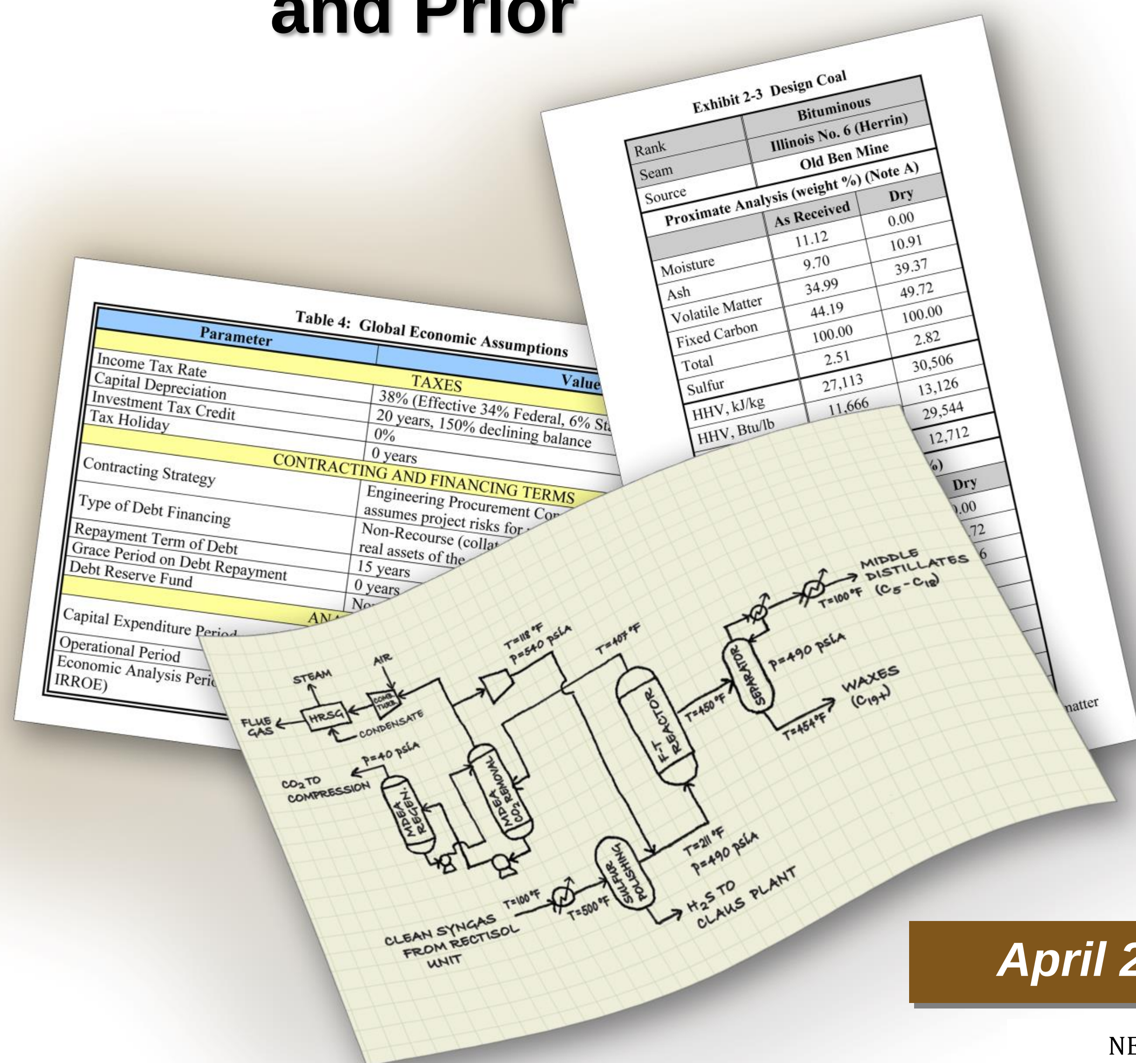
NATIONAL ENERGY TECHNOLOGY LABORATORY

QUALITY GUIDELINES
FOR ENERGY SYSTEM STUDIES

Capital Cost Scaling Methodology: Revision 3 Reports and Prior



April 2019

NETL-PUB-22537

U.S. DEPARTMENT OF ENERGY

Disclaimer

Quality Guidelines for Energy System Studies Capital Cost Scaling Methodology: Revision 3 Reports and Prior

NETL-PUB-22537

Final Report

April 26, 2019

NETL Contact:

Robert James
General Engineer
Energy Process Analysis Team

National Energy Technology Laboratory
www.netl.doe.gov

Prepared by:

Mission Execution and Strategic Analysis (MESA)

Marc J. Turner
Leidos

Alexander Zoelle
Leidos

Energy Sector Planning and Analysis (ESPA)

Lora L. Pinkerton
WorleyParsons Group, Inc.

DOE Contract Number DE-FE0004001

Acknowledgments

This report was prepared by Energy Sector Planning and Analysis (ESPA) for the United States Department of Energy (DOE), National Energy Technology Laboratory (NETL). This work was completed under DOE NETL Contract Number DE-FE0004001. This work was performed under ESPA Task 341.03.01.

This report was completed by MESA for the U.S. DOE NETL. This work was completed under DOE NETL Contract Number DE-FE0025912. This work was performed under MESA Activity 201.001.005.

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

Robert James, General Engineer, Energy Process Analysis Team (EPAT)
Travis Shultz, Supervisor, EPAT
Kristin Gerdes, Acting Deputy Director, Research & Innovation Center (RIC)
James Black, General Engineer, RIC
William Morgan Summers, General Engineer, Energy Systems Analysis Team
James C. Fisher II, Formerly of NETL

This page intentionally left blank.

Table of Contents

List of Exhibits

Acronyms and Abbreviations

acfm	Actual cubic feet per minute
AGR	Acid gas removal
ASU	Air separation unit
BEC	Bare erected cost
BFW	Boiler feed water
BOP	Balance of plant
C	Coefficient
CFBC	Circulating fluidized bed combustion
Circ.	Circulating
CO_2	Carbon dioxide
COS	Carbonyl sulfide
CTG	Combustion turbine generator
DCF	Dry coal feed, lb/hr
DOE	Department of Energy
EGR	Exhaust gas recycle
Equip.	Equipment
ESPA	Energy Sector Planning and Analysis
Exp	Exponent
FG	Flue gas
FGD	Flue gas desulfurization
FO	Fuel Oil
ft^3	Cubic feet
gpm	Gallons per minute
Hg	Mercury
HGCU	Hot-gas-cleanup unit
HP	High pressure
HRSG	Heat recovery steam generator
I&C	Instrumentation and control
IGCC	Integrated gasification combined cycle
ISO	International Standards Organization
kW	Kilowatt
kWe	Kilowatt electric
lb/hr	Pounds per hour
LT	Low temperature
MAC	Main Air Compressor
MDEA	Methyldiethanolamine
MESA	Mission Execution and Strategic Analysis
min	Minute
Misc.	Miscellaneous
MMBtu/hr	Million British thermal units per hour
MVA	Mega volt-amps
MW	Megawatt
N/A	Not applicable
ND	North Dakota
NETL	National Energy Technology Laboratory
NGCC	Natural gas combined cycle
O_2	Oxygen
PC	Pulverized coal
PRB	Powder River Basin
QGESS	Quality Guidelines for Energy System Studies
RBEC	Reference plant's BEC
RC	Reference cost
RCon	Reference plant's contingency, $
RP	Reference parameter
RTPC	Reference total plant cost for subaccount
SARU	Soot ash removal unit
SC	Scaled cost
SCon	Scaled plant's contingency, %
SGC	Synthesis gas cooler
SP	Scaled parameter
STG	Steam turbine generator
STPC	Scaled total plant cost for subaccount
TG	Turbine generator
TPC	Total plant cost
TPD	Tons per day
TPH	Tons per hour
TX	Texas
WGS	Water gas shift

1 Foreword

The National Energy Technology Laboratory (NETL) regularly updates legacy analyses with new studies and cases as the Department of Energy objectives change, technology performance improves, costs are reduced, regulations change, market drivers are established, fuel prices fluctuate, and any number of other relevant factors vary in the market. As legacy studies are updated by NETL, the underlying performance and cost of the cases presented changes, and as such, the methods for interpreting and scaling the cost estimates change. Therefore, it is important that NETL maintain public guidance documents associated with different sets of cost estimates that delineate how a specific set, based on report vintage and/or year published, should be scaled. This Quality Guidelines for Energy System Studies (QGESS) report, providing guidance on capital cost scaling, should generally be applied to NETL case costs for reports dating 2018 or older. Exhibit 2-2 provides a select set of relevant NETL studies that are applicable for this guidance document, but other studies and cases that derive from these references will also be subject to this guidance. For example, as of 2018 the most recent version of NETL's *Cost and Performance Baseline for Fossil Energy Plants* (the "Bituminous Baseline") is *Volume 1a: Bituminous Coal (PC) and Natural Gas to Electricity Revision 3*. [1] This revision was published in July 2015 and is subject to the scaling guidance contained in this document. Other NETL reports or publicly available tools may have used the cases presented therein, and developed new cases based on the reference performance and cost data. Those new cases would also be subject to this guidance document as they originated from a reference that is subject to this guidance.

2 Introduction

Costs are frequently required as part of systems analysis work at NETL. Many of the cost results provided as part of systems analysis work were created with the use of scaling, since obtaining new vendor-supplied cost quotes for each category developed by NETL would be prohibitively time consuming and costly. Additionally, many of the technologies being investigated by NETL have not progressed far enough to have quotable costs.

The costs are scaled from a quote for a similar plant configuration by use of various equations that typically employ at least one process parameter (e.g., coal-feed rate, oxidant-feed rate) and often an exponent. The primary purpose of the exponent is to account for economies of scale (i.e., as equipment size gets larger, it gets progressively cheaper to add additional capacity).

The purpose of this section of the QGESS is to provide a standard basis for scaling costs, with specific emphasis on scaling exponents. The intention of having a standardized document is to provide guidelines for proper procedures to reduce the potential of errors and increase credibility through consistency.

This document contains a listing of frequently used pieces of equipment and their corresponding scaling exponent for various plant types, along with their ranges of applicability. This document also details the equations to be used with each exponent.

The scaling exponents used in systems analysis work are logarithmically derived from previously obtained vendor supplied cost quotes using Equation 1.

