NATIONAL ENERGY TECHNOLOGY LABORATORY

Cost and Performance Baseline for Fossil Energy Plants – Volume 3

Low Rank Coal and Natural Gas to Electricity

U.S. Department of Energy
National Energy Technology Laboratory
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Project Objectives

- **Primary Goal -** Complete a comprehensive systems study that estimates performance and cost of state-of-the-art fossil-based electric generating technologies utilizing low-rank coals (PRB and lignite) as well as natural gas at western U.S. ambient conditions equipped with and without carbon capture and sequestration (CCS)

- **Project Objectives**
  - Complete cost and performance estimates for fossil-based electric generating technologies with and without CCS
    - Oxygen-blown IGCC
    - PC and CFBC
    - NGCC
  - Create baseline of present state-of-the-art such that benefits of advanced technologies can be quantified

Project Overview

Study Matrix

Plant Type	ST Cond. (psig/°F/°F)	GT	Gasifier/ Boiler	PRB	NDL	Acid Gas Removal/ CO_2 Separation / Sulfur Recovery	CO_2 Capture Target
IGCC	1800/1050/1050 (non-CO_2 capture cases) 1800/1000/1000 (CO_2 capture cases)	F Class	CoP E-Gas	√	--	MDEA/ - / Claus	--
						Selexol / Selexol / Claus	90%
			TRIG	√	--	Sulfinol-M / - / Claus	--
						Selexol / Selexol / Claus	83%
			Shell	√	√	Sulfinol-M / - / Claus	--
						Selexol / Selexol / Claus	90%
			Siemens	√	√	Sulfinol-M / - / Claus	--
						Selexol / Selexol / Claus	90%
PC	3500/1100/1100	N/A	Supercritical	√	√	SDA / - / -	--
						SDA / Econamine / -	90%
	4000/1200/1200		Ultra-Supercritical	√	√	SDA / - / -	--
						SDA / Econamine / -	90%
CFBC	3500/1100/1100	N/A	Supercritical	√	√	In-Bed Limestone / - / -	--
						In-Bed Limestone / Econamine / -	90%
NGCC	2400/1050/1050	F Class	HRSG	√	√	NA	--
						- / Econamine / -	90%

Design Basis

Coal Types

As-Received Ultimate Analysis (weight %)

	Rosebud PRB	ND Lignite
Moisture	25.77	36.08
Carbon	50.07	39.55
Hydrogen	3.38	2.74
Nitrogen	0.71	0.63
Chlorine	0.01	0.00
Sulfur	0.73	0.63
Ash	8.19	9.86
Oxygen (by difference)	11.14	10.51
HHV (Btu/lb)	8,564	6,617

As-Fed Moisture Content (weight %)

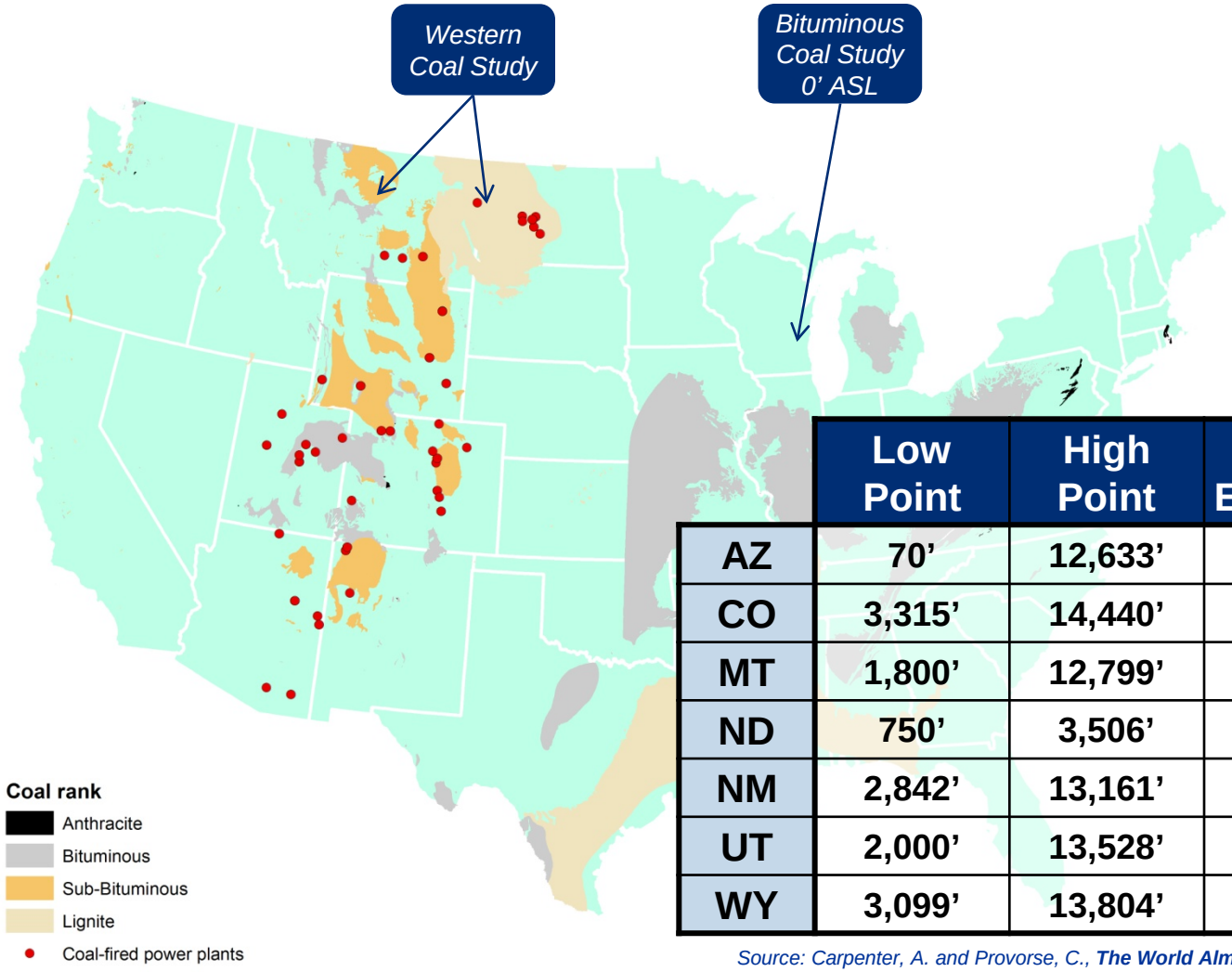
Slurry Gasifier, PC, CFBC	N/A	N/A
Transport Gasifier	18%	N/A
Dry Feed Gasifier	6%	12%

Design Basis
Ambient Conditions

	Rosebud PRB	ND Lignite
Elevation, m (ft)	1,036 (3,400)	579 (1,900)
Barometric Pressure, MPa, (psia)	0.09 (13.0)	0.10 (13.8)
Design Temperature, Dry Bulb, ºC (ºF)	5.6 (42)	4.4 (40)
Design Temperature, Wet Bulb, ºC (ºF)	2.8 (37)	2.2 (36)
Design Relative Humidity, %	62	68
Cooling/Make-up Water Source	Assume limited water availability, 50% condenser cooling load to air cooled condenser, 50% and all auxiliary cooling to wet cooling tower (municipal/ground water mix)	

Design Basis

Coal Fields/Power Plants



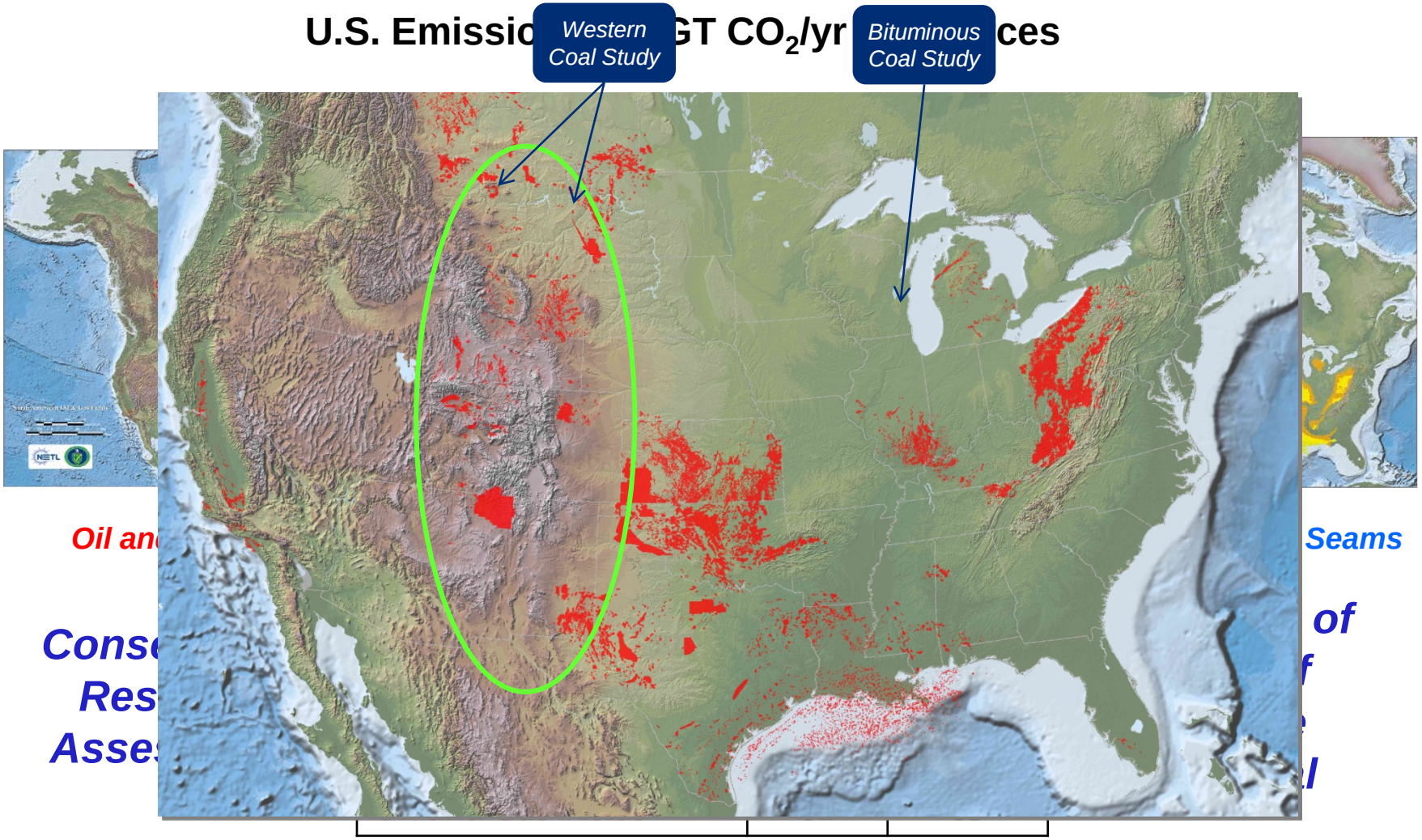
	Low Point	High Point	Mean Elevation
AZ	70'	12,633'	4,100'
CO	3,315'	14,440'	6,800'
MT	1,800'	12,799'	3,400'
ND	750'	3,506'	1,900'
NM	2,842'	13,161'	5,700'
UT	2,000'	13,528'	6,100'
WY	3,099'	13,804'	6,700'

*Source: Carpenter, A. and Provorse, C., **The World Almanac of the USA**, World Almanac Books, 1996*

Design Basis

Geologic Sequestration Opportunities

U.S. Emissio GT CO_2/yr ces



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Available at http://www.netl.doe.gov/publications/carbon_seq/refshelf.html

