$ 11,719,322	-	$ -	$ 11,719,322
22	HEAVY HAUL/LIFT		-	$ -	$ -	-	$ -	$ -
42	SMALL TOOLS AND COMSUMABLES		-	$ -	$ -	-	$ -	$ -
	CASUAL OVERTIME		-	$ -	$ -	-	$ -	$ -
50	VENDOR STARTUP ASSISTANCE (Include w/ Equip Supply)		-	$ -	$ -	-	$ -	$ -
51	CRAFT SUPPORT - COMMISSIONING		-	$ -	$ -	-	$ -	$ -
21	COMMISSIONING SPARES		-	$ -	$ -	-	$ -	$ -
21	FIRST FILLS AND CHEMICALS		-	$ -	$ -	-	$ -	$ -
	INDIRECT FIELD COST		-	**$ 29,391,317**	**$ 11,719,322**	-	**$ -**	**$ 41,110,639**
	TOTAL FIELD COST		-	**$ 270,861,156**	**$ 142,291,467**	-	**$ -**	**$ 413,152,622**
31A	CONST. MANAGEMENT STAFF & SERVICES			$ 20,648,330				$ 20,648,330
61	HOME OFFICE SERVICES			$ 24,182,729				$ 24,182,729
	START UP AND COMMISSIONING SERVICES			$ 4,464,504				$ 4,464,504
	TOTAL FIELD AND HOME OFFICE	-	-	**$ 320,156,718**	**$ 142,291,467**	-	**$ -**	**$ 462,448,185**
71	BONDING/BAR (INCLUDED BELOW)							$ -
71	AUTO INSURANCE, TAXES, BONDS, WARRANTY				$ -			$ -
	Total Other Cost			**$ -**	**$ -**	-	**$ -**	**$ -**
94	ESCALATION	0.00%		$ -				$ -
	Total Escalated Cost		0	**$ 320,156,718**	**$ 142,291,467**	-	**$ -**	**$ 462,448,185**
92	CONTINGENCY	0.00%		$ -	$ -		$ -	$ -
	TOTAL INSTALLED COST		-	**$ 320,156,718**	**$ 142,291,467**	-	**$ -**	**$ 462,448,185**
99	G&A	5.00%		$ 16,007,836	$ 7,114,573		$ -	$ 23,122,409
	SUBTOTAL			**$ 336,164,554**	**$ 149,406,040**	-	**$ -**	**$ 485,570,594**
	FEE	8.00%		$ 26,893,164	$ 11,952,483		$ -	$ 38,845,648
	SUBTOTAL			**$ 363,057,719**	**$ 161,358,523**	-	**$ -**	**$ 524,416,242**
71	INSURANCE						$ 1,265,062	$ 1,265,062
	GRAND TOTAL			**$ 363,057,719**	**$ 161,358,523**		**$ 1,265,062**	**$ 525,681,304**
	GE BOILER & AQCS SUPPLY				$ 225,000,000			$ 225,000,000
	GE TURBINE SUPPLY				$ 15,000,000			$ 15,000,000
	GE CCS				$ 254,000,000			$ 254,000,000
	TOTAL PROJECT COST		-	**$ 363,057,719**	**$ 655,358,523**	-	**$ 1,265,062**	**$ 1,019,681,000**

4.1 O&M Costs Description

The operating and maintenance (O&M) cost estimates have been prepared for the following cases:

1. 309 MW gross / 284 MW net Advanced Ultra-supercritical Coal-Fired (AUSC) Power Plant located in the midwestern United States.
2. 278 MW gross / 227 MW net Advanced Ultra-supercritical Coal-Fired (AUSC) Power Plant with integrated CCS located in midwestern United States.

The O&M cost estimates were based on the same NETL reference plants that the EPC cost estimates were based on. Each O&M cost estimate is made up of Fixed Operating Cost and Variable Operating Cost.

The Fixed Costs include:

1. Annual Operating Labor
2. Maintenance Labor
3. Administration & Support Labor
4. Property Taxes & Insurance

The annual operating labor costs for the AUSC and AUSC with CCS O&M estimates were slightly less than those of the NETL reference plants. The smaller size power plant still need about the same amount of operations personnel to operate the plant. The annual operating labor rate used was the base rate ($/hour) plus a 30% burden.

The maintenance labor costs for the AUSC and AUSC with CCS O&M estimates were based on the maintenance material costs which were assumed to be 1% of the cost of the plant. The maintenance labor then would be calculated as a 40/60 split for labor/materials.

The administrative and support labor was calculated as 25% of the operating labor cost.

The property taxes and insurance were assumed to be 2% of the cost of the plant.