Equation 1

$$Exp = \frac{\ln\left({RC_1}/{RC_2}\right)}{\ln\left({RP_1}/{RP_2}\right)}$$

Where:

- Exp – Exponent
- RC – Reference cost
- RP – Reference parameter

Exhibit 2-1 provides a listing of the categories used in this document and a description of the types of technologies to which the associated exponents are applicable. Exhibit 2-2 provides a representative listing of reference reports for the various categories.

The listings are divided into three major technologies frequently analyzed at NETL: combustion [pulverized coal (PC) and circulating fluidized bed combustion (CFBC)], integrated gasification combined cycle (IGCC), and natural gas combined cycle (NGCC).

Exhibit 2-1. Category matrix

Category	Technologies
PC/CFBC	
1	Supercritical PC, air-fired, with and without CO_2 capture, Illinois No. 6 coal with hybrid poplar
	Supercritical PC, oxy-fired, with CO_2 capture, Illinois No. 6 coal with hybrid poplar
	Supercritical and ultra-supercritical[A] PC, oxy-fired, with CO_2 capture, Illinois No. 6 coal
2	CFBC, air-fired, with and without CO_2 capture, PRB and ND Lignite coals
	CFBC, oxy-fired, with CO_2 capture, PRB and ND Lignite coals
3	Supercritical PC, air-fired, with and without CO_2 capture, ND Lignite and PRB coals
	Ultra-supercritical PC,[A] air-fired, with and without CO_2 capture, ND Lignite and PRB coals
	Supercritical PC, oxy-fired, with CO_2 capture, ND Lignite and PRB coals
	Ultra-supercritical PC,[A] oxy-fired, with CO_2 capture, ND Lignite and PRB coals
4	Supercritical and ultra-supercritical PC,[A] air-fired, with and without CO_2 capture, Illinois No. 6 coal
5	Subcritical PC, air-fired, with and without CO_2 capture, Illinois No. 6 coal
IGCC	
6	Single-stage, dry-feed, oxygen-blown, down-flow gasifier with and without CO_2 capture, PRB and ND Lignite coals
7	Two-stage, slurry-feed, oxygen-blown gasifier with and without CO_2 capture, PRB and Illinois No. 6 coal
	Single-stage, slurry-feed, oxygen-blown gasifier with and without CO_2 capture, Illinois No. 6 coal
8	Single-stage, dry-feed, oxygen-blown, up-flow gasifier, with CO_2 capture, PRB coal with and without switchgrass
	Single-stage, dry-feed, oxygen-blown, up-flow gasifier with CO_2 capture, Illinois No. 6 coal with switchgrass
	Single-stage, dry-feed, oxygen-blown, up-flow gasifier, with and without CO_2 capture, PRB and ND Lignite coals
	Single-stage, dry-feed, oxygen-blown, up-flow gasifier with and without CO_2 capture, Illinois No. 6 coal
9	Transport gasifier, air- and oxygen-blown, with and without CO_2 capture, PRB and TX Lignite coals
	Transport gasifier, oxygen-blown with CO_2 capture, TX Lignite coal, with hybrid poplar
NGCC	
10	Natural gas, air-fired, with and without CO_2 capture
	Natural gas, air-fired with CO_2 capture and gas recycle

[A]Ultra-supercritical PC plants have a 10-percent process contingency applied to line item 4.1 (PC Boiler and Accessories) and a 15-percent process contingency applied to line item 8.1 (Steam Turbine Generator and Accessories).

Exhibit 2-2. Representative reference cost estimates

Category	Technologies Report Hyperlinks
PC/CFBC	
1	*Greenhouse Gas Reductions in the Power Industry Using Domestic Coal and Biomass – Volume 2: PC Plants* [2]
	Advancing Oxycombustion Technology for Bituminous Coal Power Plants: An R&D Guide [3]
2	*Cost and Performance Baseline for Fossil Energy Plants – Volume 3b: Low Rank Coal and Natural Gas to Electricity: Combustion Cases* [4]
	Advancing Oxycombustion Technology for Bituminous Coal Power Plants: An R&D Guide [3]
3	*Cost and Performance Baseline for Fossil Energy Plants – Volume 3b: Low Rank Coal and Natural Gas to Electricity: Combustion Cases* [4]
4	*Cost and Performance Baseline for Fossil Energy Plants, Volume 1a: Bituminous Coal (PC) and Natural Gas to Electricity Revision 3* [1]
5	*Cost and Performance Baseline for Fossil Energy Plants, Volume 1a: Bituminous Coal (PC) and Natural Gas to Electricity Revision 3* [1]
IGCC	
6	*Cost and Performance Baseline for Fossil Energy Plants – Volume 3a: Low Rank Coal to Electricity: IGCC Cases* [5]
7	*Cost and Performance Baseline for Fossil Energy Plants – Volume 3a: Low Rank Coal to Electricity: IGCC Cases* [5]
	Cost and Performance Baseline for Fossil Energy Plants, Volume 1b: Bituminous Coal (IGCC) to Electricity Revision 2b – Year Dollar Update [6]
8	*Greenhouse Gas Reductions in the Power Industry Using Domestic Coal and Biomass – Volume 1: IGCC Plants* [7]
	Cost and Performance Baseline for Fossil Energy Plants – Volume 3a: Low Rank Coal to Electricity: IGCC Cases [5]
	Cost and Performance Baseline for Fossil Energy Plants, Volume 1b: Bituminous Coal (IGCC) to Electricity Revision 2b – Year Dollar Update [6]
9	*Cost and Performance Baseline for Fossil Energy Plants – Volume 3a: Low Rank Coal to Electricity: IGCC Cases* [5]
NGCC	
10	*Cost and Performance Baseline for Fossil Energy Plants – Volume 3b: Low Rank Coal and Natural Gas to Electricity: Combustion Cases* [4]
	Cost and Performance Baseline for Fossil Energy Plants, Volume 1a: Bituminous Coal (PC) and Natural Gas to Electricity Revision 3 [1]

2.1 Limitations of Scaling Approach

It is important to note that when scaling costs, the technologies must be as similar as possible. For instance, if scaling a plant that fires Illinois No. 6, both the scaling exponents and the reference cost should be for a plant that fires Illinois No. 6. The same is true for the following specifications as well:

- Oxidant type (air or oxygen)
- Elevation/Location (International Standards Organization [ISO], North Dakota, Montana, etc.)
- Plant type (sub-critical, supercritical, ultra-supercritical, etc.)
- Technology type (PC, IGCC, NGCC, etc.)
- Emissions control technologies (with/without CO_2 capture, with/without flue gas desulfurization [FGD], etc.)

For many of the items provided in this report, the approach presented scales on a single parameter for a given account. In reality, some accounts, particularly some of the major equipment items, may be impacted by more than one parameter. For example, a line item may be scaled on one or more flows/outputs but should, in reality, be scaled on multiple flows/outputs and on both pressure and temperature, or thermal duty and delta temperature. While the single-parameter approach can be used for high-level scaling, it is recommended that individual items/systems be scaled from the most similar reference possible, particularly for the cost drivers.

There are limitations on the ranges that can accurately be addressed by the scaling approach. There can be step changes in pricing at certain equipment sizes that may not be captured by the scaling exponents. Care should be taken in applying the scaling factors when there is a large percentage difference between the scaling parameters. This is particularly true for the major equipment items. For example, it is known that the combustion turbine is an incremental cost and is specific to one level of performance.

The configuration also has a significant impact on costs. In addition to the base scaling, adjustments must be made for considerations such as number of trains for a particular system and equipment redundancy (i.e. 2 x 100% versus 3 x 50%).

The plant location is another issue that must be kept in mind when scaling costs. Project location and labor basis can have a significant impact on overall project costs. An additional adjustment to the labor component may be required to reflect local wage rates, local labor productivity, and a union versus non-union environment.

It is imperative that the reader understand that even subtle differences in equipment specifications can result in significant cost impacts. Adjustments, often in the form of additions or deductions, must be incorporated to address these elements. These could include items such as unique site considerations (piles, access requirements, salt water environment), or specific equipment requirements (stack height, re-heat versus non re-heat, single pressure versus multiple pressure, turbine backpressure).

Finally, the cost basis date must be considered. Equipment, material, and labor costs may need to be escalated or de-escalated to adjust for the differences between the cost basis date for the scaled estimate and the reference estimate. Additionally, significant elapsed time between the reference cost date and the desired date for the scaled estimate could potentially encompass technology or approach changes for a specific item and/or system.

The scaling methodology reported here is specifically developed from and intended for use with June 2007 cost data, with the exception of the cases reported in Volume 1a Revision 3 [1] and Volume 1b Revision 2b [6] of the Bituminous Baseline, which have been validated for use with the methodology reported here for June 2011 costs as well (variances in methodologies are noted, where necessary).

In general, the approach presented in this report is valid for high-level evaluation only. The accuracy of the factored estimate will be less than or equal to that for a reference estimate.

2.2 Methodology

When developing a cost estimate for a plant that requires scaled costing, determine the category type from the category matrix in Exhibit 2-1 that exhibits as much commonality as possible when compared to the plant of interest. Once the category type has been determined, an estimate for a plant of the same type must be obtained for use as a reference. A listing of reports containing example reference cost estimates for each category type is provided in Exhibit 2-2. Reference cost estimates may also be found on the NETL Energy Analysis website.[1]

If the plant of interest does not match any of the available reference cost estimates, select one that most suitably matches, taking care to minimize the impact from the limitations of the scaling approach detailed in Section 3.

For plants of interest that differ significantly from any available reference cost estimates, the plant of interest may still have many of the same subsystems as one or more of the reference cost estimates. If so, then the reference cost estimate used may be a combination of various individual reference cost estimates, matched based on subaccount.

Using the category type obtained from the category matrix, utilize Exhibit 3-2 through Exhibit 3-43 to obtain the scaling parameters, exponents, and coefficients. The scaling parameter values associated with the reference cost estimate will be taken from the report from which the reference cost estimate was obtained.

Determine the scaling parameter values for the plant of interest and compare them to the range of applicability provided in Exhibit 3-2 through Exhibit 3-43. If the value is outside the recommended range, significant deviation from realistic results could occur.