Design Basis

Impact of Altitude on GT Output

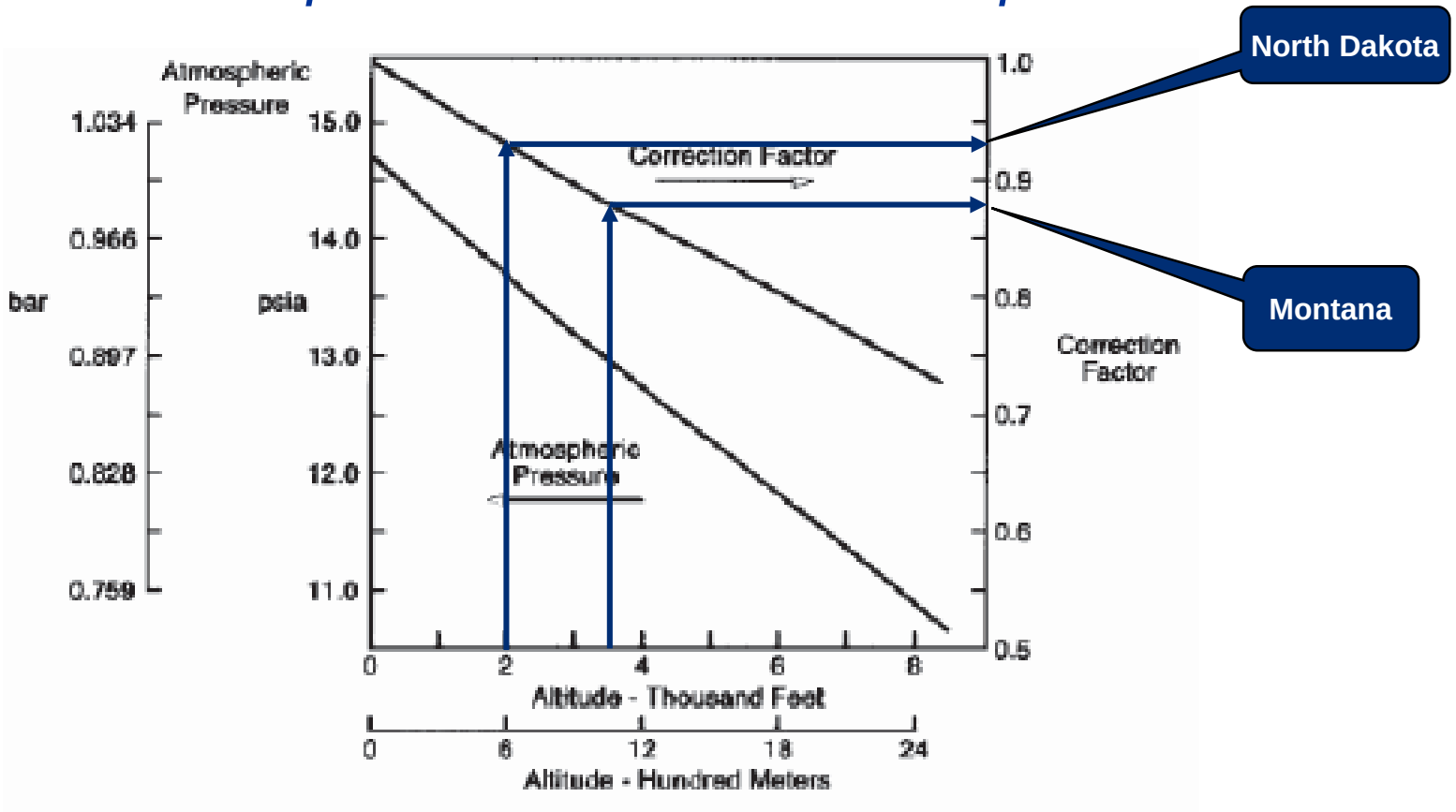


Figure 10. Altitude correction curve

While lower GT output results, the heat rate is largely unaffected

Source: GE Power Systems, **GE Gas Turbine Performance Characteristics**, GER-3567H (10/00)

Design Basis

Environmental Targets

	IGCC	PC		CFBC		NGCC
SO_2	0.0128 lb/MMBtu	0.132 lb/MMBtu		0.132 lb/MMBtu		Negligible
NOx	15 ppmv (dry) @ 15% O_2	0.07 lb/MMBtu		0.07 lb/MMBtu		2.5 ppmv (dry) @ 15% O_2
PM	0.0071 lb/MMBtu	0.013 lb/MMBtu		0.013 lb/MMBtu		N/A
Hg	> 90% capture	PRB	LIG	PRB	LIG	N/A
		0.6 lb/TBtu	1.1 lb/TBtu	3.0 lb/TBtu	4.8 lb/TBtu	

Design Basis

Sequestration Assumptions

Plant Gate CO_2 Pressure (psia)	2,215
Wellhead CO_2 Pressure (psia)	1,515
Inlet Temp (°F)	79
Maximum N_2 Concentration (ppmv)	<300
Maximum O_2 Concentration (ppmv)	<40
Maximum Ar Concentration (ppmv)	<10
Pipeline Length (miles)	50
Formation Depth (ft)	4,055
Formation Permeability (millidarcy)	22
Formation Pressure (psig)	1,220

Design Basis

Other Assumptions

- **Coal drying processes**
  - Dry-feed entrained flow gasifiers – WTA process
  - Transport gasifier – indirectly heated fluidized bed
  - Slurry-feed gasifier, PC & CFBC – no drying
- **Nitrogen dilution was used to the maximum extent possible in all IGCC cases and air extraction from the turbine was integrated into the ASU MAC, where applicable**
- **Capacity Factor assumed to equal Availability**
  - IGCC capacity factor = 80% w/ no spare gasifier
  - PC and CFBC capacity factor = 85%

Economic Assumptions

First Year of Capital Expenditure	*2007*
Effective Levelization Period (Years)	*35 (PC & IGCC)*
	33 (NGCC)

	5 Year Construction Period		3 Year Construction Period	
	High Risk	Low Risk	High Risk	Low Risk
Capital Charge Factor	12.4%	11.6%	11.1%	10.5%

Dollars	*2007*
PRB Coal ($/MMBtu)	*0.89*
ND Lignite ($/MMBtu)	*0.83*
Natural Gas ($/MMBtu)	*7.13*
Capacity Factor	
IGCC	*80*
PC/NGCC	*85*

Capital Cost Levels and their Elements

process equipment
supporting facilities
direct and indirect labor

BEC

EPC contractor services
process contingency
project contingency

TPC

preproduction costs
inventory capital
financing costs
other owner's costs

TOC

escalation during capital expenditure period
interest on debt during capital expenditure period

TASC

Bare Erected Cost
Total Plant Cost
Total Overnight Cost
Total As-Spent Cost

BEC, TPC and TOC are all "overnight" costs expressed in base-year dollars.

TASC is expressed in mixed-year current dollars, spread over the capital expenditure period.

Technical Merit

TECHNOLOGY

- **"Early commercial deployment" of technologies for fossil-based electricity generation**
  - All components commercially available today
  - "Next-of-a-kind" application, contingencies and financial risk assigned as appropriate
  - Design basis appropriate to Western United States
    - Montana PRB
    - North Dakota Lignite

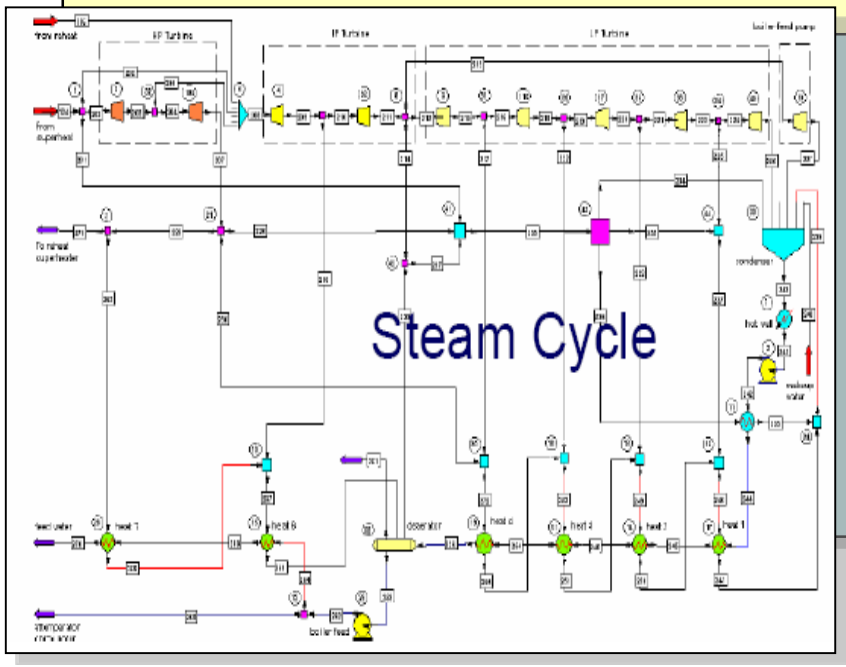
PROJECT

- **Technology vendor input for all major systems**
- **Detailed Aspen Plus process simulations**
- **Interactions with experts in the field**
  - Technology developers – process input
  - WorleyParsons – EPC firm for capital/operating cost estimates

Technical Approach - Overview

1. ***Extensive Process Simulation (ASPEN)***

- *All major chemical processes and equipment are simulated*
- *Detailed mass and energy balances*
- *Performance calculations (auxiliary power, gross/net power output)*



2. ***Cost Estimation***

- ***Inputs from process simulation*** *(Flow Rates/Gas Composition/Pressure/Temp.)*
- ***Sources for cost estimation***
  - *WorleyParsons*
  - *Vendor sources where available*
- ***Follow DOE Analysis Guidelines***

Technical Approach - Project Methodology

- **Process configurations & modeled results subject to vendor review**
  - Gasification cases sent individually to specific technology vendors/developers (CoP, Shell, Siemens, SoCo) for iterative review
    - Facility Design
      - Gasification block I/O
      - Facility integration
    - Performance Results
    - Economic Results
    - Technology Description
  - Combustion cases sent to two combustion technology vendors (B&W, F-W)
  - “Low Rank” NGCC cases based on in-house adjustments for ambient conditions using vendor performance estimates at ISO conditions

Technical Approach

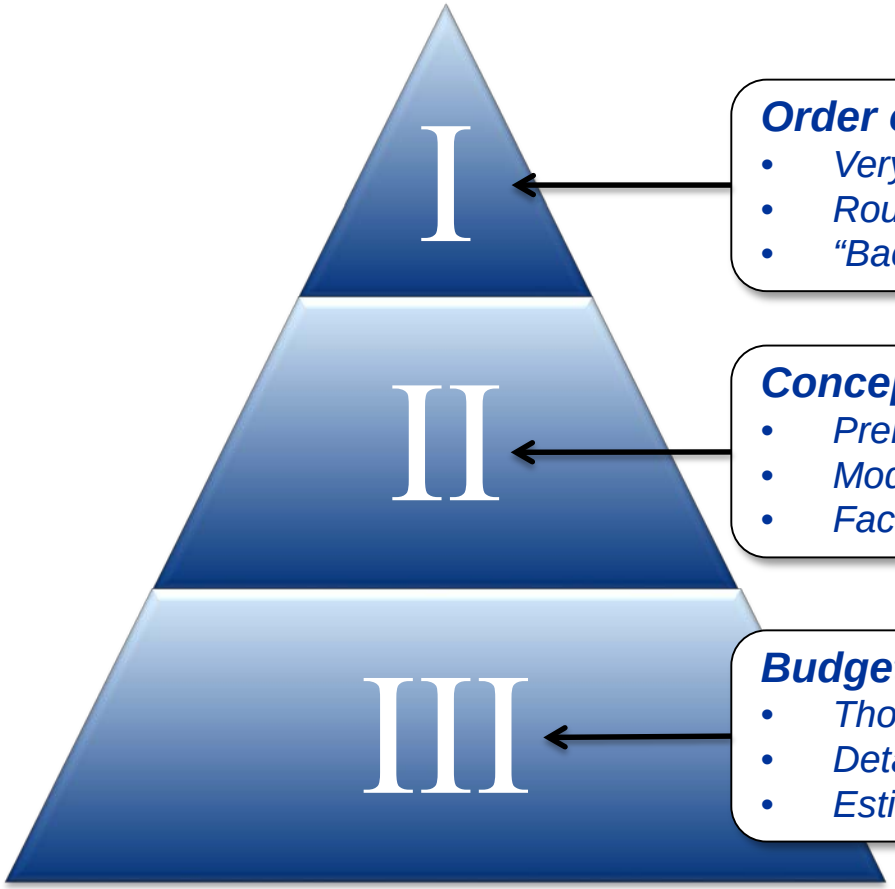
Project Methodology (cont.)

- **Segmented Peer Review**
  - Design basis and Consolidated Combustion Report externally reviewed by industry experts
    - EPRI
    - EPC firm
    - Electric utility industry
    - Coal industry
    - Academia
    - Independent consultants
  - Previous external review of Bituminous IGCC and NGCC at sea-level viewed as sufficient for the low-rank analyses
- **Performed sensitivity studies of select system parameters**
  - Varied economic parameters (on-stream factor, fuel price)

Technical Approach

Systems Analyses Categorization

STUDY CATEGORY



Order of Magnitude Estimate (+/- >50% Accuracy)

- *Very little project-specific definition*
- *Rough scaling of previous related but dissimilar analyses*
- *"Back-of-the-envelope" analyses*

Concept Screening (+/- 50% Accuracy)

- *Preliminary mass and energy balances*
- *Modeling and simulation of major unit operations*
- *Factored estimate based on previous similar analyses*

Budget Estimate (+30% / -15% Accuracy)

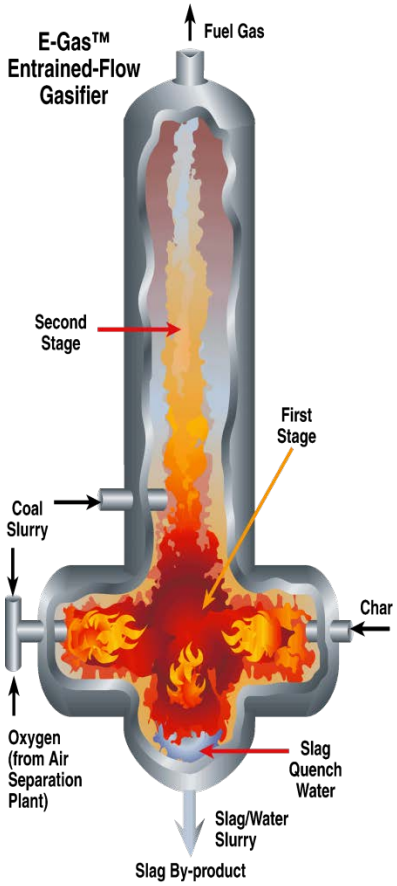
- *Thorough mass and energy balances*
- *Detailed process and economic modeling*
- *Estimate based on vendor quotes, third-party EPC firms*