The Variable Cost include:

1. Maintenance Materials
2. Consumables
3. Waste Disposal Cost

The Variable Operating Cost Consumables include a breakdown for the following:

1. Water
2. Makeup and Waste Water Treatment
3. Brominated Activated Carbon

4. Enhanced Hydrated Lime
5. Ammonia
6. SCR Catalyst
7. CO_2 Capture System Chemicals (CCS only)
8. Triethylene Glycol (CCS only)

The Variable Operating Cost Waste Disposal includes a breakdown for the following;

1. Fly Ash
2. Bottom Ash
3. SCR Catalyst
4. Triethylene Glycol (CCS only)
5. Thermal Reclaimer Unit Waste (CCS only)
6. Prescrubber Blowdown Waste (CCS only)

The variable cost consumables and waste disposal costs were calculated based on usage as dictated by the size of the plant in MW. The water, makeup water and water treatment were factored downward based on the efficiency of an AUSC plant over a SC plant.

The table presented below (in section 5) shows the comparison of O&M costs between the NETL reference plants and the corresponding AUSC Coal FIRST plants.

5 Class 4 Estimates Documents O&M Estimate

AECOM

EPRI Coal FIRST Project Class 4 Estimate

Operations and Maintenance Cost Estimate

Rev: 6
Date: 3/30/2020
Est: CY

Description	NETL Concep - SC PC wo CCS 685/650 MW (2018$)		EPRI Class 4 - AUSC PC wo CCS 309/284 MW (2020$)		NETL Concep - SC PC w CCS 776/650 MW (2018$)		EPRI Class 4 - AUSC PC w CCS 278/227 MW (2020$)	
	Total	($/kW-net)	Total	($/kW-net)	Total	($/kW-net)	Total	($/kW-net)
Fixed Operating Cost								
Annual Operating Labor	$ 6,138,132	$ 9.443	$ 5,402,258	$ 19.022	$ 7,161,008	$ 11.017	$ 6,752,822	$ 29.748
Maintenance Labor	$ 8,729,809	$ 13.430	$ 4,829,054	$ 17.004	$ 15,797,590	$ 24.304	$ 7,408,757	$ 32.638
Administrative & Support Labor	$ 3,716,985	$ 5.718	$ 2,557,828	$ 9.006	$ 5,739,649	$ 8.830	$ 3,540,395	$ 15.596
Property Taxes and Insurance	$ 27,280,654	$ 41.970	$ 14,487,160	$ 51.011	$ 49,367,468	$ 75.950	$ 22,226,160	$ 97.913
Total Fixed Operating Cost	**$ 45,865,580**	**$ 70.562**	**$ 27,276,299**	**$ 96.043**	**$ 78,065,715**	**$ 120.101**	**$ 39,928,134**	**$ 175.895**
	Total $	($/MWh-net)	Total $	($/MWh-net)	Total $	($/MWh-net)	Total $	($/MWh-net)
Varialble Operating Cost								
Maintenance Materials	$ 13,094,714	$ 2.70558	$ 7,243,580	$ 3.42540	$ 23,696,385	$ 4.89605	$ 11,113,080	$ 6.57485
Consumables								
Water	$ 2,569,326	$ 0.53086	$ 1,161,344	$ 0.54919	$ 4,206,523	$ 0.86913	$ 1,442,059	$ 0.85317
Makeup and Waste Water Treatment Chemicals	$ 2,215,533	$ 0.45776	$ 1,002,597	$ 0.47412	$ 3,627,291	$ 0.74946	$ 1,245,997	$ 0.73717
Brominated Activated Carbon	$ 604,623	$ 0.12492	$ 280,508	$ 0.13265	$ 772,686	$ 0.15965	$ 280,508	$ 0.16596
Enhanced Hydrated Lime	$ 2,321,985	$ 0.47976	$ 1,076,047	$ 0.50885	$ 2,967,412	$ 0.61311	$ 1,076,047	$ 0.63662
Limestone	$ 3,739,990	$ 0.77274	$ 1,732,482	$ 0.81927	$ 4,779,570	$ 0.98753	$ 1,732,482	$ 1.02499
Deduct Limestone (N/A with NID)			$ (1,732,482)	$ (0.81927)			$ (1,732,482)	$ (1.02499)
Ammonia	$ 4,830,710	$ 0.99810	$ 2,237,454	$ 1.05807	$ 6,420,577	$ 1.32659	$ 2,237,454	$ 1.32375
SCR Catalyst	$ 579,125	$ 0.11966	$ 267,287	$ 0.12640	$ 740,101	$ 0.15292	$ 267,287	$ 0.15814
CO_2 Capture System Chemicals	$ -	$ -	$ -	$ -	$ 9,225,455	$ 1.90613	$ 3,304,995	$ 1.95534
Triethylene Gycol	$ -	$ -	$ -	$ -	$ 1,147,315	$ 0.23705	$ 422,171	$ 0.24977
Waste Disposal								
Fly Ash	$ 6,060,275	$ 1.25215	$ 2,807,024	$ 1.32741	$ 7,744,619	$ 1.60016	$ 2,807,024	$ 1.66072
Bottom Ash	$ 1,346,208	$ 0.27815	$ 623,542	$ 0.29487	$ 1,720,404	$ 0.35546	$ 623,542	$ 0.36891
SCR Catalyst	$ 9,652	$ 0.00199	$ 4,471	$ 0.00211	$ 12,335	$ 0.00255	$ 4,471	$ 0.00264
Triethylene Gycol	$ -	$ -	$ -	$ -	$ 59,053	$ 0.01220	$ 21,729	$ 0.01286
Thermal Reclaimer Unit Waste	$ -	$ -	$ -	$ -	$ 41,395	$ 0.00855	$ 15,222	$ 0.00901
Prescrubber Blowdown Waste	$ -	$ -	$ -	$ -	$ 614,467	$ 0.12696	$ 225,945	$ 0.13368
Total Variable Operating Cost	**$ 37,372,141**	**$ 7.72168**	**$ 16,703,855**	**$ 7.89906**	**$ 67,775,588**	**$ 14.00351**	**$ 25,087,532**	**$ 14.84257**