Once the scaling parameters, exponents, and coefficients as well as the reference cost and scaling parameter values are obtained, the scaled cost estimate can be developed by utilizing the equations provided in Section 3. Specific guidelines are available in subsections, as follows:

[1]http://www.netl.doe.gov/research/energy-analysis

- Section 3.1 "PC and CFBC"
- Section 3.2 "IGCC"
- Section 3.3 "NGCC"

The following subsection provides an example for developing cost estimates.

2.3 Scaled Cost Estimate Development Examples

Plant of interest

The plant of interest is an oxygen-blown two-stage slurry feed gasifier, firing Powder River Basin (PRB) coal at ISO elevation. The plant is equipped with CO_2 capture and compression systems and utilizes a wet cooling tower.

Category type

Category 7 from the category matrix (Exhibit 2-1) most suitably matches the plant of interest as it shares the following items in common:

1. Two-stage slurry feed gasifier
2. Oxygen-blown
3. CO_2 capture
4. PRB coal

Reference plant

No exact match is available for a 'reference plant' as a comparison to the 'plant of interest.' Therefore, the reference plant will have to be a combination of various reference plants based on subaccount matches. The reference plants selected are Case S4B from the Category 7 report Volume 3a of the Low Rank Baseline [5] (Exhibit 2-2) and Case 4 from a legacy version of the Category 8 report, Volume 1b Revision 2b of the Bituminous Baseline [6] (Exhibit 2-2). (Case 4 was selected rather than the more recent version, Case B4B, so as to match the estimate year dollars with Case S4B.)

Case 4 matches:

1. Cooling type
2. Elevation
3. CO_2 capture
4. Gasifier type

Case S4B matches:

1. Coal type
2. CO_2 capture
3. Gasifier type

It was decided that all accounts that have direct influence from coal will be scaled using Case S4B. All other accounts will be scaled using Case 4.

Accounts scaled using Case S4B include:

1) Coal and Sorbent Handling
2) Coal and Sorbent Preparation and Feed
4) Gasifier and Accessories

5A) Gas Cleanup and Piping
6) Combustion Turbine and Accessories

The section that will be utilized in the example will be Account 5 "Gas Cleanup and Piping"

Obtaining scaling parameters

Exhibit 3-21 contains the scaling parameters, exponents, coefficients, and ranges for Account 5 of the selected category 7 plant type.

Exhibit 2-3 provides the account number, item description, scaling parameter, exponent and coefficient, range of applicability, reference parameter value, reference cost, and scaling parameter value.

Exhibit 2-3. Example Account 5: Parameter listing

Account Number	Item Description	Parameter[A]	Exponent [Coefficient][A]	Range[A]	Reference Parameter[B]	Case S4B Reference Costs in June 2007 1000$ (Equipment/ TPC)[B]	Scaling Parameter[C]
5A.1	Selexol (Double)	Gas flow to AGR, acfm	0.79	5,000 – 30,000	11,389	$73,047/$210,112	12,068
5A.2	Elemental Sulfur Plant	Sulfur Production, lb/hr	0.67	200 – 44,000	4,901	$5,613/$18,396	5,339
5A.3	Mercury Removal	Hg bed carbon fill, ft^3	See Note[D]	2,000 – 35,000	N/A	$1,328/$3,218	3,916
5A.4	Shift Reactors	WGS Catalyst volume, ft^3	0.80	1,000 – 11,000	6,257	$8,762/$16,160	6,692
5A.6	Blowback Gas Systems	Candle filter flow rate, acfm	0.30	2,000 – 96,000	24,282	$2,030/$3,368	26,838
5A.7	Fuel Gas Piping	Fuel gas flow, lb/hr	0.72	185,000 – 2,490,000	202,347	$0/$1,747	221,487
5A.9	HGCU Foundations	Sulfur Production, lb/hr	0.79	200 – 44,000	4,901	$0/$1,853	5,339

[A]Information from exhibits in this document
[B]Information from the 'reference' plant report
[C]Scaling parameter from the 'plant of interest'
[D]The exponent 1.57 is used with PRB coal, the exponent 1.64 is used with Illinois No. 6 coal without CO_2 capture, and the exponent 1.59 is used with Illinois No. 6 coal with CO_2 capture. The coefficient 0.0141 is used with all instances.

Calculating scaled cost estimates

Unless otherwise specified, calculating the material cost, labor costs, and equipment cost differs only in the value used as the reference plants reference cost (RC). When calculating the scaled plant's equipment cost, one should use the reference plant's equipment cost as the reference cost; likewise, when calculating the scaled plant's material cost, one should use the reference plant's material cost as the reference cost, etc. The sum of these costs is the bare erected cost (BEC).

The process contingency, project contingency, engineering construction management, home office, and fee are based on a percentage of the BEC. These percentages can be calculated by using Equation 2:

Equation 2

$$SCon = \frac{RCon}{RBEC}$$

Where:

- SCon – Scaled plant's contingency, %
- RCon – Reference plant's contingency, $
- RBEC – Reference plant's BEC, $

The scaled plant's contingency percentage is multiplied by the scaled plant's BEC to get the scaled plant's contingency dollar value. The process is repeated for each of the individual contingencies.

The sum of the BEC and the contingencies is the total plant cost (TPC) for each sub-account.

The example calculations will focus on determining a scaled equipment cost for each subaccount. As such, subaccounts 5A.7 and 5A.9 will not be demonstrated, as their reference value is $0.

By comparing the scaling parameter to the range of applicability, it is confirmed that it is suitable to develop a scaled cost estimate for the plant of interest using the scaling parameters, exponents, and coefficients obtained from within this document.

Based on the general guidelines provided in Section 3 along with the specific guidelines provided in Section 3.2 for IGCC plants, the following equations will be utilized:

For all categories, unless otherwise specified, Equation 3 is used to scale costs.

Equation 3

$$SC = RC * \left(\frac{SP}{RP}\right)^{Exp}$$

Where:

- Exp – Exponent
- RC– Reference cost
- RP – Reference parameter

- SC – Scaled cost
- SP – Scaling parameter

For IGCC categories, use Equation 4 for items that utilize a coefficient in addition to an exponent.

Equation 4

$$SC = \frac{RC}{RTPC} * C * SP^{Exp}$$

Where:

- C – Coefficient
- Exp – Exponent
- RC– Reference cost
- RTPC – Reference total plant cost for subaccount
- SC – Scaled cost
- SP – Scaling parameter

Account 5A.1 will use Equation 3 with the parameter "Gas flow to AGR" in actual ft^3/min. The equation is as follows:

Example 1

$$SC = \$76{,}466 = \$73{,}047 * \left(\frac{12{,}068 \frac{ft^3}{min}}{11{,}389 \frac{ft^3}{min}} \right)^{0.79}$$

Based on the Note for Account 5A.3, it contains a coefficient. Therefore, this account will use Equation 4 with the parameter "Hg bed carbon fill" in ft^3. The equation is as follows:

Example 2

$$SC = \$2{,}544 = \frac{\$1{,}328}{\$3{,}218} * 0.0141 * 3{,}916 ft^{3^{1.57}}$$

All other subaccounts will use Equation 3 as was demonstrated in Example 1. Exhibit 2-4 provides the results of the calculations and compares them to the reference value.

Exhibit 2-4. Example Account 5: Parameter listing

Account Number	Item Description	Parameter	Reference Parameter	Reference Cost (Equipment)	Scaling Parameter	Scaled Cost (Equipment)
5A.1	Selexol (Double)	Gas flow to AGR, acfm	11,389	$73,047	12,068	$76,466
5A.2	Elemental Sulfur Plant	Sulfur Production, lb/hr	4,901	$5,613	5,339	$5,944
5A.3	Mercury Removal	Hg bed carbon fill, ft^3	N/A	$1,328	3,916	$2,544
5A.4	Shift Reactors	WGS Catalyst volume, ft^3	6,257	$8,762	6,692	$9,246
5A.6	Blowback Gas Systems	Candle filter flow rate, acfm	24,282	$2,030	26,838	$2,092

3 Scaling Exponents and Equations

In all instances, the range is intended to present the reader with the ranges at which the exponents have already been utilized. It is expected that the ranges, in reality, would be capable of being applied to the median range ± 25 percent.

For all categories, unless otherwise specified, Equation 3 is used to scale costs.

Equation 3

$$SC = RC * \left(\frac{SP}{RP}\right)^{Exp}$$

Where:

- Exp – Exponent
- RC– Reference cost
- RP – Reference parameter
- SC – Scaled cost
- SP – Scaling parameter

3.1 PC and CFBC

For PC and CFBC categories, use Equation 5 for items that utilize a coefficient in addition to an exponent. In the "Scaling parameters and exponents" tables below, the values presented within brackets [] are coefficients.

Equation 5

$$SC = \frac{RC}{RTPC} * (C * SP)^{Exp}$$

Where:

- C – Coefficient
- Exp – Exponent
- RC– Reference cost
- RTPC – Reference total plant cost of subaccount
- SC – Scaled cost
- SP – Scaling parameter

Exhibit 3-1 provides the category matrix for the PC and CFBC categories.

Exhibit 3-1. Category matrix: PC and CFBC

Category	Technologies
1	Supercritical PC, air-fired, with and without CO_2 capture, Illinois No. 6 coal with hybrid poplar
	Supercritical PC, oxy-fired, with CO_2 capture, Illinois No. 6 coal with hybrid poplar
	Supercritical and ultra-supercritical[A] PC, oxy-fired, with CO_2 capture, Illinois No. 6 coal
2	CFBC, air-fired, with and without CO_2 capture, PRB and ND Lignite coals
	CFBC, oxy-fired, with CO_2 capture, PRB and ND Lignite coals
3	Supercritical PC, air-fired, with and without CO_2 capture, ND Lignite and PRB coals
	Ultra-supercritical PC,[A] air-fired, with and without CO_2 capture, ND Lignite and PRB coals
	Supercritical PC, oxy-fired, with CO_2 capture, ND Lignite and PRB coals
	Ultra-supercritical PC,[A] oxy-fired, with CO_2 capture, ND Lignite and PRB coals
4	Supercritical and ultra-supercritical[A] PC, air-fired, with and without CO_2 capture, Illinois No. 6 coal
5	Subcritical PC, air-fired, with and without CO_2 capture, Illinois No. 6 coal

[A]Ultra-supercritical PC plants have a 10 percent process contingency applied to line item 4.1 (PC Boiler and Accessories) and a 15 percent process contingency applied to line item 8.1 (Steam Turbine Generator and Accessories).