IGCC, PC, CFB, NGCC Power Plants

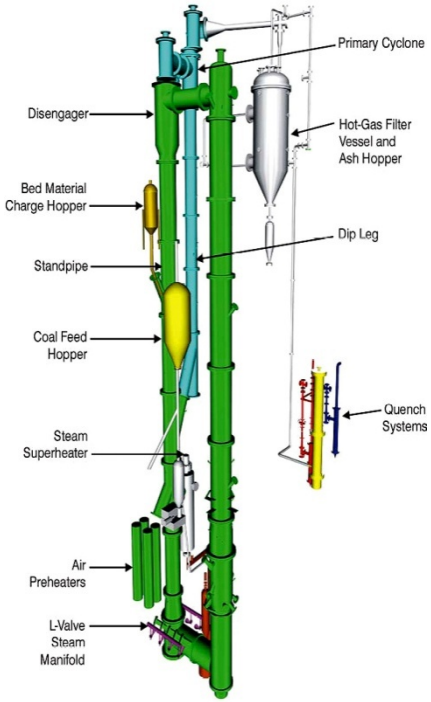
Current State-of-the-Art

Gasifiers

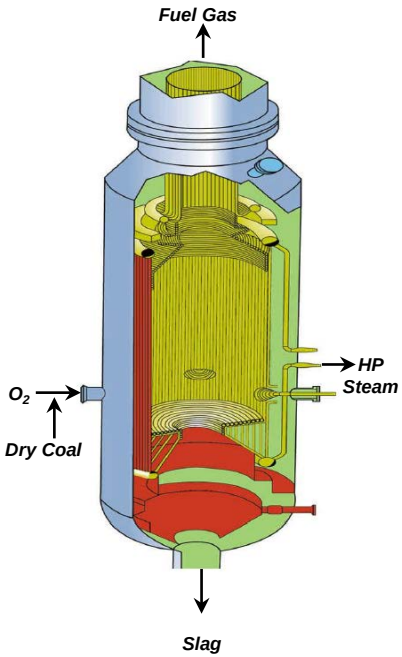
ConocoPhillips E-Gas



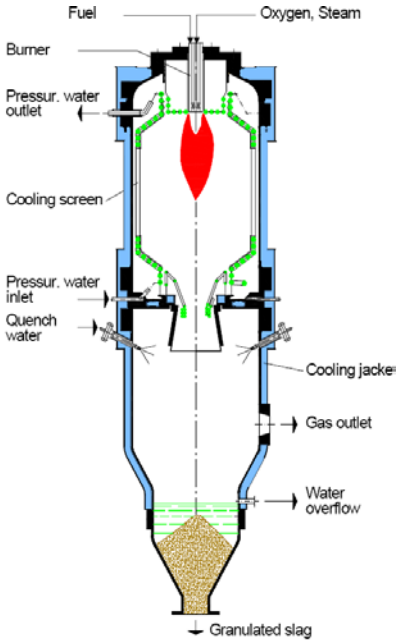
Southern Company TRIG



Shell SCGP

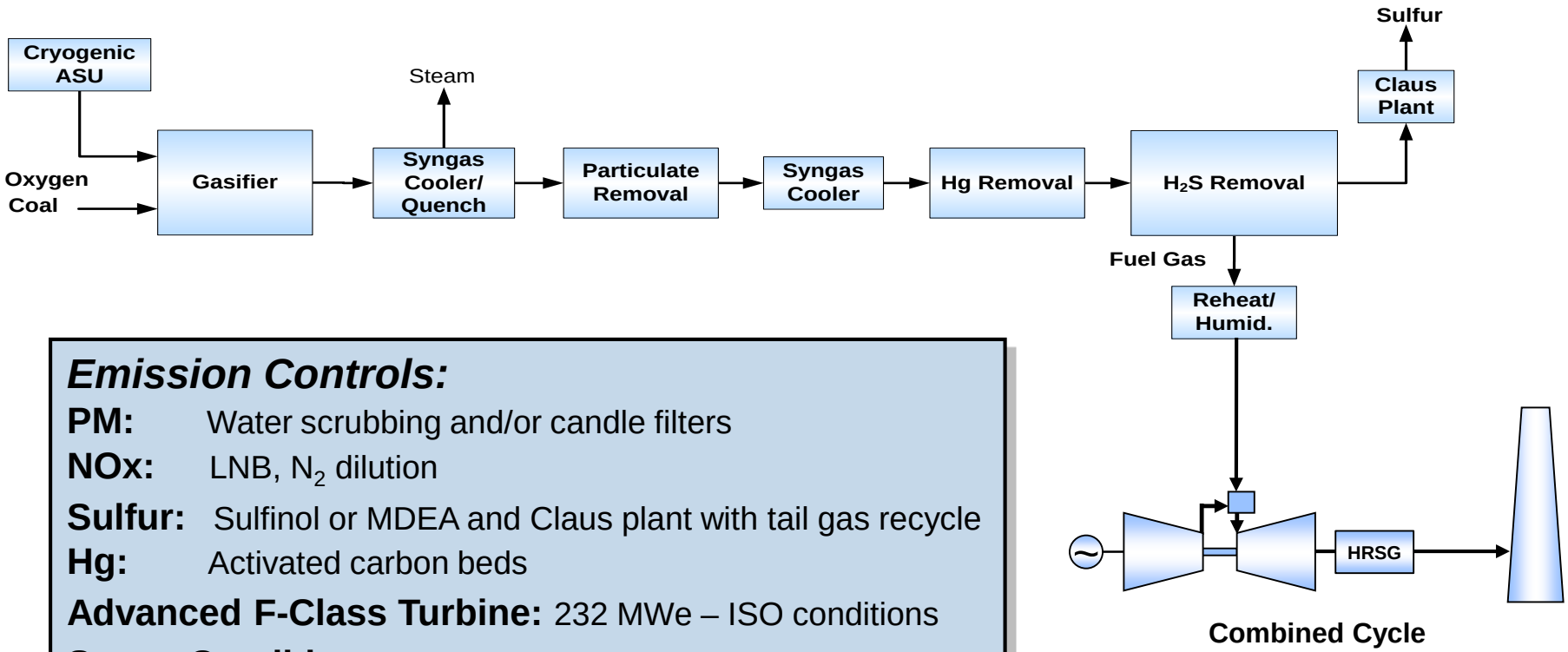


Siemens (GSP/Noell)



SOA Technology

IGCC without CCS



Emission Controls:

PM: Water scrubbing and/or candle filters

NOx: LNB, N_2 dilution

Sulfur: Sulfinol or MDEA and Claus plant with tail gas recycle

Hg: Activated carbon beds

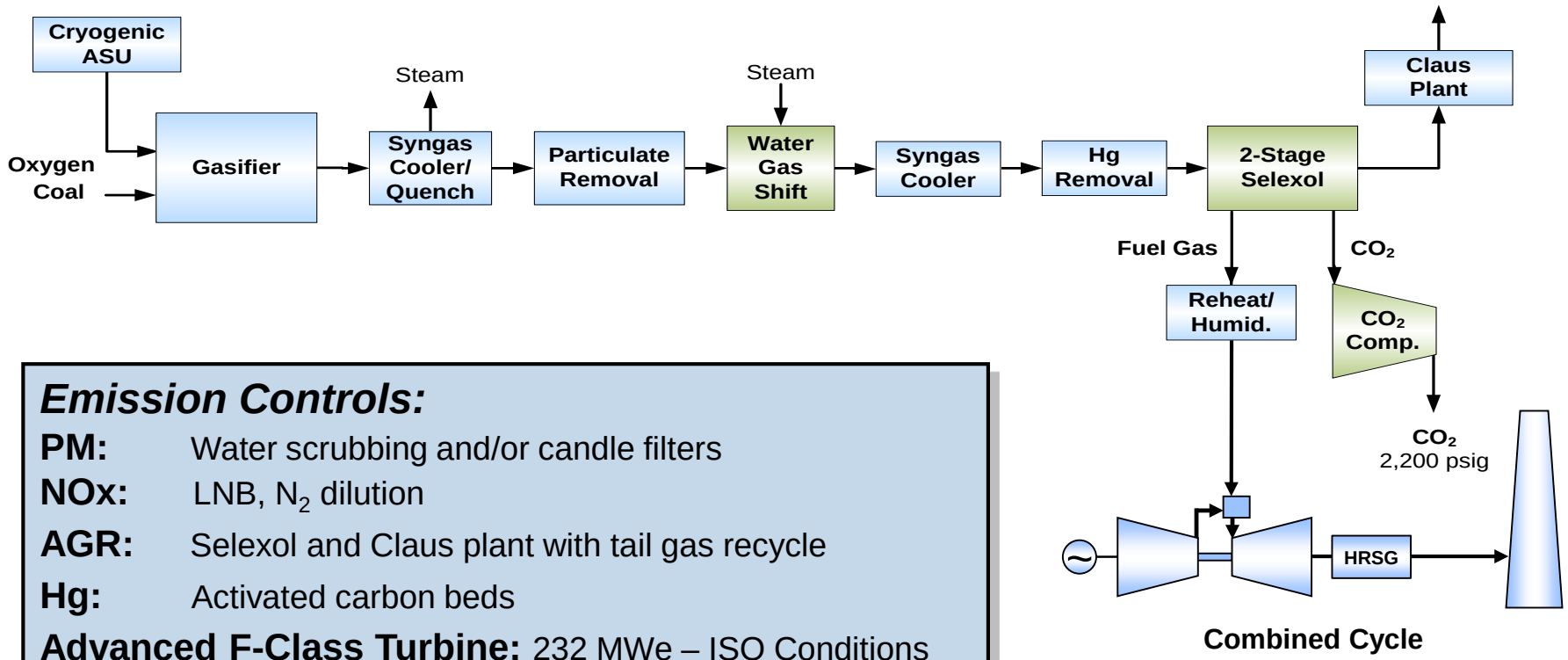
Advanced F-Class Turbine: 232 MWe – ISO conditions

Steam Conditions: 1800 psig/1050°F/1050°F

SOA Technology

IGCC with CCS

Green Blocks Indicate Unit Operations Added for CO_2 Capture Case



Emission Controls:

PM: Water scrubbing and/or candle filters

NOx: LNB, N_2 dilution

AGR: Selexol and Claus plant with tail gas recycle

Hg: Activated carbon beds

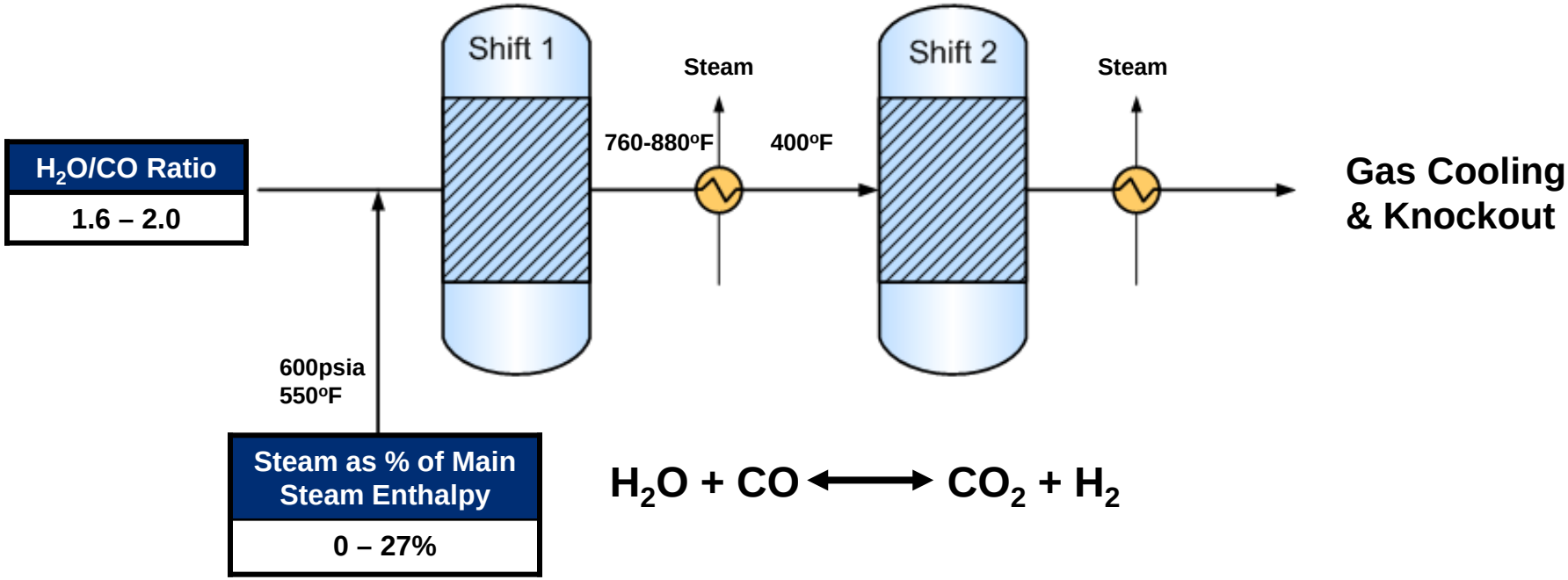
Advanced F-Class Turbine: 232 MWe – ISO Conditions

Steam Conditions: 1800 psig/1000°F/1000°F

Water-Gas Shift Reactor System

General Design:

- Sour Gas Shift Catalyst
- Up to 99% CO Conversion
- Multiple Stages with Intercooling
- H_2O:CO Adjusted for Carbon Removal while Maintaining Minimum Outlet Ratio (H_2O to dry gas)
- Overall ΔP ~ 30 psia