6 Cost Study Estimating Methodology for GE Equipment

The capital cost estimate is for a greenfield 300 MW Gross 209 MW Net AUSC power plant. The in furnace combustion control uses TFS XP™ Ultra Low NO_X Firing System. The post combustion equipment consists of SCR, NID (FGD / Baghouse) and an Amine based CCP Plant capturing 90% of the CO_2.

7 Boiler AQCS Costs Description

The boiler and AQCS were priced based on analogy to similarly sized equipment with modifications to account higher than typical temperatures and pressures.

Equipment and manufacturing cost basis is predominantly US (>80%) except where impractical or unavailable. Engineering costs are a combination hourly rates from the US as well as leveraging some low-cost engineering from a GE owned and managed centre.

Pricing considers modular configurations to reduce field construction durations and labor costs.

The accuracy of the cost estimate is within the required range of -40 %/+40 %

The proposed steam turbine concept combines the existing capabilities of the GE USC modular steam turbine product platform with the use of high temperature materials, scaled to a plant size normally associated with much lower steam conditions.

8 CCS Costs Description

According AACE International recommended Practice No. 18R-97 for each case a Class 4 cost estimate has been prepared for the CCS equipment. With Baker Hughes' internal developed and over several years used and experienced cost estimation tool Qfact we run a pure inhouse "Equipment Factorized Cost Estimate" based on major equipment data (dimensions, design conditions, material selection etc.). Each equipment has been estimated piece by piece, afterwards based on consolidated equipment data the tool Qfact generates estimated quantities for bulk material and construction. For engineering service, the overall equipment piece count is the relevant basis.

The cost level for estimates are based preferably on US cost basis:

- On equipment and material over 80% of costs are based on US local content, while cost for Baker Hughes equipment, e.g. compressor, air coolers and some pumps, and some noncritical low-cost equipment items, e.g. vessels, shell & tube exchangers, are based from other countries
- On detailed engineering services an average rate of local US contractor rates in combination with rates of a low-cost engineering center (Asian region) have been applied.

The cost estimate includes cost for the entire process plant such as equipment, bulk material and engineering, but excluded electrical equipment, e.g. switchgear & transformers. The first fill for the process plant with amine solution and lubricants is included in the cost estimate as well. Major quantities are provided for construction.

Since the major process equipment has large dimensions, modularization for this equipment is not reflected in the cost estimate. For smaller equipment (especially the smaller pumps, the exchangers and the filter packages) steel structures have been foreseen.

Regarding spares, construction and commissioning spares are included, only, while operational spares, capital spares and installed spare equipment are excluded. The plant has been designed for average five thousand (5000) full load operating hours per year (for yearly consumptions / productions calculations) and a plant availability of eight thousand (8000) hours per year as defined in the Basis of Design. The remaining time periods can be used for maintenance. Cost elements - like license fee - which are depending on yearly plant capacity have been based on the above mentioned average five thousand (5000) full load operating hours per year.

All cost of the estimate is based on today's cost, no escalation has been foreseen. The accuracy of the cost estimate is within the required range of -40 %/+40 %. The cost estimate and given quantities have been benchmarked against other experienced cost estimates done in the past for subject process.

Reference Documents and Resources:

The following documents and resources were used to develop the estimate summary and estimate detail.

1. U.S. Energy Information Administration, "Capital Cost and Performance Characteristic Estimates for Utility Scale Electric Power Generating Technologies", February 2020
2. AACE International, "Recommended Practice 58R-10, Escalation Estimating Principles and Methods Using Indices", May 25, 2011
3. AACE International, "Recommended Practice 59R-10, Development of Factored Cost Estimates – As Applied in Engineering, Procurement, and Construction for the Process Industries", June 18, 2011
4. U.S. Department of Labor, Bureau of Labor Statistics, "Consumer Price Index", January 2020

5. Please note that the cost estimates provided herein are dependent upon the various underlying assumptions, inclusions, and exclusions utilized in developing them. Actual project costs will differ, and can be significantly affected by factors such as changes in the external environment, the manner in which the project is implemented, and other factors which impact the estimate basis or otherwise affect the project. Estimate accuracy ranges are only projections based upon cost estimating methods and are not a guarantee of actual project costs.