Exhibit 3-2 through Exhibit 3-15 contains the scaling parameters and exponents that are suitable for PC and CFBC plants at the given ranges.

Exhibit 3-2. Scaling parameters and exponents for categories 1-5: "Fuel and Sorbent Handling"

Account Number	Item Description	Parameter	Exponent					Range
Category		1-5	1	2	3	4	5	1-5
1	FUEL & SORBENT HANDLING							
1.1	Coal Receive & Unload	Coal Feed Rate, lb/hr	0.62					275,000 – 1,110,000
1.2	Coal Stackout & Reclaim	Coal Feed Rate, lb/hr	0.62					275,000 – 1,110,000
1.3	Coal Conveyors & Yard Crushing	Coal Feed Rate, lb/hr	0.62					275,000 – 1,110,000
1.4	Other Coal Handling	Coal Feed Rate, lb/hr	0.62					275,000 – 1,110,000
1.5	Biomass Receiving & Processing	Biomass Feed Rate, lb/hr	See Note[A]					412,000 – 616,000
1.6	Sorbent Receive & Unload	Limestone Feed Rate, lb/hr	0.64					9,000 – 63,000
1.7	Sorbent Stackout & Reclaim	Limestone Feed Rate, lb/hr	0.64					9,000 – 63,000
1.8	Sorbent Conveyors	Limestone Feed Rate, lb/hr	0.64					9,000 – 63,000
1.9	Other Sorbent Handling	Limestone Feed Rate, lb/hr	0.64					9,000 – 63,000
1.10	Coal & Sorbent Handling Foundations	Coal and Limestone Feed Rate, lb/hr	0.62					302,000 – 1,150,000

[A]Only applicable to plants co-firing hybrid poplar. Use Equation 6 with exponent 0.37 for equipment and Equation 7 with exponent 0.45 for direct labor. Values provided in $1,000 (2007$).

Equation 6

$$SC = 215,062 * \left(\frac{SP}{2000} * 24\right)^{Exp}$$

Equation 7

$$SC = 132,454 * \left(\frac{SP}{2000} * 24\right)^{Exp}$$

Exhibit 3-3. Scaling parameters and exponents for categories 1-5: "Fuel and Sorbent Prep and Feed"

Account Number	Item Description	Parameter	Exponent					Range
Category		1-5	1	2	3	4	5	1-5
2	FUEL & SORBENT PREP & FEED							
2.1	Coal Crushing & Drying	Coal Feed Rate, lb/hr	0.66					275,000 – 1,110,000
2.2	Prepared Coal Storage & Feed	Coal Feed Rate, lb/hr	0.66					275,000 – 1,110,000
2.5	Biomass Drying	Biomass Feed Rate, lb/hr	0.66[A]					412,000 – 616,000
2.6	Biomass Pelletization	Biomass Feed Rate, lb/hr	0.66[B]					412,000 – 616,000
2.7	Prepared Biomass Storage & Feed	Biomass Feed Rate, lb/hr	0.66					412,000 – 616,000
2.8	Sorbent Prep Equipment	Limestone Feed Rate, lb/hr	0.65					10,000 – 57,000
2.9	Sorbent Storage & Feed	Limestone Feed Rate, lb/hr	0.65					10,000 – 57,000
2.12	Coal & Sorbent Feed Foundation	Coal and Limestone Feed Rate, lb/hr	0.64					303,000 – 1,150,000

[A]Only applicable to plants co-firing hybrid poplar. Use Equation 8 with a coefficient of 7.0428 for equipment and 1.3724 for direct labor. Values provided in $1,000 (2007$).
[B]Only applicable to plants co-firing hybrid poplar. Use Equation 9 for equipment.

Equation 8

$$\boldsymbol{SC = C * \left(\frac{SP}{2000} * 24\right)^{Exp}}$$

Equation 9

$$SC = RC * \left(\frac{SP}{10 * 1.1 * 2000}\right)^{Exp}$$

Exhibit 3-4. Scaling parameters and exponents for categories 1-5: "Feedwater and Miscellaneous BOP Systems"

Account Number	Item Description	Parameter	Exponent					Range
Category		1-5	1	2	3	4	5	1-5
3	FEEDWATER & MISC. BOP SYSTEMS							
3.1	Feedwater System	HP BFW Flow Rate, lb/hr	0.68					1,960,000 – 5,600,000
3.2	Water Makeup & Pretreating	Raw Water Withdrawal, gpm	0.71					2,000 – 11,000
3.3	Other Feedwater Subsystems	HP BFW Flow Rate, lb/hr	0.68					1,960,000 – 5,600,000
3.4	Service Water Systems	Raw Water Withdrawal, gpm	0.71					2,000 – 11,000
3.5	Other Boiler Plant Systems	HP BFW Flow Rate, lb/hr	0.75					1,960,000 – 5,600,000
3.6	FO Supply Sys & Nat Gas	Total Fuel Feed, lb/hr	0.25					410,000 – 1,110,000
3.7	Waste Treatment Equipment	Water to Treatment, lb/hr	0.71					100 – 1,210,000
3.8	Misc. Power Plant Equipment	Total Fuel Feed, lb/hr	0.25					410,000 – 1,110,000

Exhibit 3-5. Scaling parameters and exponents for categories 1-5: "PC Boiler and Accessories"

Account Number	Item Description	Parameter	Exponent					Range
Category		1-5	1	2	3	4	5	1-5
4	PC BOILER & ACCESSORIES							
4.1	PC Boiler & Accessories	See Note[A]	0.69					See Note[A]
4.2	ASU/Oxidant Compression	O_2 Flow Rate, TPD	0.60					13,200 – 15,100

[A]CFBC plants use the sum of limestone and coal feed rates (lb/hr) with the total ranging from 303,000 – 1,150,000; Oxy-fired PC with no biomass use coal-feed rates (lb/hr) ranging from 275,000 – 1,112,000; PC air-fired and PC with biomass use high pressure (HP) boiler feed water (BFW) flow rates (lb/hr) ranging from 1,958,000 – 5,603,000.

Exhibit 3-6. Scaling parameters and exponents for categories 1-5: "Flue Gas Cleanup"

Account Number	Item Description	Parameter	Exponent [Coefficient]					Range
Category		1-5	1	2	3	4	5	1-5
5	FLUE GAS CLEANUP							
5A.1	Absorber Vessels & Accessories	FGD Exit Flow, acfm	0.73 [3.08]	N/A	0.59 [23.75][A]	0.73	0.73	1,020,000 – 2,560,000
5A.2	Other FGD	FGD Exit Flow, acfm	0.73 [0.28]	N/A	0.49[B]	0.73	0.73	1,020,000 – 2,560,000
5A.3	Bag House & Accessories	Baghouse Flow, acfm	0.78 [0.47]	N/A	N/A	0.79	0.79	1,390,000 – 2,560,000
5A.4	Other Particulate Removal Materials	Baghouse Flow, acfm	0.77	N/A	0.40 [112.22][C]	0.79	0.79	1,390,000 – 2,560,000
5A.5	Gypsum Dewatering System	Gypsum Flow, lb/hr	0.60	N/A	N/A	0.60	0.60	42,900 – 96,600
5A.6	Mercury Removal System	Activated Carbon Flow, lb/hr	N/A	N/A	N/A	0.61	0.61	230 – 300

[A]Ultra-supercritical plants use a coefficient of 25.9090 and an exponent of 0.5810.
[B]Ultra-supercritical plants use an exponent of 0.46.
[C]Ultra-supercritical plants use a coefficient of 92.44 and an exponent of 0.4152.

Exhibit 3-7. Scaling parameters and exponents for categories 1-5: "CO_2 Removal and Compression"

Account Number	Item Description	Parameter	Exponent [Coefficient]					Range
Category		1-5	1	2	3	4	5	1-5
5B	CO_2 REMOVAL & COMPRESSION							
5B.1	CO_2 Condensing Heat Exchanger	Heat Duty, MMBtu/hr	0.80	0.80	0.80	N/A	N/A	200 – 600
	CO_2 Removal System	CO_2 Flowrate, lb/hr Inlet to Absorber, acfm	0.60[A]	N/A	N/A	0.60[A]	0.60[A]	850,000 – 2,290,000 N/A[B]
5B.2	CO_2 Compression & Drying	CO_2 Flowrate, lb/hr	0.61[C]					850,000 – 2,290,000

[A]For cases reported in Revision 2a of the Bituminous Baseline, use exponent 0.70 and the parameter "Volumetric flow to stack, acfm."
[B]For cases reported in Revision 2a of the Bituminous Baseline, use exponent 0.70.
[C]For cases reported in Revision 2a of the Bituminous Baseline, use exponent 0.35.

Exhibit 3-8. Scaling parameters and exponents for categories 1-5: "HRSG, Ducting, and Stack"

Account Number	Item Description	Parameter	Exponent [Coefficient]					Range
Category		1-5	1	2	3	4	5	1-5
7	HRSG, DUCTING & STACK							
7.1	Flue Gas Recycle Heat Exchanger	Heat Duty, MMBtu/hr	0.80					20 – 1,000
7.3	Ductwork	Total Fuel Feed, lb/hr	0.38 [126.25]	0.38 [126.25]	0.38 [126.25]	0.29[A]	0.29[A]	410,000 – 1,110,000
7.4	Stack	Stack Flow, acfm	0.48 [19.52]	0.48 [19.52]	0.48 [19.52]	0.06[B]	0.06	378,000 – 1,840,000
7.9	HRSG, Duct & Stack Foundations	Total Fuel Feed, lb/hr	0.14 [471.71]	0.14 [471.71]	0.14 [471.71]	0.06[A]	0.06[A]	410,000 – 1,110,000

[A]For cases reported in Revision 2a of the Bituminous Baseline, use exponent 0.70 and the parameter "Volumetric flow to stack, acfm."
[B]For cases reported in Revision 2a of the Bituminous Baseline, use exponent 0.70.