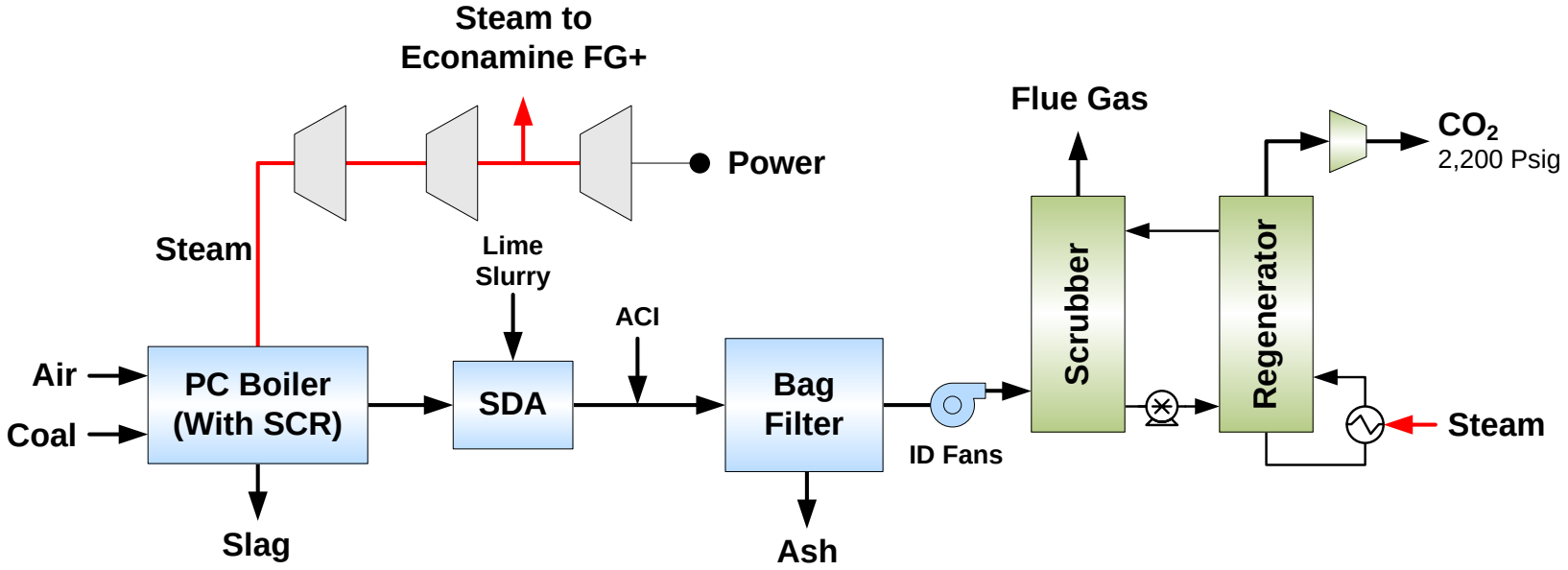


$$H_2O + CO \longleftrightarrow CO_2 + H_2$$

SOA Technology

Pulverized Coal Power Plant

Green Blocks Indicate Unit Operations Added for CO_2 Capture Case



PM Control: Baghouse

NOx Control: LNB + OFA + SCR

Sulfur Control: SDA

Mercury Control: Co-benefit capture + ACI trim

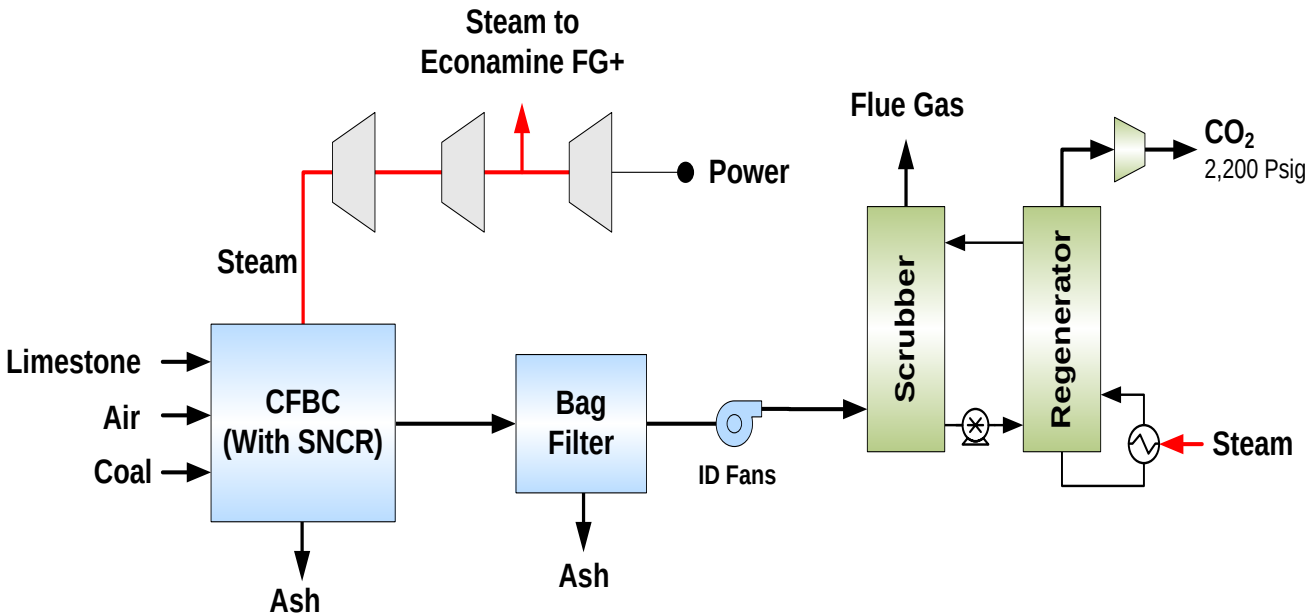
Steam Conditions (SC): 3500 psig/1100°F/1100°F

Steam Conditions (USC): 4000 psig/1200°F/1200°F

SOA Technology

Circulating Fluidized Bed

Green Blocks Indicate Unit Operations Added for CO_2 Capture Case



PM Control: Baghouse

NOx Control: SNCR

Sulfur Control: In-bed Limestone Injection

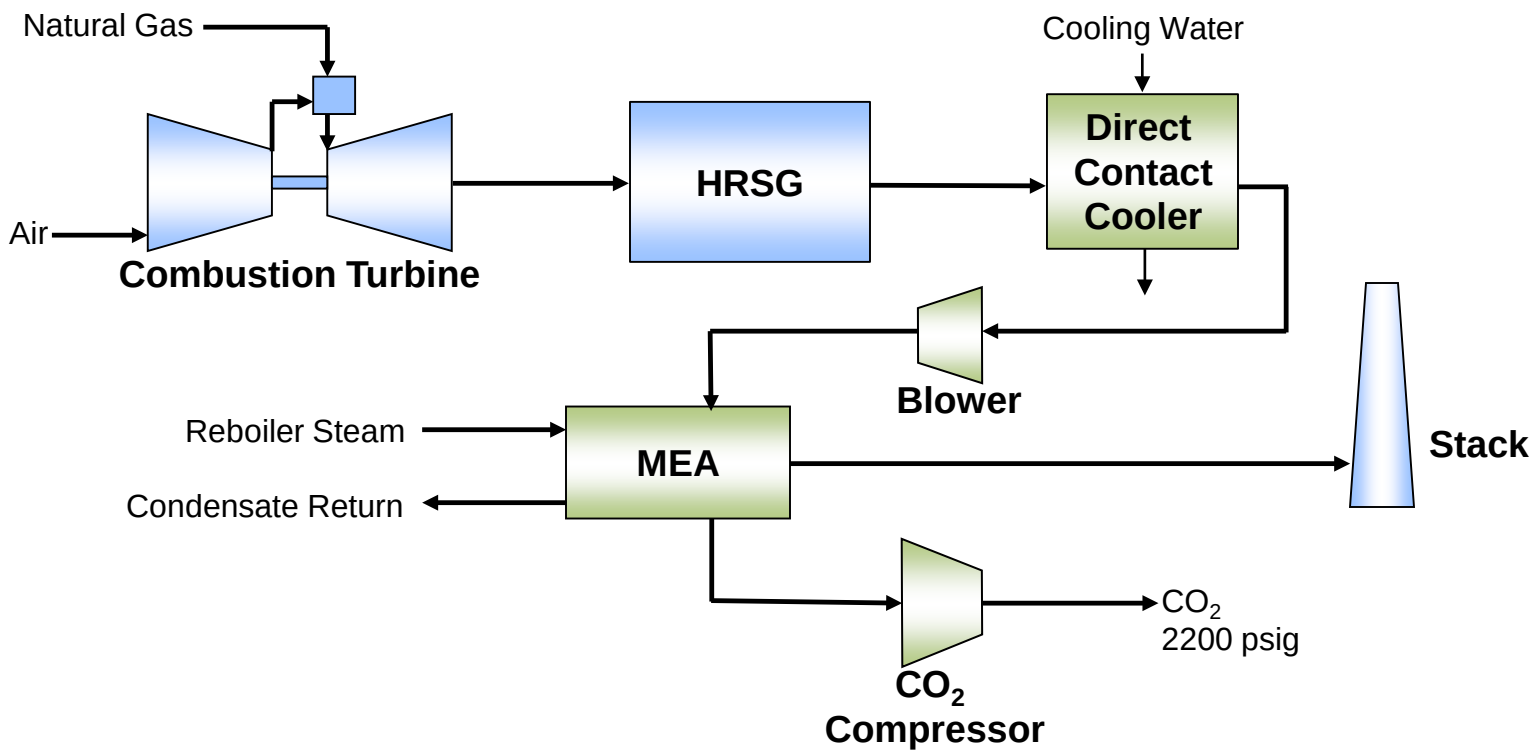
Mercury Control: Co-benefit capture

Steam Conditions (SC): 3500 psig/1100°F/1100°F

SOA Technology

Natural Gas Combined Cycle

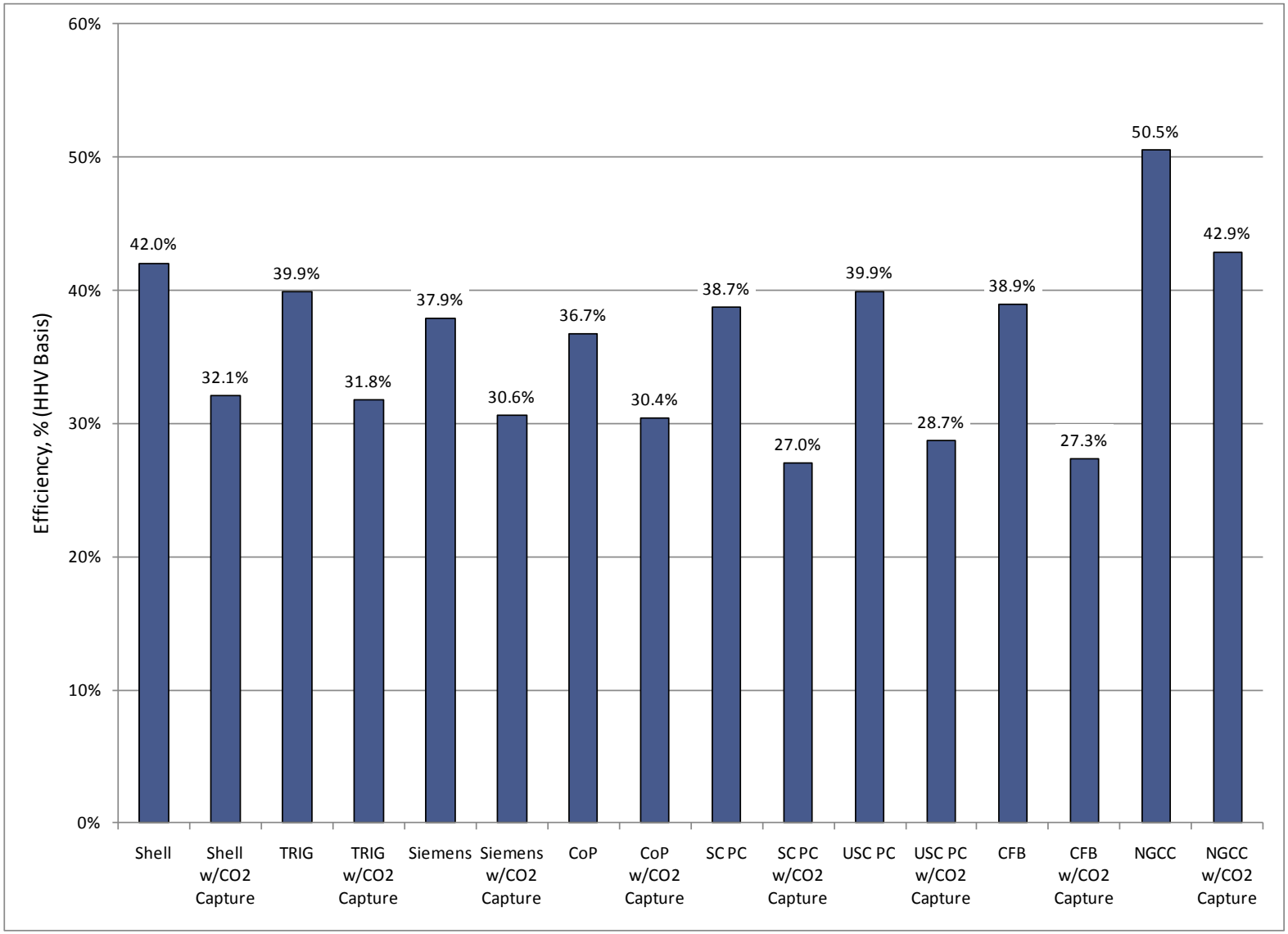
Green Blocks Indicate Unit Operations Added for CO_2 Capture Case



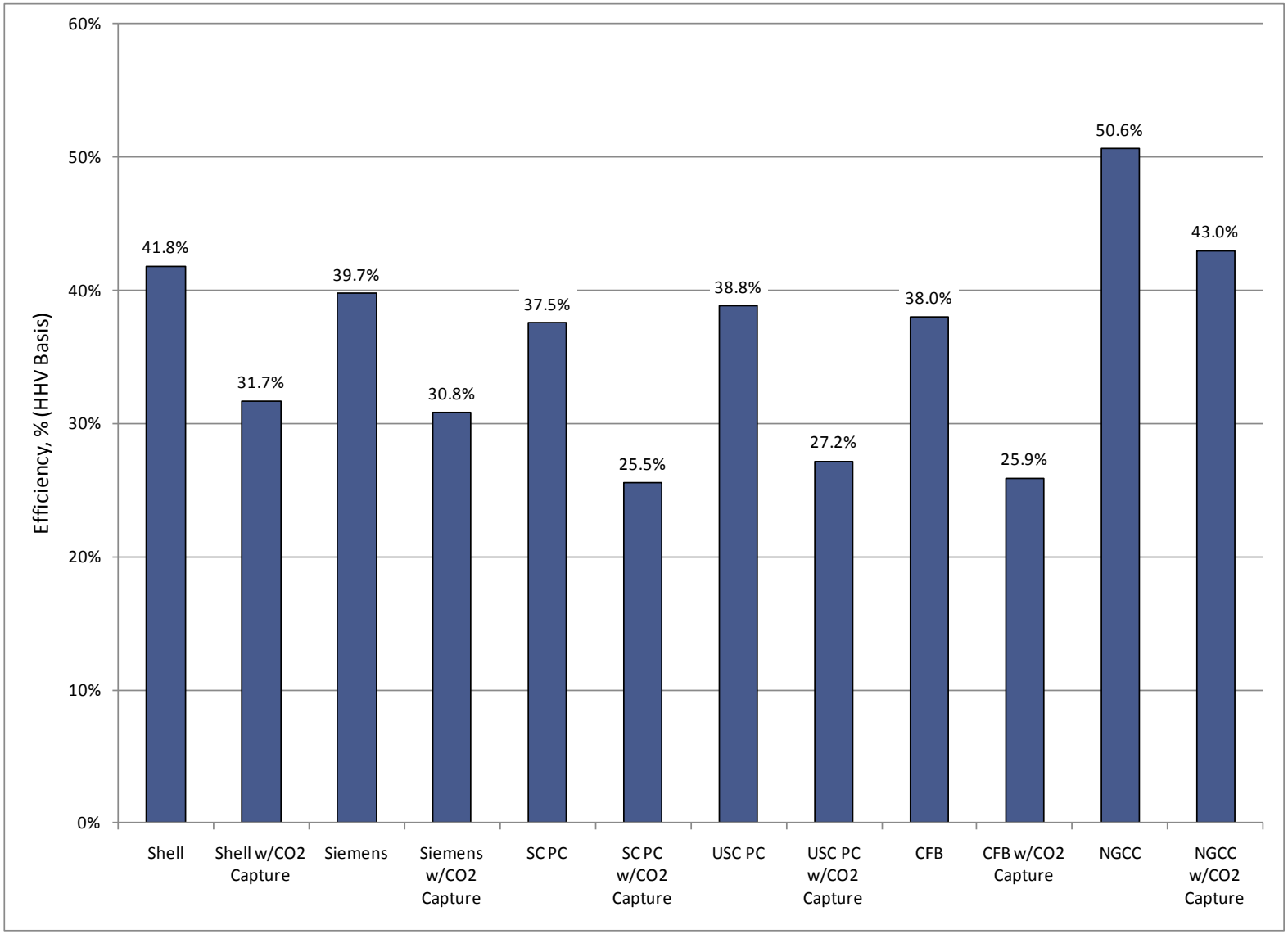
NOx Control: LNB + SCR to maintain 2.5 ppmvd @ 15% O_2