Exhibit 3-9. Scaling parameters and exponents for categories 1-5: "Steam Turbine Generator"

Account Number	Item Description	Parameter	Exponent					Range
Category		1-5	1	2	3	4	5	1-5
8	STEAM TURBINE GENERATOR							
8.1	Steam TG & Accessories	Turbine Capacity, MW	0.70					600 – 800
8.2	Turbine Plant Auxiliaries	Turbine Capacity, MW	0.70					600 – 800
8.3a	Condenser & Auxiliaries	Condenser Duty, MMBtu/hr	0.67	0.67	0.67	0.67	0.40	1,000 – 3,000
8.3b	Air Cooled Condenser	Condenser Duty, MMBtu/hr	N/A	N/A	N/A	0.70	N/A	1,000 – 3,000
8.4	Steam Piping	HP BFW Flow Rate, lb/hr	0.70[A]					1,960,000 – 5,600,000
8.9	TG Foundations	Turbine Capacity, MW	0.71					600 – 800

[A]For cases reported in Revision 2a of the Bituminous baseline, use exponent 0.60.

Exhibit 3-10. Scaling parameters and exponents for categories 1-5: "Cooling Water System"

Account Number	Item Description	Parameter	Exponent					Range
Category		1-5	1	2	3	4	5	1-5
9	COOLING WATER SYSTEM							
9.1	Cooling Towers	Cooling Tower Duty, MMBtu/hr	0.74[A]					1,000 – 6,000
9.2	Circulating Water Pumps	Circulating Water Flow Rate, gpm	0.86	0.73	0.73	0.86[A]	0.73[A]	115,000 – 550,000
9.3	Circ. Water System Auxiliaries	Circulating Water Flow Rate, gpm	0.63					115,000 – 550,000
9.4	Circ. Water Piping	Circulating Water Flow Rate, gpm	0.63					115,000 – 550,000
9.5	Make-up Water System	Raw Water Withdrawal, gpm	0.64	0.64	0.64[B]	0.64	0.64	2,000 – 11,200
9.6	Component Cooling Water System	Circulating Water Flow Rate, gpm	0.63					115,000 – 550,000
9.9	Circ. Water System Foundations	Circulating Water Flow Rate, gpm	0.58					115,000 – 550,000

[A]For cases reported in Revision 2a of the Bituminous Baseline, use exponent 0.70.
[B]The exponent 0.82 should be used with ultra-supercritical plants.

Exhibit 3-11. Scaling parameters and exponents for categories 1-5: "Ash and Spent Sorbent Handling System"

Account Number	Item Description	Parameter	Exponent					Range
Category		1-5	1	2	3	4	5	1-5
10	ASH/SPENT SORBENT HANDLING SYSTEM							
10.6	Ash Storage Silos	Total Ash Flow, TPH	0.56					10 – 100
10.7	Ash Transport & Feed Equipment	Total Ash Flow, TPH	0.56					10 – 100
10.9	Ash/Spent Sorbent Foundation	Total Ash Flow, TPH	0.56					10 – 100

Exhibit 3-12. Scaling parameters and exponents for categories 1-5: "Accessory Electric Plant"

Account Number	Item Description	Parameter	Exponent [Coefficient]					Range
Category		1-5	1	2	3	4	5	1-5
11	ACCESSORY ELECTRIC PLANT							
11.1	Generator Equipment	Turbine Capacity, MW	0.57					600 – 800
11.2	Station Service Equipment	Auxiliary Load, kW	0.43					28,300 – 272,000
11.3	Switchgear & Motor Control	Auxiliary Load, kW	0.43					28,300 – 272,000
11.4	Conduit & Cable Tray	Auxiliary Load, kW	0.43					28,300 – 272,000
11.5	Wire & Cable	Auxiliary Load, kW	0.43					28,300 – 272,000
11.6	Protective Equipment	Auxiliary Load, kW	0.00					28,300 – 272,000
11.7	Standby Equipment	Turbine Capacity, MW	0.46					588 – 835
11.8	Main Power Transformers	STG Rating, MVA	0.46 [418.03]	0.46 [418.03]	0.46 [418.03]	0.48	2.11	10 – 1000
11.9	Electrical Foundations	Turbine Capacity, MW	0.69					600 – 800

Exhibit 3-13. Scaling parameters and exponents for categories 1-5: "Instrumentation and Control"

Account Number	Item Description	Parameter	Exponent [Coefficient]					Range
Category		1-5	1	2	3	4	5	1-5
12	INSTRUMENTATION & CONTROL							
12.6	Control Boards, Panels & Racks	Auxiliary Load, kW	0.13					28,300 – 272,000
12.7	Computer Accessories	Auxiliary Load, kW	0.13					28,300 – 272,000
12.8	Instrument Wiring & Tubing	Auxiliary Load, kW	0.13					28,300 – 272,000
12.9	Other I&C Equipment	Auxiliary Load, kW	0.13					28,300 – 272,000

Exhibit 3-14. Scaling parameters and exponents for categories 1-5: "Improvements to Site"

Account Number	Item Description	Parameter	Exponent					Range
Category		1-5	1	2	3	4	5	1-5
13	IMPROVEMENTS TO SITE							
13.1	Site Preparation	BEC (Minus Acts. 13 and 14)	0.20					735,000 – 1,630,000
13.2	Site Improvements	BEC (Minus Acts. 13 and 14)	0.20					735,000 – 1,630,000
13.3	Site Facilities	BEC (Minus Acts. 13 and 14)	0.20					735,000 – 1,630,000

Exhibit 3-15. Scaling parameters and exponents for categories 1-5: "Buildings and Structures"

Account Number	Item Description	Parameter	Exponent					Range
Category		1-5	1	2	3	4	5	1-5
14	BUILDINGS & STRUCTURES							
14.1	Boiler Building	BEC (Minus Acts. 13 and 14)	0.09					735,000 – 1,630,000
14.2	Turbine Building	BEC (Minus Acts. 13 and 14)	0.12					735,000 – 1,630,000
14.3	Administration Building	BEC (Minus Acts. 13 and 14)	0.10					735,000 – 1,630,000
14.4	Circulation Water Pumphouse	Circulating Water Flow Rate, gpm	0.60					115,000 – 550,000
14.5	Water Treatment Buildings	Raw Water Withdrawal, gpm	0.65					2,000 – 11,200
14.6	Machine Shop	BEC (Minus Acts. 13 and 14)	0.10					735,000 – 1,630,000
14.7	Warehouse	BEC (Minus Acts. 13 and 14)	0.10					735,000 – 1,630,000
14.8	Other Buildings & Structures	BEC (Minus Acts. 13 and 14)	0.10					735,000 – 1,630,000
14.9	Waste Treating Building & Structures	Raw Water Withdrawal, gpm	0.07					2,000 – 11,200

3.2 IGCC

Exhibit 3-16 provides the category matrix for IGCC categories.

Exhibit 3-16. Category matrix: IGCC

Category	Technologies
6	Single-stage, dry-feed, oxygen-blown, down-flow gasifier with and without CO_2 capture, PRB and ND Lignite coals
7	Two-stage, slurry-feed, oxygen-blown gasifier with and without CO_2 capture, PRB and Illinois No. 6 coal
	Single-stage, slurry-feed, oxygen-blown gasifier with and without CO_2 capture, Illinois No. 6 coal
8	Single-stage, dry-feed, oxygen-blown, up-flow gasifier, with CO_2 capture, PRB coal with and without switchgrass
	Single-stage, dry-feed, oxygen-blown, up-flow gasifier with CO_2 capture, Illinois No. 6 coal with switchgrass
	Single-stage, dry-feed, oxygen-blown, up-flow gasifier, with and without CO_2 capture, PRB and ND Lignite coals
	Single-stage, dry-feed, oxygen-blown, up-flow gasifier with and without CO_2 capture, Illinois No. 6 coal
9	Transport gasifier, air- and oxygen-blown, with and without CO_2 capture, PRB and TX Lignite coals
	Transport gasifier, oxygen-blown with CO_2 capture, TX Lignite coal, with hybrid poplar

For IGCC categories, use Equation 4 for items that utilize a coefficient in addition to an exponent. In the "scaling parameters and exponents" tables below, the values presented within brackets [] are coefficients.

Equation 4

$$SC = \frac{RC}{RTPC} * C * SP^{Exp}$$

Exhibit 3-17 through Exhibit 3-31 contain the scaling parameters and exponents that are suitable for IGCC plants at the given ranges.

Exhibit 3-17. Scaling parameters and exponents for categories 6-9: "Fuel and Sorbent Handling"

Account Number	Item Description	Parameter	Exponent				Range
Category		6-9	6	7	8	9	6-9
1	FUEL & SORBENT HANDLING						
1.1	Coal Receive & Unload	Coal Feed Rate, lb/hr	0.62				18,400 – 1,750,000
1.2	Coal Stackout & Reclaim	Coal Feed Rate, lb/hr	0.62				18,400 – 1,750,000
1.3	Coal Conveyors & Yard Crush	Coal Feed Rate, lb/hr	0.62				18,400 – 1,750,000
1.4	Other Coal Handling	Coal Feed Rate, lb/hr	0.62				18,400 – 1,750,000
1.5	Biomass Receive & Unload	Biomass Feed, lb/hr	0.62	0.62	0.62	See Note[A]	6,000 – 934,000
1.6	Biomass Handling	Biomass Feed, lb/hr	0.62				6,000 – 934,000
1.7	Biomass Conveyors	Biomass Feed, lb/hr	0.62				6,000 – 934,000
1.8	Biomass Handling Foundations	Biomass Feed, lb/hr	0.62				6,000 – 934,000
1.9	Coal & Sorbent Handling Foundations	Coal Feed Rate, lb/hr	0.62				18,400 – 1,750,000

[A]Use Equation 6 with exponent 0.37 for equipment and Equation 7 with exponent 0.45 for direct labor. Values provided in $1,000 (2007$).