Steam Conditions: 2400 psig/1050°F/1050°F

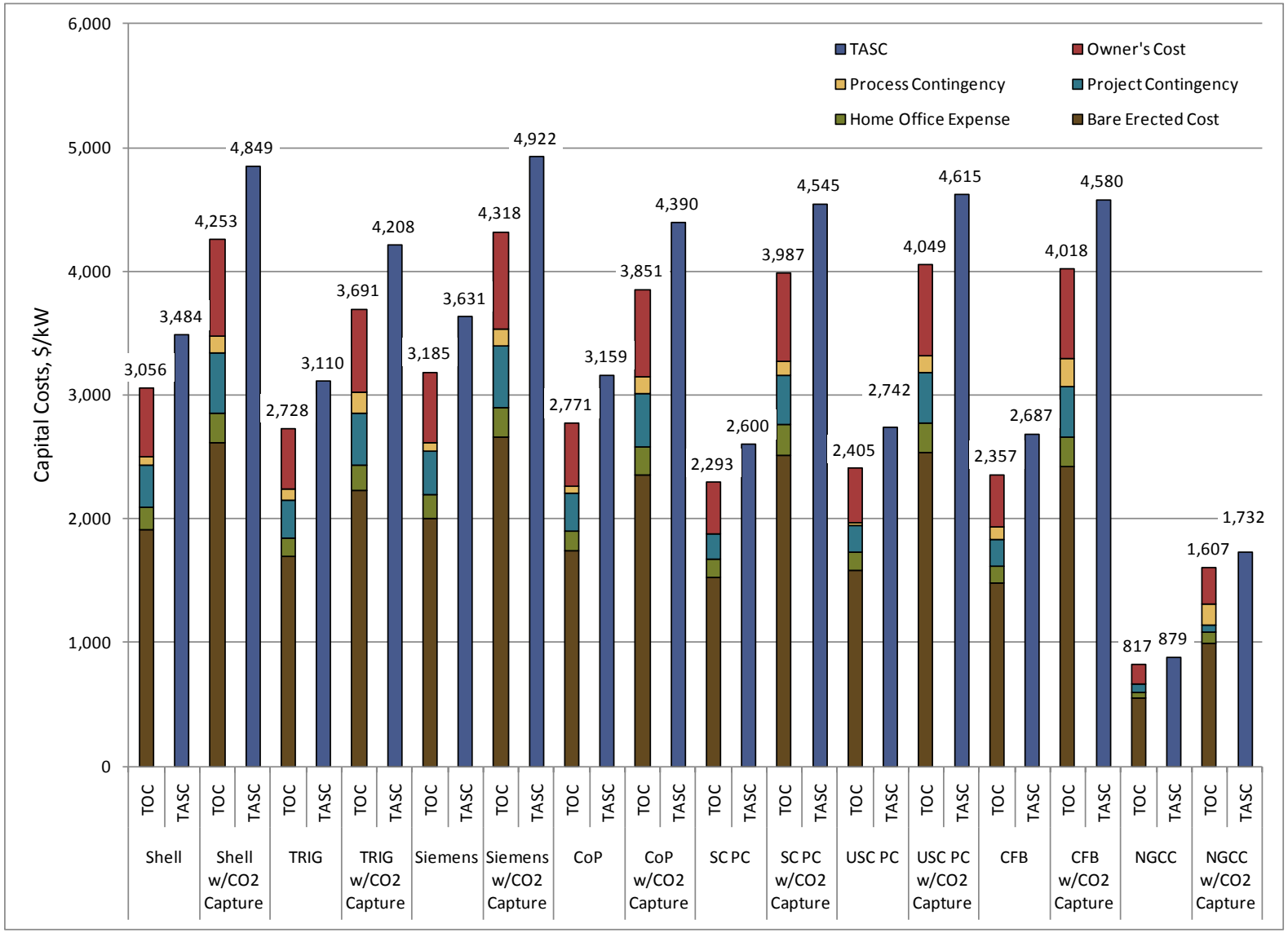
Plant Efficiency, Montana Site



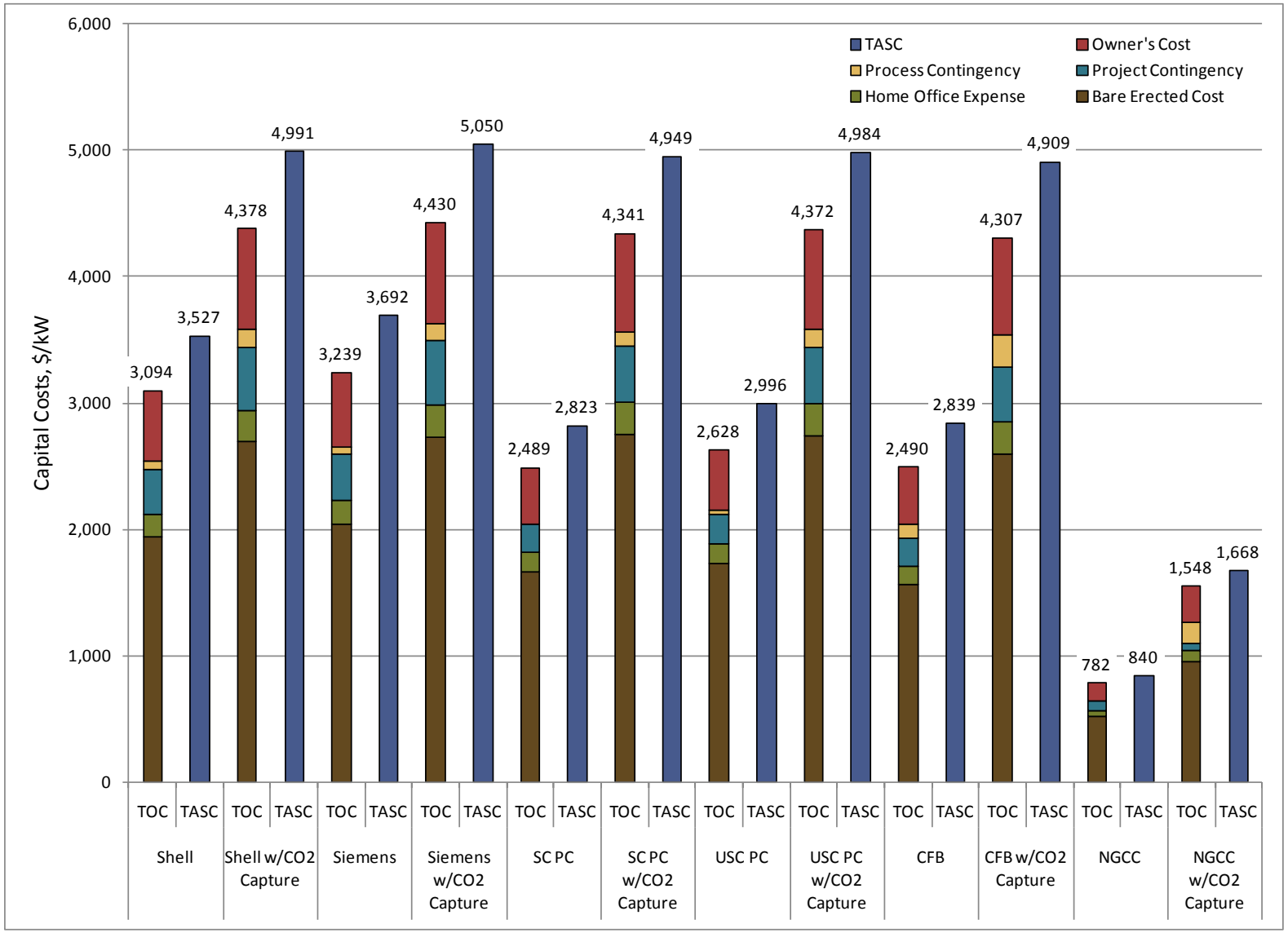
Plant Efficiency, North Dakota Site



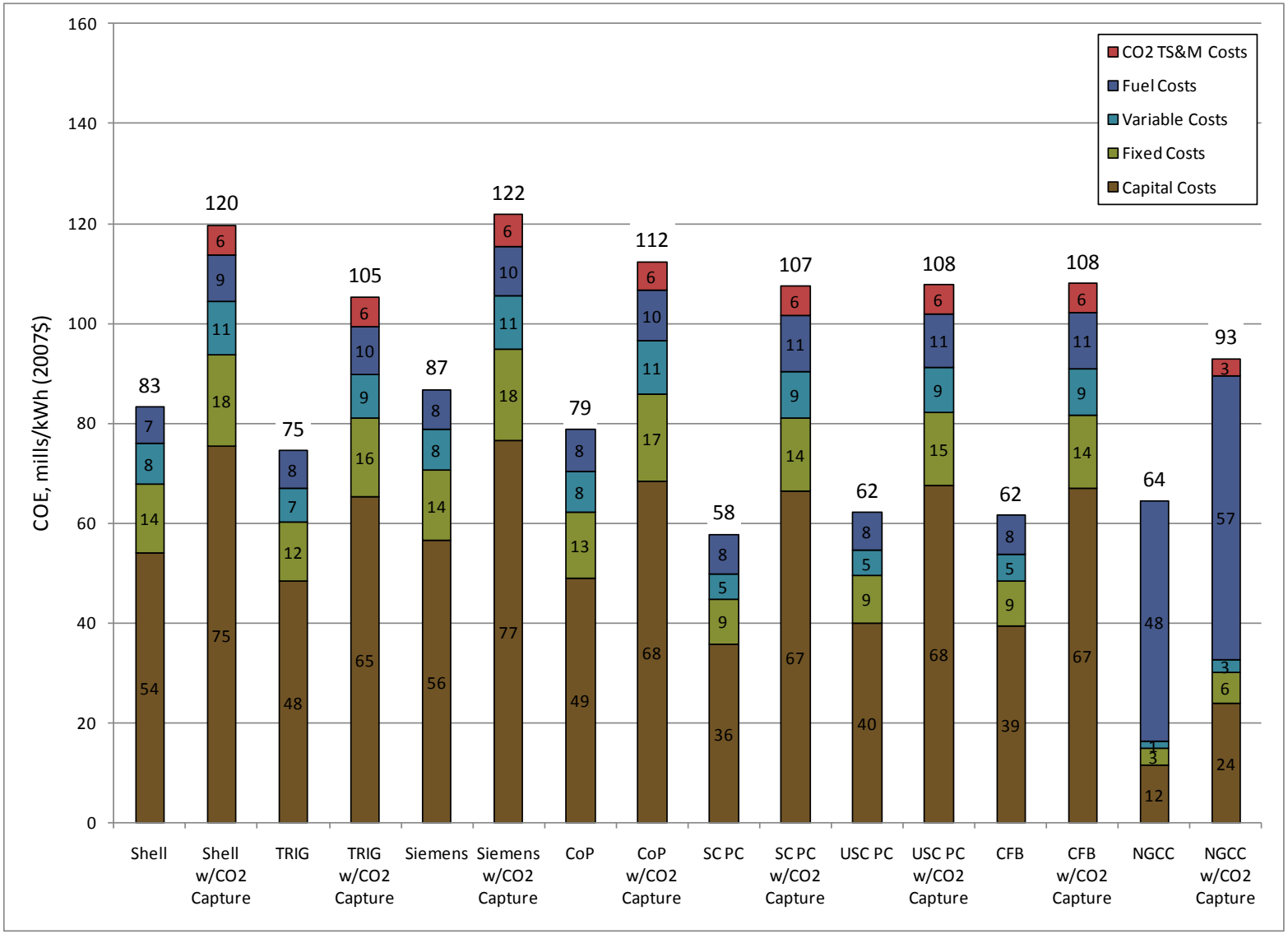
Plant Cost, Montana Site



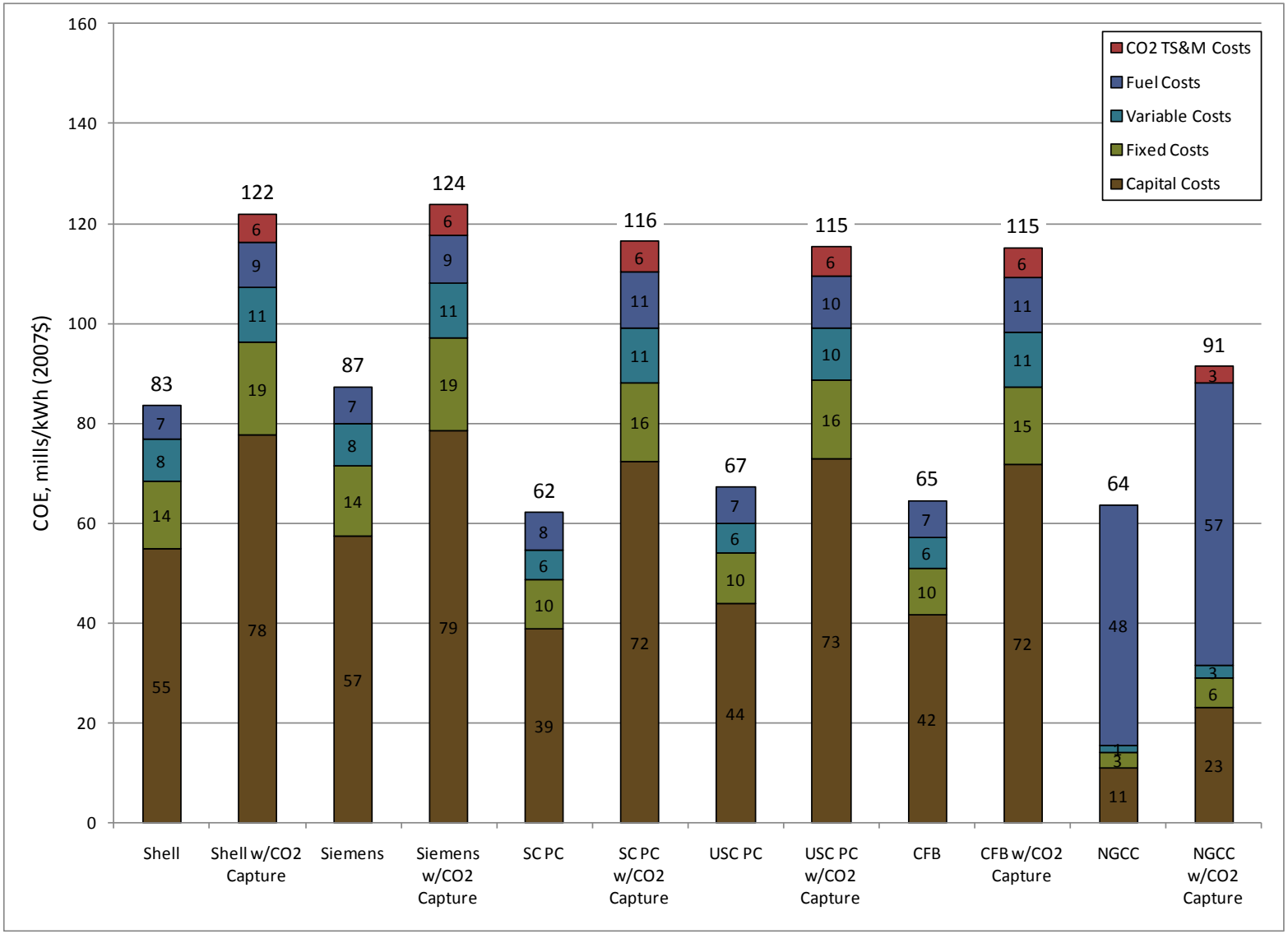
Plant Cost, North Dakota Site



Cost of Electricity, Montana Site



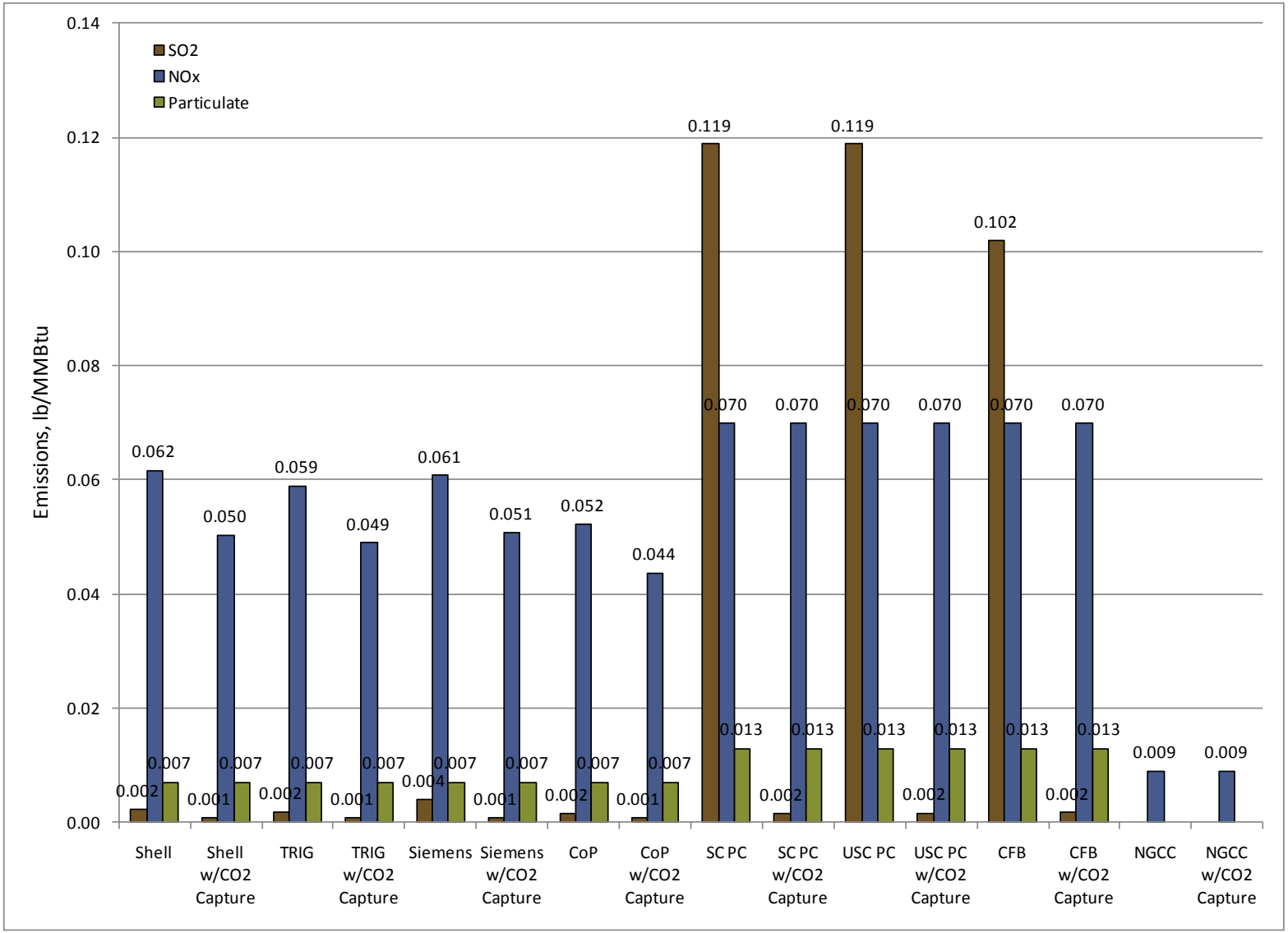
Cost of Electricity, North Dakota Site



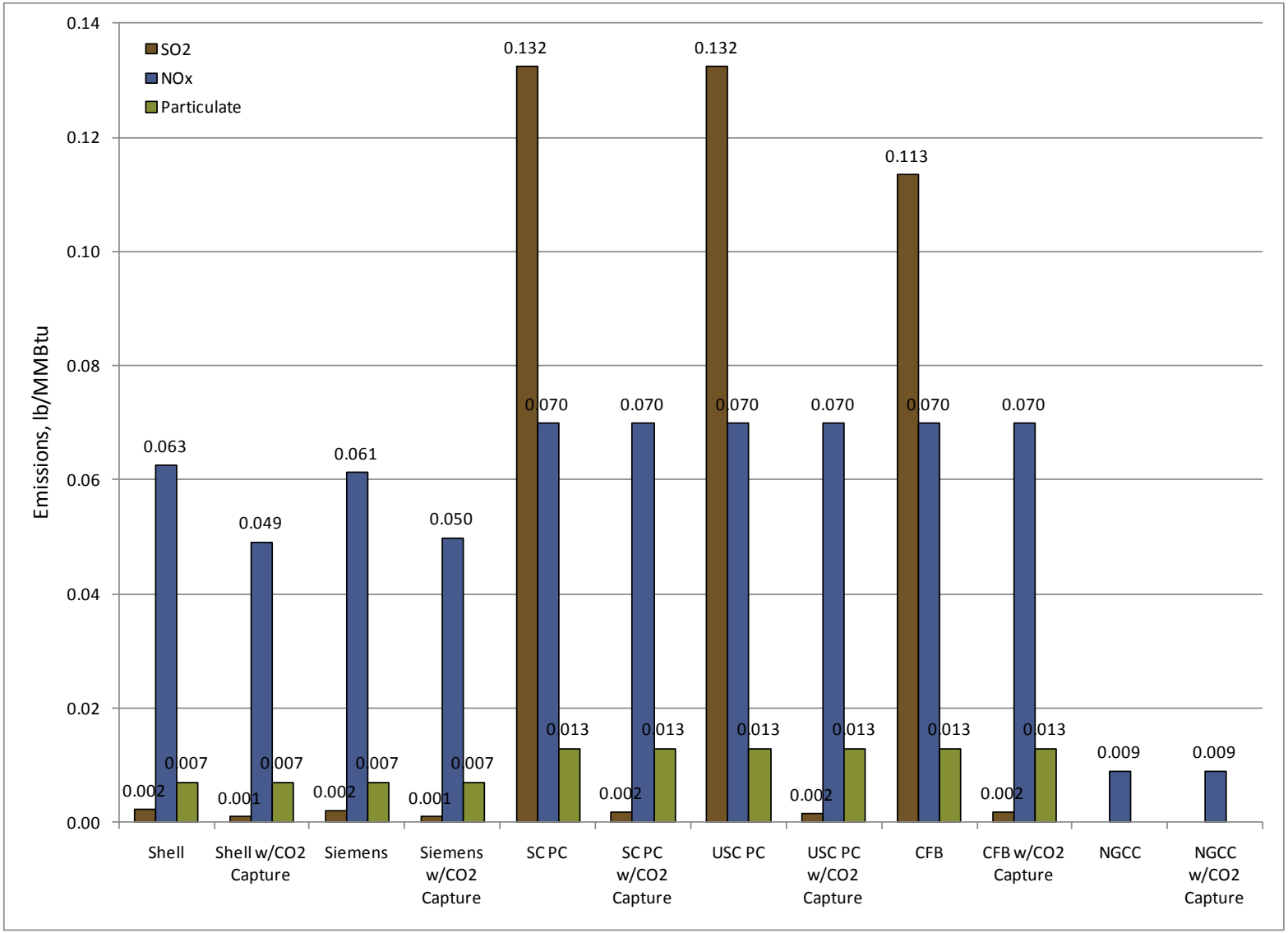
Environmental Performance Comparison

IGCC, PC, CFB, and NGCC

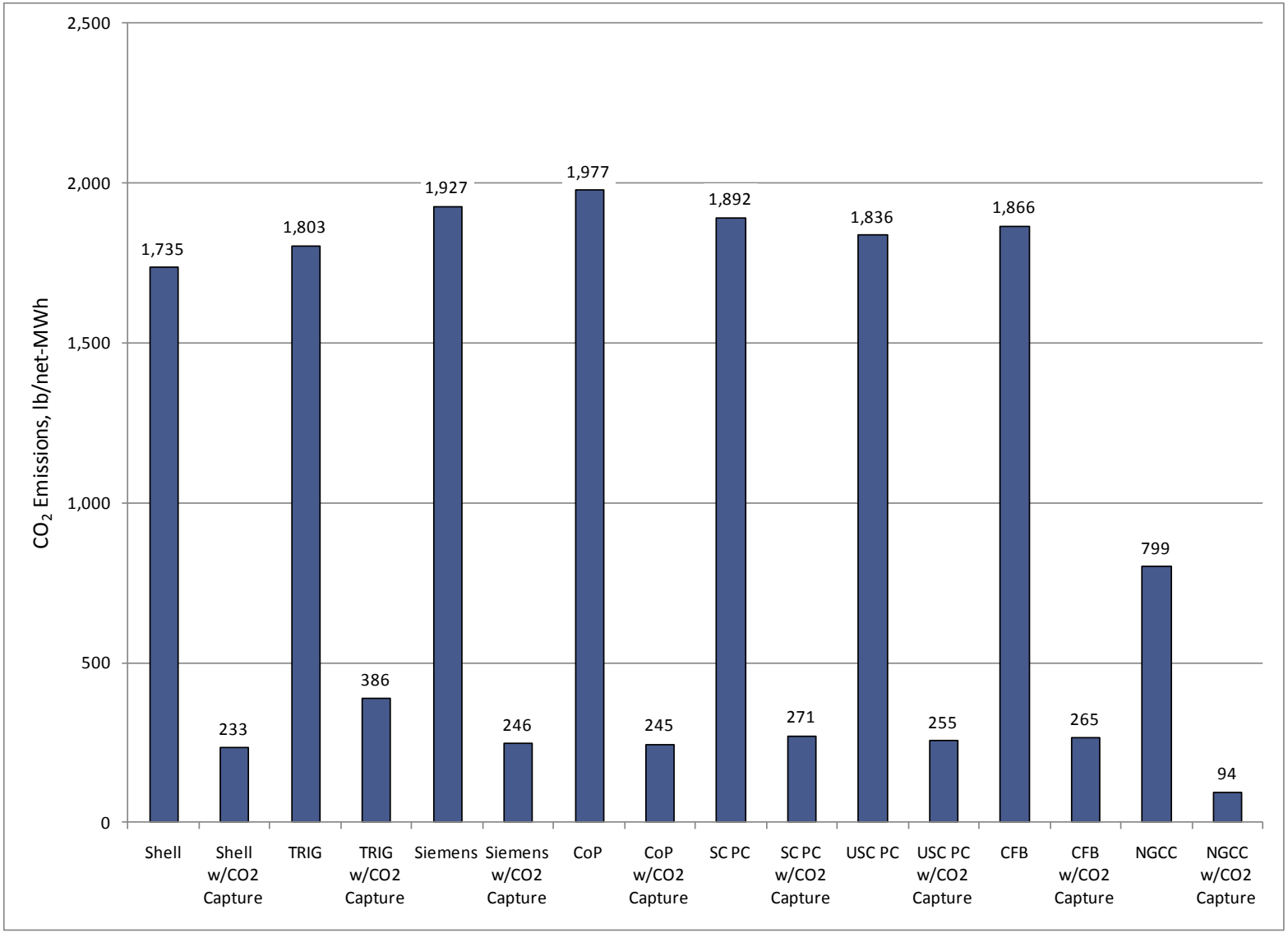
Criteria Pollutant Emissions, Montana Site