Exhibit 3-18. Scaling parameters and exponents for categories 6-9: “Fuel and Sorbent Prep and Feed”

<table>
<tr><th>Account Number</th><th>Item Description</th><th>Parameter</th><th colspan="4">Exponent [Coefficient]</th><th>Range</th></tr>
<tr><td colspan="2">Category</td><td>6-9</td><td>6</td><td>7</td><td>8</td><td>9</td><td>6-9</td></tr>
<tr><td>2</td><td colspan="7">FUEL & SORBENT PREP & FEED</td></tr>
<tr><td>2.1</td><td>Coal Crushing & Drying</td><td>Coal Feed Rate, lb/hr</td><td colspan="4">0.66</td><td>18,400 – 1,750,000</td></tr>
<tr><td>2.2</td><td>Prepared Coal Storage & Feed</td><td>Coal Feed Rate, lb/hr</td><td colspan="4">0.66</td><td>18,400 – 1,750,000</td></tr>
<tr><td>2.3</td><td>Dry Coal Injection System/
Slurry Prep and Feed</td><td>Coal Feed Rate, lb/hr</td><td colspan="4">0.66</td><td>18,400 – 1,750,000</td></tr>
<tr><td>2.4</td><td>Misc. Coal Prep & Feed</td><td>Coal Feed Rate, lb/hr</td><td>0.66</td><td>0.66</td><td>0.66</td><td>0.90</td><td>18,400 – 1,750,000</td></tr>
<tr><td>2.5</td><td>Biomass Shredding & Drying</td><td>Biomass Feed, lb/hr</td><td colspan="4">0.66[A]</td><td>6,000 – 934,000</td></tr>
<tr><td>2.6</td><td>Biomass Pelletization/
Dry Biomass Injection System</td><td>Biomass Feed, lb/hr</td><td colspan="4">0.66</td><td>6,000 – 934,000</td></tr>
<tr><td>2.7</td><td>Prepared Biomass Storage & Feed</td><td>Biomass Feed, lb/hr</td><td colspan="4">0.66</td><td>6,000 – 934,000</td></tr>
<tr><td>2.9</td><td>Coal & Sorbent Feed Foundation</td><td>Total Feed Flow Rate, lb/hr</td><td colspan="4">0.66</td><td>467,100 – 1,750,000</td></tr>
</table>

[A]For oxygen-blown transportation gasification with CO_2 capture firing TX Lignite coal with hybrid poplar co-fire, use Equation 8 with a coefficient of 7.0428 to calculate equipment costs and a coefficient of 1.3724 to calculate direct labor costs. Values are provided in $1,000 (2007$).

Equation 8

$$SC = C * \left(\frac{SP}{2000} * 24\right)^{Exp}$$

Exhibit 3-19. Scaling parameters and exponents for categories 6-9: "Feedwater and Miscellaneous BOP Systems"

Account Number	Item Description	Parameter	Exponent [Coefficient]				Range
Category		6-9	6	7	8	9	6-9
3	FEEDWATER & MISC. BOP SYSTEMS						
3.1	Feedwater System	BFW (HP only), lb/hr	0.71				500,000 – 2,000,000
3.2	Water Makeup & Pretreating	Raw Water Withdrawal, gpm	0.71				300 – 9,000
3.3	Other Feedwater Subsystems	BFW (HP only), lb/hr	0.71				500,000 – 2,000,000
3.4	Service Water Systems	Raw Water Withdrawal, gpm	0.71				300 – 9,000
3.5	Other Boiler Plant Systems	Raw Water Withdrawal, gpm	0.73	0.73	0.73	0.25	300 – 9,000
3.6	FO Supply Sys & Nat Gas	Total Feed Flow Rate, lb/hr	0.00	0.24	0.24	0.00	467,000 – 1,750,000
3.7	Waste Treatment Equipment	Raw Water Withdrawal, gpm	0.71[A]				300 – 9,000
3.8	Misc. Power Plant Equipment	Total Feed Flow Rate, lb/hr	0.66	0.24	0.24	0.06	467,000 – 1,750,000

[A]For waste treatment equipment that includes systems designed to achieve zero liquid discharge, scale on the parameter "Gray water flow rate, gpm."

Exhibit 3-20. Scaling parameters and exponents for categories 6-9: "Gasifier and Accessories"

Account Number	Item Description	Parameter	Exponent [Coefficient]				Range
Category		6-9	6	7	8	9	6-9
4	GASIFIER & ACCESSORIES						
4.1	Gasifier, Syngas Cooler & Auxiliaries	SGC Duty, MMBtu/hr Total Feed Flow Rate, lb/hr	0.00	0.77/1.19 [0.29/0.71][A]	0.53 [214.0][B]	0.31/0.64 [0.51/0.49][A]	200 – 1,000 467,000 – 1,750,000
4.3	ASU/Oxidant Compression	O_2 Production, TPD MAC Power, kW	2.39/0.89 [0.09/0.91][A]	0.70/0.70 [0.50/0.50][A]	0.70/0.54 [0.80/0.20][C]	0.36/0.36[D] [0.50/0.50][A]	3,400 – 21,000 5,000 – 316,000
4.4	LT Heat Recovery & FG Saturation/ Scrubber & Low Temperature Cooling	Total Feed Flow Rate, lb/hr	See Note[E]				467,000 – 1,750,000
4.6	Flare Stack System/ Soot Recovery & SARU/ Other Gasification Equipment	Total Feed Flow Rate, lb/hr	See Note[F]	0.50	0.50	0.40	467,000 – 1,750,000
4.9	Gasification Foundations	Total Feed Flow Rate, lb/hr	0.50	0.50	0.50	0.40	467,000 – 1,750,000

[A]Use Equation 10.
[B]Non-biomass plants with PRB or ND Lignite coal use Equation 11. Non-biomass plants with Illinois No. 6 coal use exponent 0.66 with Equation 3. For cases from Revision 2b of the Bituminous Baseline see Category 7.
[C]Biomass plants use Equation 13, values provided in $1,000 (2007$). Non-biomass plants use Equation 10 with Exponents of 0.70/0.70 and Coefficients of 0.50/0.50.
[D]TRIG air-fired plants scale on combustion turbine extraction air flow rate, lb/hr, rather than O_2 production rate.
[E]The ratio of Account 4.4 divided by Account 4.1 should be maintained from the reference case.
[F]Use Equation 12.

Equation 10

$$SC = C_1 * RC * \left(\frac{SP_1}{RP_1}\right)^{Exp_1} + C_2 * RC * \left(\frac{SP_2}{RP_2}\right)^{Exp_2}$$

Equation 11

$$SC = \frac{RC}{RTPC} * (40{,}689 * DCF^{0.136} + 289{,}128 * DCF)$$

Equation 12

$$\boldsymbol{STPC = 10^{\left[\begin{array}{c}(52.825736*\log_{10} SP^3)-(924.074743*\log_{10} SP^2)+\\ (5388.117529*\log_{10} SP)-10468.642234\end{array}\right]}}$$

Equation 13

$$SC = C_1 * RC_1 * SP_1^{Exp} + C_2 * RC_2 * SP_2^{Exp}$$

Where:

- STPC – Scaled total plant cost for subaccount
- DCF – Dry coal feed, lb/hr

Exhibit 3-21. Scaling parameters and exponents for categories 6-9: "Gas Cleanup and Piping"

Account Number	Item Description	Parameter	Exponent [Coefficient]				Range
	Category	6-9	6	7	8	9	6-9
5	GAS CLEANUP & PIPING						
5A.1	Sulfinol/Selexol (Single and Double)/MDEA-LT	Gas flow to AGR, acfm	0.85	0.79	0.79	0.95	5,700 – 30,500
5A.2	Elemental Sulfur Plant	Sulfur Production, lb/hr	0.67	0.67	0.58 [131.42][A]	0.67	300 – 43,900
5A.3	Mercury Removal	Hg bed carbon fill, ft^3	0.69 [11.05]	See Note[B]	0.034 [1.461][C]	0.70	2,000 – 35,100
5A.4	Shift Reactors/COS Hydrolysis	WGS Catalyst volume, ft^3 COS Catalyst volume, ft^3	0.12	0.80	0.59/0.78	0.75	2,000 – 10,600 9,000 – 25,500
5A.5	Blowback Gas Systems	Candle filter flow rate, acfm	N/A	0.30[D]	0.75[E]	0.41	2,000 – 96,000
5A.6	Fuel Gas Piping	Fuel gas flow, lb/hr	0.7224 [2.282]	0.72	0.78 [1.87][F]	0.58	185,000 – 2,490,000
5A.9	HGCU Foundations	Sulfur Production, lb/hr	0.79	0.79	0.52[G]	0.79	300 – 43,900

[A] Non-biomass plants use the exponent 0.67 and coefficient 61.981. For cases from Revision 2b of the Bituminous Baseline, use exponent 0.67 with Equation 3.
[B] Use exponent 1.57 with PRB coal, use exponent 1.64 with Illinois No. 6 coal without CO_2 capture, and use exponent 1.59 with Illinois No. 6 coal with CO_2 capture. The coefficient 0.0141 is used with all plants. For cases from Revision 2b of the Bituminous Baseline, use exponent 0.68 with Equation 3.
[C] Non-biomass plants with Illinois No. 6 coal, use Equation 3 with an exponent of 0.60. All other non-biomass plants use the coefficient of 0.0141 and exponent of 1.5742. For cases from Revision 2b of the Bituminous Baseline, use exponent 0.68 with Equation 3.
[D] For cases from Revision 2b of the Bituminous Baseline, use exponent 0.75.
[E] Non-biomass plants use the exponent of 0.30. For cases from Revision 2b of the Bituminous Baseline, use exponent 0.75.
[F] Non-biomass plants use the coefficient 2.282 and exponent 0.7224.
[G] Non-biomass plants use the exponent of 0.79.

Exhibit 3-22. Scaling parameters and exponents for categories 6-9: “CO_2 Compression”

Account Number	Item Description	Parameter	Exponent				Range
Category		6-9	6	7	8	9	6-9
5B	CO_2 COMPRESSION						
5B.2	CO_2 Compression & Drying	Compressor Power, kW	0.63	0.88	0.88[A]	0.67	28,300 – 43,500

[A]Biomass plants use the exponent 0.79 with the scaling parameter “CO2 Captured, lb/hr,” and a range of 1,000,000 – 2,200,000 lb/hr.

Exhibit 3-23. Scaling parameters and exponents for categories 6-9: “Combustion Turbine and Accessories”

Account Number	Item Description	Parameter	Exponent				Range
Category		6-9	6	7	8	9	6-9
6	COMBUSTION TURBINE/ACCESSORIES						
6.1	Combustion Turbine Generator	Fuel gas flow, lb/hr	0.00				185,000 – 2,490,000
6.2	Sweet Gas Expander	Fuel gas flow, lb/hr	N/A	0.04	N/A	N/A	198,808 – 875,333
6.9	Combustion Turbine Foundations	Fuel gas flow, lb/hr	0.00				185,000 – 2,490,000

Exhibit 3-24. Scaling parameters and exponents for categories 6-9: “HRSG, Ducting, and Stack”

Account Number	Item Description	Parameter	Exponent				Range
Category		6-9	6	7	8	9	6-9
7	HRSG, DUCTING & STACK						
7.1	Heat Recovery Steam Generator	HRSG duty, MMBtu/hr	0.70				600 – 5,000
7.3	Ductwork	Volumetric flow to stack, acfm	0.70	0.70	0.70	0.57	1,010,000 – 2,810,000
7.4	Stack	Volumetric flow to stack, acfm	0.70				1,010,000 – 2,810,000
7.9	HRSG, Duct & Stack Foundations	Volumetric flow to stack, acfm	0.70	0.70	0.70	0.67	1,010,000 – 2,810,000

Exhibit 3-25. Scaling parameters and exponents for categories 6-9: "Steam Turbine Generator"

Account Number	Item Description	Parameter	Exponent [Coefficient]				Range
Category		6-9	6	7	8	9	6-9
8	STEAM TURBINE GENERATOR						
8.1	Steam TG & Accessories	Turbine capacity, kW	0.70				195,000 – 371,000
8.2	Turbine Plant Auxiliaries	Turbine capacity, kW	0.72				195,000 – 371,000
8.3a	Condenser & Auxiliaries	Condenser duty, MMBtu/hr	0.71	0.71	0.70 [52.90][A]	0.71	500 – 2,000
8.3b	Air Cooled Condenser	BFW (HP only), lb/hr {Condenser Duty, MMBtu/hr}	0.36	0.73	{0.70}	1.14	500,000 – 2,000,000 500 – 2,000
8.4	Steam Piping	BFW (HP only), lb/hr	0.72	0.72[B]	0.63 [122.80][C]	0.72	500,000 – 2,000,000
8.9	TG Foundations	Turbine capacity, kW	0.72				195,000 – 371,000

[A]Non-biomass plants use a coefficient of 45.921 and exponent of 0.7. For cases reported in Revision 2b of the Bituminous Baseline, use exponent 0.67 with Equation 3.
[B]For cases reported in Revision 2b of the Bituminous Baseline, use exponent 0.61
[C]Non-biomass plants with PRB or ND Lignite coal use the exponent 0.7018 and coefficient 71.1. Non-biomass plants with Illinois No. 6 coal use the exponent 0.70 with Equation 3. For cases reported in Revision 2b of the Bituminous Baseline, use exponent 0.61 with Equation 3.

Exhibit 3-26. Scaling parameters and exponents for categories 6-9: "Cooling Water System"

Account Number	Item Description	Parameter	Exponent [Coefficient]				Range
Category		6-9	6	7	8	9	6-9
9	COOLING WATER SYSTEM						
9.1	Cooling Towers	Cooling tower duty, MMBtu/hr	0.90	0.72[A]	0.72[A]	0.72	1,000 – 4,000
9.2	Circulating Water Pumps	Circulating Water Flow Rate, gpm	0.72	0.72	0.69 [0.54][B]	0.72	92,600 – 330,000
9.3	Circ. Water System Auxiliaries	Circulating Water Flow Rate, gpm	0.64				92,600 – 330,000
9.4	Circ. Water Piping	Circulating Water Flow Rate, gpm	0.61				92,600 – 330,000
9.5	Make-up Water System	Raw Water Withdrawal, gpm	0.60				300 – 9,000
9.6	Component Cooling Water System	Circulating Water Flow Rate, gpm	0.64				92,600 – 330,000
9.9	Circ. Water System Foundations	Circulating Water Flow Rate, gpm	0.59				92,600 – 330,000

[A]For cases reported in Revision 2b of the Bituminous Baseline, use exponent 0.80.
[B]Non-biomass plants use the coefficient 0.6273 and exponent 0.6714. For cases reported in Revision 2b of the Bituminous Baseline, use exponent 0.71 with Equation 3.

Exhibit 3-27. Scaling parameters and exponents for categories 6-9: "Ash and Spent Sorbent Handling System"

Account Number	Item Description	Parameter	Exponent [Coefficient]				Range
Category		6-9	6	7	8	9	6-9
10	ASH/SPENT SORBENT HANDLING SYSTEM						
10.1	Slag Dewatering & Cooling	Slag production, lb/hr	0.64				7,000 – 351,000
10.6	Ash Storage Silos	Slag production, lb/hr	0.55				7,000 – 351,000
10.7	Ash Transport & Feed Equipment	Slag production, lb/hr	0.55				7,000 – 351,000
10.8	Misc. Ash Handling Equipment	Slag production, lb/hr	0.55				7,000 – 351,000
10.9	Ash/Spent Sorbent Foundation	Slag production, lb/hr	0.55				7,000 – 351,000

Exhibit 3-28. Scaling parameters and exponents for categories 6-9: "Accessory Electric Plant"

Account Number	Item Description	Parameter	Exponent				Range
Category		6-9	6	7	8	9	6-9
11	ACCESSORY ELECTRIC PLANT						
11.1	Generator Equipment	Turbine capacity, kW	0.54^{A}				195,000 – 371,000
11.2	Station Service Equipment	Auxiliary load, kW	0.45				107,000 – 423,000
11.3	Switchgear & Motor Control	Auxiliary load, kW	0.45				107,000 – 423,000
11.4	Conduit & Cable Tray	Auxiliary load, kW	0.45				107,000 – 423,000
11.5	Wire & Cable	Auxiliary load, kW	0.45				107,000 – 423,000
11.6	Protective Equipment	Auxiliary load, kW	0.00	0.00	0.00	0.65	107,000 – 423,000
11.7	Standby Equipment	Total Gross Output, kW	0.48	0.48	0.48	0.00	621,000 – 835,000
11.8	Main Power Transformers	Total Gross Output, kW	0.71	0.71	0.71	0.00	621,000 – 835,000
11.9	Electrical Foundations	Total Gross Output, kW	0.70	0.70	0.70	0.00	621,000 – 835,000

[A]For cases reported in Revision 2b of the Bituminous Baseline in categories 7 and 8, use exponent 0.21

Exhibit 3-29. Scaling parameters and exponents for categories 6-9: "Instrumentation and Control"

Account Number	Item Description	Parameter	Exponent				Range
Category		6-9	6	7	8	9	6-9
12	INSTRUMENTATION & CONTROL						
12.4	Other Major Component Control	Auxiliary load, kW	0.24	0.13	0.13	0.24	107,000 – 423,000
12.6	Control Boards, Panels & Racks	Auxiliary load, kW	0.24	0.13	0.13	0.24	107,000 – 423,000
12.7	Computer & Accessories	Auxiliary load, kW	0.24	0.13	0.13	0.24	107,000 – 423,000
12.8	Instrument Wiring & Tubing	Auxiliary load, kW	0.24	0.13	0.13	0.24	107,000 – 423,000
12.9	Other I&C Equipment	Auxiliary load, kW	0.24	0.13	0.13	0.24	107,000 – 423,000

Exhibit 3-30. Scaling parameters and exponents for categories 6-9: "Improvements to Site"

Account Number	Item Description	Parameter	Exponent				Range
Category		6-9	6	7	8	9	6-9
13	IMPROVEMENTS TO SITE						
13.1	Site Preparation	BEC Accts 1-12	0.34	0.08	0.08	0.34	1,040,000 – 1,680,000
13.2	Site Improvements	BEC Accts 1-12	0.33	0.08	0.08	0.33	1,040,000 – 1,680,000
13.3	Site Facilities	BEC Accts 1-12	0.34	0.08	0.08	0.34	1,040,000 – 1,680,000

Exhibit 3-31. Scaling parameters and exponents for categories 6-9: "Buildings and Structures"

Account Number	Item Description	Parameter	Exponent				Range
Category		6-9	6	7	8	9	6-9
14	BUILDINGS & STRUCTURES						
14.1	Combustion Turbine Area	Gas Turbine Power, kWe	0.00				51,200 – 471,000
14.2	Steam Turbine Building	BEC Accts 1-12	0.17	0.17	0.17	0.45	1,040,000 – 1,680,000
14.3	Administration Building	BEC Accts 1-12	0.00	0.10	0.10	0.00	1,040,000 – 1,680,000
14.4	Circulation Water Pumphouse	Circ. water flow rate, gpm	0.01	0.46	0.46	0.46	92,600 – 330,000
14.5	Water Treatment Buildings	Raw Water Withdrawal, gpm	0.71				300 – 9,000
14.6	Machine Shop	BEC Accts 1-12	0.32	0.10	0.02	0.00	1,040,000 – 1,680,000
14.7	Warehouse	BEC Accts 1-12	0.32	0.10	0.02	0.00	1,040,000 – 1,680,000
14.8	Other Buildings & Structures	BEC Accts 1-12	0.35	0.10	0.02	0.21	1,040,000 – 1,680,000
14.9	Waste Treating Building & Str.	Raw Water Withdrawal, gpm	0.08	0.08	0.08	0.08	300 – 9,000

3.3 NGCC

Exhibit 3-32 provides the category matrix for NGCC categories.

Exhibit 3-32. Category matrix: NGCC

Category	Technologies
10	Natural gas, air-fired, with and without CO_2 capture
	Natural gas, air-fired with CO_2 capture and gas recycle

Exhibit 3-33 through Exhibit 3-43

Exhibit 3-43contain the scaling parameters and exponents that are suitable for NGCC plants at the given ranges.

Exhibit 3-33. Scaling parameters and exponents for category 10: "Feedwater and Miscellaneous BOP Systems"

Account Number	Item Description	Parameter	Exponent	Range
	Category	10	10	10
3	FEEDWATER & MISC. BOP SYSTEMS			
3.1	Feedwater System	Feedwater flow (HP only), lb/hr	0.72	886,000 – 1,350,000
3.2	Water Makeup & Pretreating	Raw Water Withdrawal, gpm	0.71	2,600 – 5,000
3.3	Other Feedwater Subsystems	Feedwater flow (HP only), lb/hr	0.72	886,000 – 1,350,000
3.4	Service Water Systems	Raw Water Withdrawal, gpm	0.71	2,600 – 5,000
3.5	Other Boiler Plant Systems	Raw Water Withdrawal, gpm	0.71	2,600 – 5,000
3.6	Natural Gas, incl. pipeline	Fuel gas flow, acfm average	0.07[A]	2,000 – 4,000
3.7	Waste Treatment Equipment	Raw Water Withdrawal, gpm	0.71	2,600 – 5,000
3.8	Misc. Equip. (cranes, Air Compressor, etc.)	Fuel gas flow, acfm average	0.76	2,000 – 4,000

[A]As noted in the item description, this line item also includes the natural gas pipeline. The natural gas pipeline is an additive cost and would not be scaled. The pipeline cost is specific to the plant location and needs. Scaling over larger ranges will result in unrealistic costs since this has the effect of essentially increasing and decreasing the pipe length.

Exhibit 3-34. Scaling parameters and exponents for category 10: "Gas Cleanup and Piping"

Account Number	Item Description	Parameter	Exponent	Range
	Category	10	10	10
5A	GAS CLEANUP & PIPING			
5A.6	Exhaust Gas Recycle System	EGR Flowrate, lb/hr	1.47	3,150,000 – 3,280,000

Exhibit 3-35. Scaling parameters and exponents for category 10: “CO_2 Removal and Compression”

Account Number	Item Description	Parameter	Exponent	Range
Category		10	10	10
5B	CO_2 REMOVAL & COMPRESSION			
5B.1	CO_2 Removal System	CO_2 Flowrate, lb/hr Inlet to Absorber, acfm	0.61[A]	445,000 – 689,000 N/A[B]
5B.2	CO_2 Compression & Drying	CO_2 Flowrate, lb/hr	0.77[C]	445,000 – 689,000

[A]40% of cost is applied to gas flow and the remainder is applied to CO_2 capture.
[B]Range has not yet been developed as parameter has not been implemented to date.
[C]For cases reported in Revision 2a of the Bituminous Baseline, use exponent 0.35.

Exhibit 3-36. Scaling parameters and exponents for category 10: “Combustion Turbine and Accessories”

Account Number	Item Description	Parameter	Exponent	Range
Category		10	10	10
6	COMBUSTION TURBINE/ACCESSORIES			
6.1	Combustion Turbine Generator	Fuel Gas Flow, acfm	0.00	N/A
6.9	Combustion Turbine Foundations	Gas Turbine Power, kWe	0.00	421,000 – 811,000

Exhibit 3-37. Scaling parameters and exponents for category 10: “HRSG, Ducting, and Stack”

Account Number	Item Description	Parameter	Exponent	Range
Category		10	10	10
7	HRSG, DUCTING & STACK			
7.1	Heat Recovery Steam Generator	HRSG Duty, MMBtu/hr	0.70	2,000 – 3,800
7.2	HRSG Accessories	HRSG Duty, MMBtu/hr	1.40	2,000 – 3,800
7.9	HRSG, Duct & Stack Foundations	Volumetric flow to stack, acfm	0.70[A]	2,390,000 – 2,860,000

[A]Natural gas, air-fired with CO_2 capture and gas recycle uses an exponent of 0.47.

Exhibit 3-38. Scaling parameters and exponents for category 10: "Steam Turbine Generator"

Account Number	Item Description	Parameter	Exponent	Range
Category		10	10	10
8	STEAM TURBINE GENERATOR			
8.1	Steam TG & Accessories	Turbine capacity, kWe	0.80	179,000 – 321,000
8.2	Turbine Plant Auxiliaries	Turbine capacity, kWe	0.73	179,000 – 321,000
8.3	Condenser & Auxiliaries	Condenser Duty, MMBtu/hr	See Note[A]	800 – 1,300
8.4	Steam Piping	HRSG Duty, MMBtu/hr	0.83	2,000 – 3,800
8.9	TG Foundations	Turbine capacity, kWe	0.73	179,000 – 321,000

[A]Natural gas, air-fired without CO_2 capture uses the exponent 0.83. Natural gas, air-fired with CO_2 capture uses the exponent 0.66. Natural gas, air-fired with CO_2 capture and gas recycle uses the exponent 1.17.

Exhibit 3-39. Scaling parameters and exponents for category 10: "Cooling Water System"

Account Number	Item Description	Parameter	Exponent	Range
Category		10	10	10
9	COOLING WATER SYSTEM			
9.1	Cooling Towers	Cooling Tower Duty, MMBtu/hr	0.71	1,000 – 3,000
9.2	Circulating Water Pumps	Circulating Water Flow Rate, gpm	0.72	124,000 – 294,000
9.3	Circ. Water System Auxiliaries	Circulating Water Flow Rate, gpm	0.60	124,000 – 294,000
9.4	Circ. Water Piping	Circulating Water Flow Rate, gpm	0.60	124,000 – 294,000
9.5	Make-up Water System	Raw Water Withdrawal, gpm	0.60	2,600 – 5,000
9.6	Component Cooling Water Sys.	Circulating Water Flow Rate, gpm	0.60	124,000 – 294,000
9.9	Circ. Water System Foundations	Circulating Water Flow Rate, gpm	0.60	124,000 – 294,000

Exhibit 3-40. Scaling parameters and exponents for category 10: "Accessory Electric Plant"

Account Number	Item Description	Parameter	Exponent	Range
Category		10	10	10
11	ACCESSORY ELECTRIC PLANT			
11.1	Generator Equipment	Gross Total, kWe	0.59	600,000 – 1,130,000
11.2	Station Service Equipment	Auxiliary Load, kWe	0.64	11,000 – 73,500
11.3	Switchgear & Motor Control	Auxiliary Load, kWe	0.64	11,000 – 73,500
11.4	Conduit & Cable Tray	Auxiliary Load, kWe	0.64	11,000 – 73,500
11.5	Wire & Cable	Auxiliary Load, kWe	0.64	11,000 – 73,500
11.6	Protective Equipment	Auxiliary Load, kWe	0	11,000 – 73,500
11.7	Standby Equipment	Gross Total, kWe	0.48	600,000 – 1,130,000
11.8	Main Power Transformers	STG output, MVA PLUS CTG output, MVA	0.70	440 – 820
11.9	Electrical Foundations	Gross Total, kWe	0.70	600,000 – 1,130,000

Exhibit 3-41. Scaling parameters and exponents for category 10: "Instrumentation and Control"

Account Number	Item Description	Parameter	Exponent	Range
Category		10	10	10
12	INSTRUMENTATION & CONTROL			
12.4	Other Major Component Control	Auxiliary Load, kWe	0.60	11,000 – 73,500
12.6	Control Boards, Panels & Racks	Auxiliary Load, kWe	0.60	11,000 – 73,500
12.7	Computer & Accessories	Auxiliary Load, kWe	0.60	11,000 – 73,500
12.8	Instrument Wiring & Tubing	Auxiliary Load, kWe	0.60	11,000 – 73,500
12.9	Other I&C Equipment	Auxiliary Load, kWe	0.60	11,000 – 73,500

Exhibit 3-42. Scaling parameters and exponents for category 10: "Improvements to Site"

Account Number	Item Description	Parameter	Exponent	Range
Category		10	10	10
13	IMPROVEMENTS TO SITE			
13.1	Site Preparation	Gross Total, kWe	0.47	600,000 – 1,130,000
13.2	Site Improvements	Gross Total, kWe	0.47	600,000 – 1,130,000
13.3	Site Facilities	Gross Total, kWe	0.47	600,000 – 1,130,000

Exhibit 3-43. Scaling parameters and exponents for category 10: "Buildings and Structures"

Account Number	Item Description	Parameter	Exponent	Range
	Category	10	10	10
14	BUILDINGS & STRUCTURES			
14.1	Combustion Turbine Area	Gas Turbine Power, kWe	0.53	421,000 – 811,000
14.2	Steam Turbine Building	Steam Turbine Power, kWe	0.60	179,000 – 321,000
14.3	Administration Building	Gross Total, kWe	0.34	600,000 – 1,130,000
14.4	Circulation Water Pumphouse	Circulating Water Flow Rate, gpm	0.60[A]	124,000 – 294,000
14.5	Water Treatment Buildings	Raw Water Withdrawal, gpm	0.66	2,600 – 5,000
14.6	Machine Shop	Gross Total, kWe	0.34	600,000 – 1,130,000
14.7	Warehouse	Gross Total, kWe	0.34	600,000 – 1,130,000
14.8	Other Buildings & Structures	Gross Total, kWe	0.34	600,000 – 1,130,000
14.9	Waste Treating Building & Str.	Gross Total, kWe	0.34	600,000 – 1,130,000

[A]Natural gas, air-fired without CO_2 capture uses an exponent of 0.82.

4 Revision Control

Exhibit 4-1. Revision table

Revision Number	Revision Date	Description of Change	Comments
1	February 5, 2014	Document formatted and edited.	
2	March 2, 2016	Methodology validated for June 2011 data reported in Revisions 2a and 2b of the Bituminous Baseline. Values edited where necessary.	
3	April 9, 2019	Parameters, exponents, and ranges were compared against similar internal categories within this document, and against the Aspen performance template results for Revision 3 cases. Adjustments were made as necessary. Document was also formatted.	

5 References

[1] National Energy Technology Laboratory (NETL), "Cost and Performance Baseline for Fossil Energy Plants Volume 1a: Bituminous Coal (PC) and Natural Gas to Electricity Revision 3," Pittsburgh, PA, 2015.

[2] National Energy Technology Laboratory (NETL), "Greenhouse Gas Reductions in the Power Industry Using Domestic Coal and Biomass Volume 2: Pulverized Coal Cases," Pittsburgh, PA, 2012.

[3] National Energy Technology Laboratory (NETL), "Advancing Oxycombustion Technology for Bituminous Coal Power Plants: An R&D Guide," Pittsburgh, PA, 2012.

[4] National Energy Technology Laboratory (NETL), "Cost and Performance Baseline for Fossil Energy Plants Volume 3b: Low Rank Coal to Electricity: Combustion Cases," Pittsburgh, PA, 2011.

[5] National Energy Technology Laboratory (NETL), "Cost and Performance Baseline for Fossil Energy Plants Volume 3a: Low Rank Coal to Electricity: IGCC Cases," Pittsburgh, PA, 2011.

[6] National Energy Technology Laboratory (NETL), "Cost and Performance Baseline for Fossil Energy Plants Volume 1b: Bituminous Coal (IGCC) to Electricity Revision 2b - Year Dollar Update," Pittsburgh, PA, 2015.

[7] National Energy Technology Laboratory (NETL), "Greenhouse Gas Reductions in the Power Industry Using Domestic Coal and Biomass Volume 1: IGCC," Pittsburgh, PA, 2012.