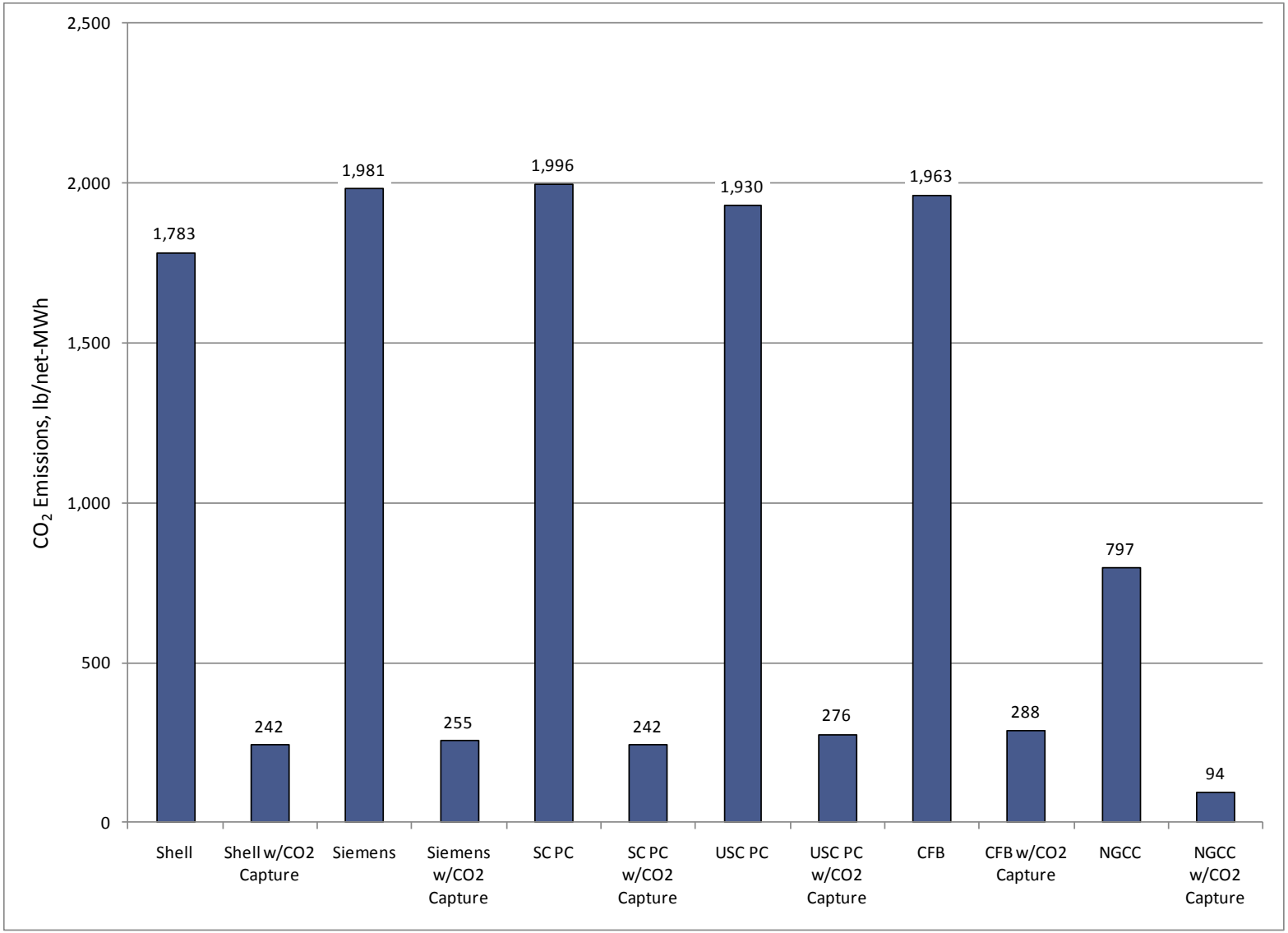
Criteria Pollutant Emissions, ND Site



CO_2 Emissions, Montana Site

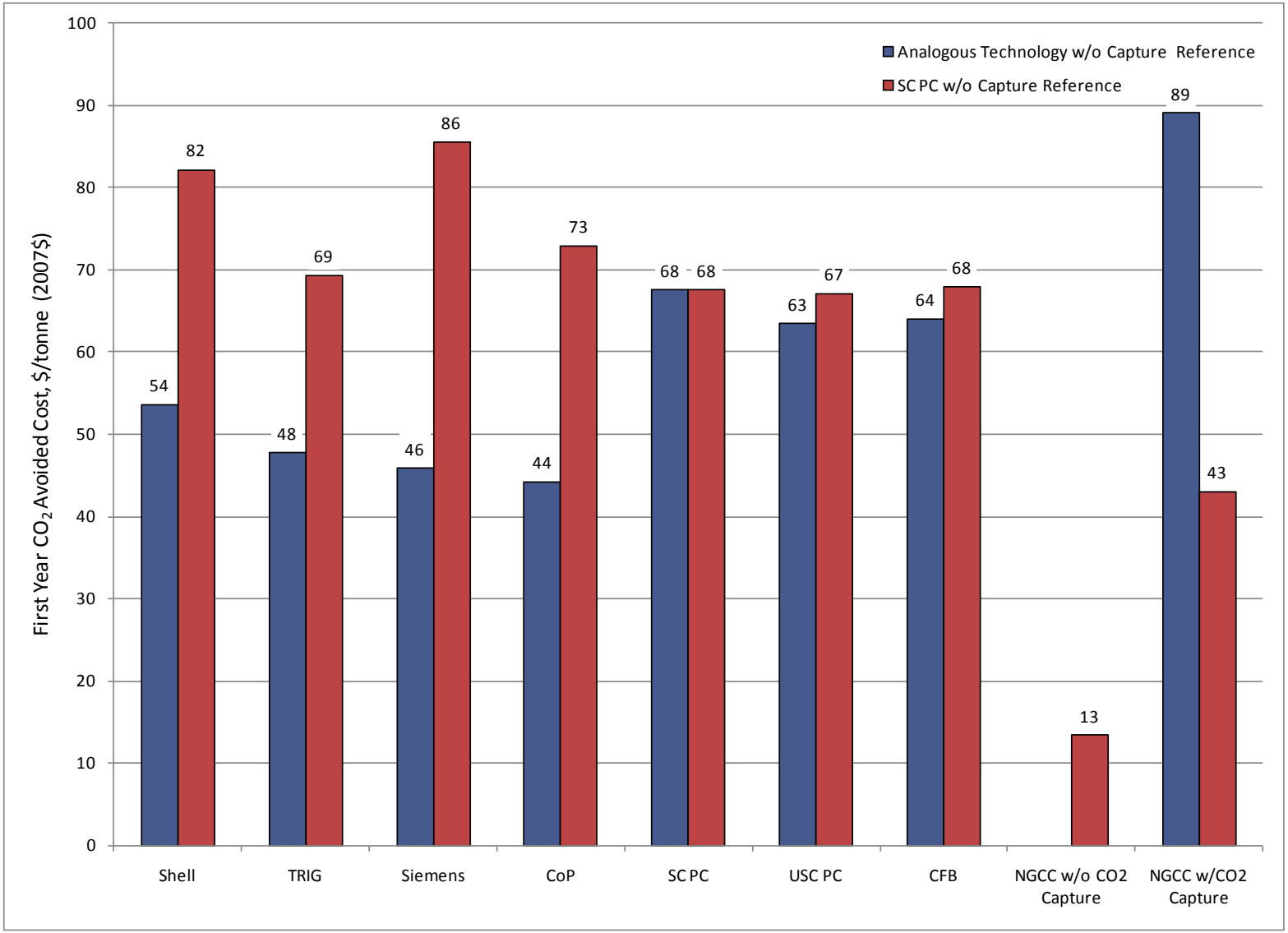


CO_2 Emissions, North Dakota Site

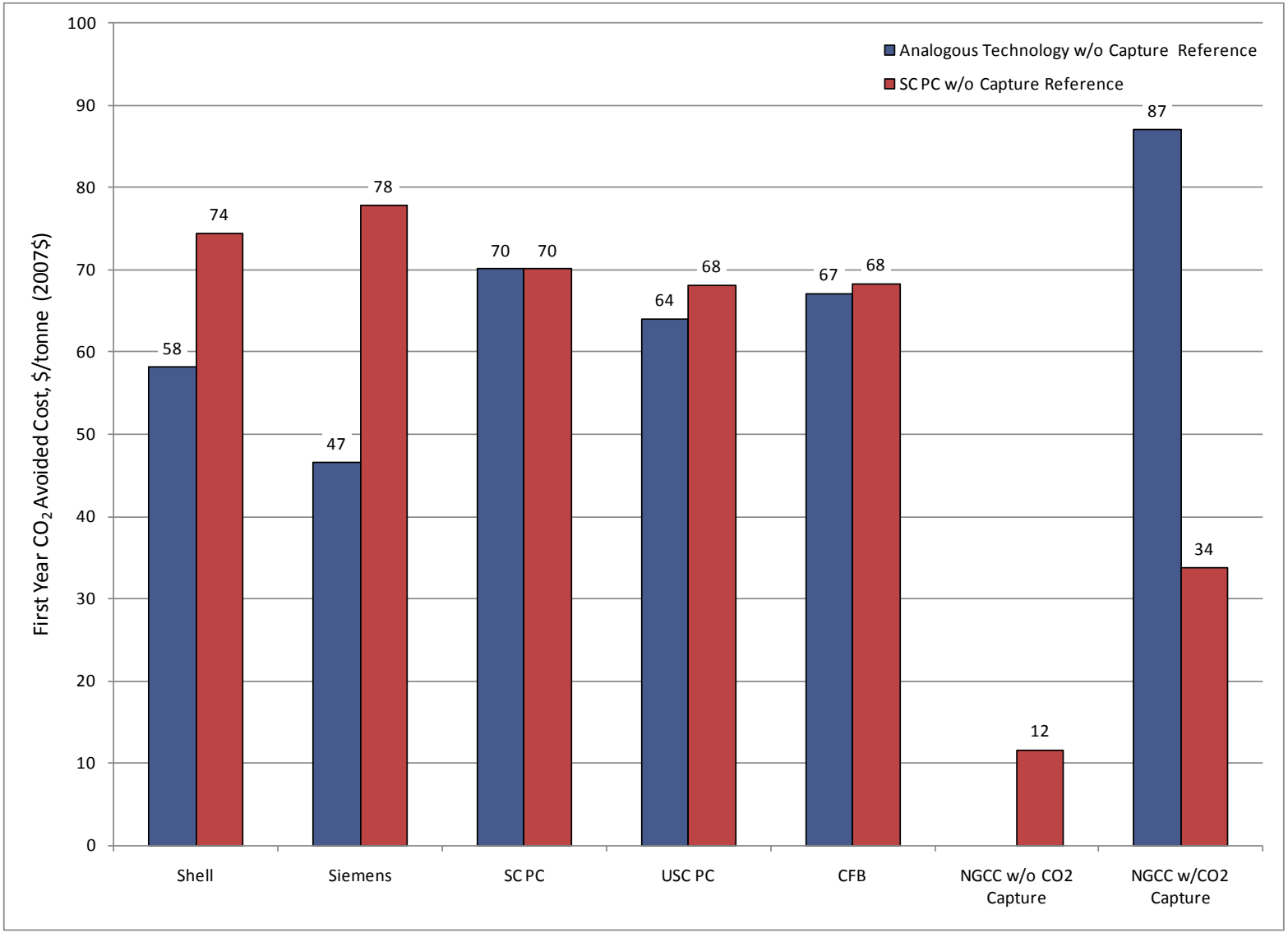


Highlights

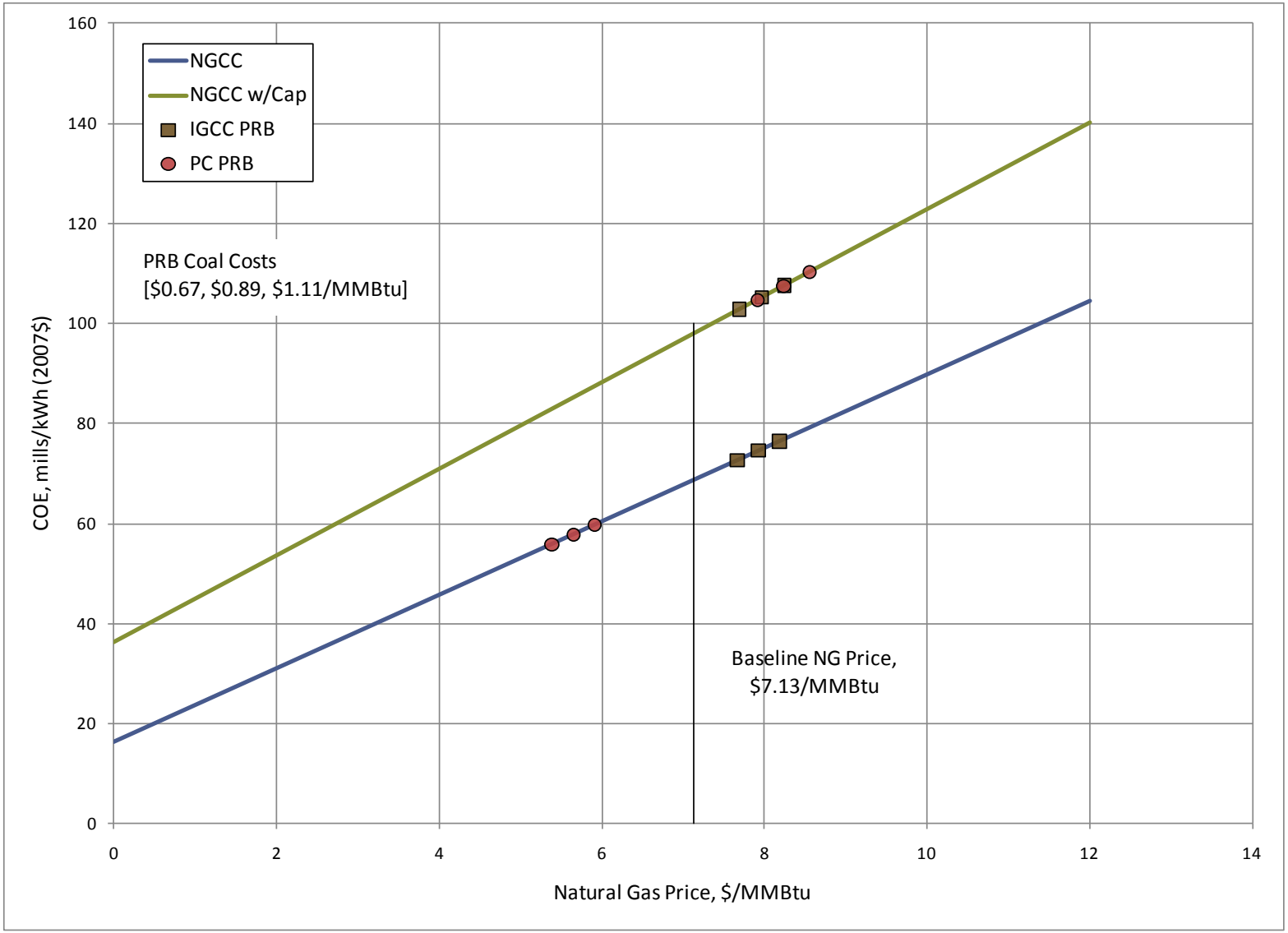
CO_2 Avoided Cost, Montana Site



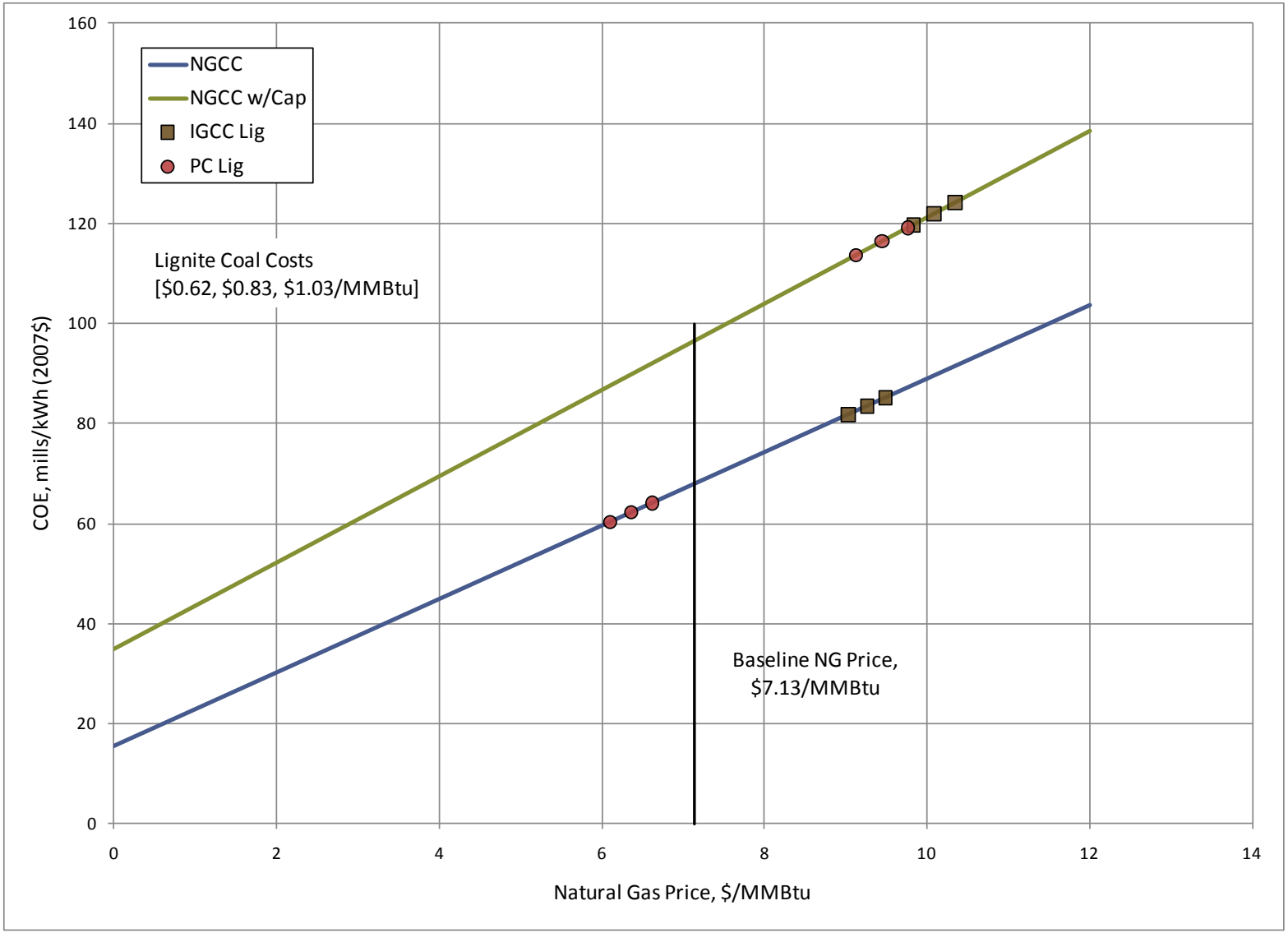
CO_2 Avoided Cost, North Dakota Site



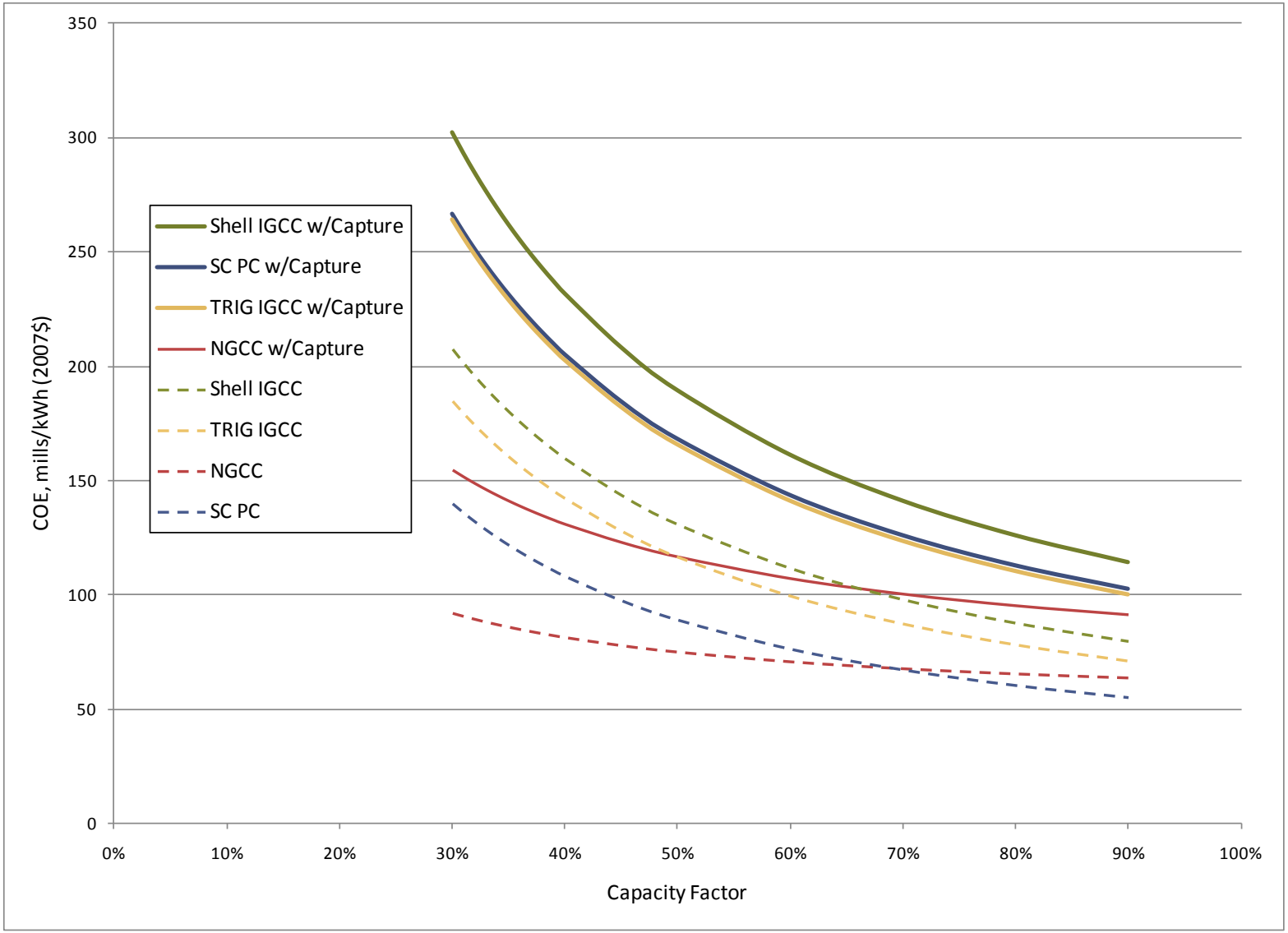
Natural Gas Price Sensitivity, Montana Site



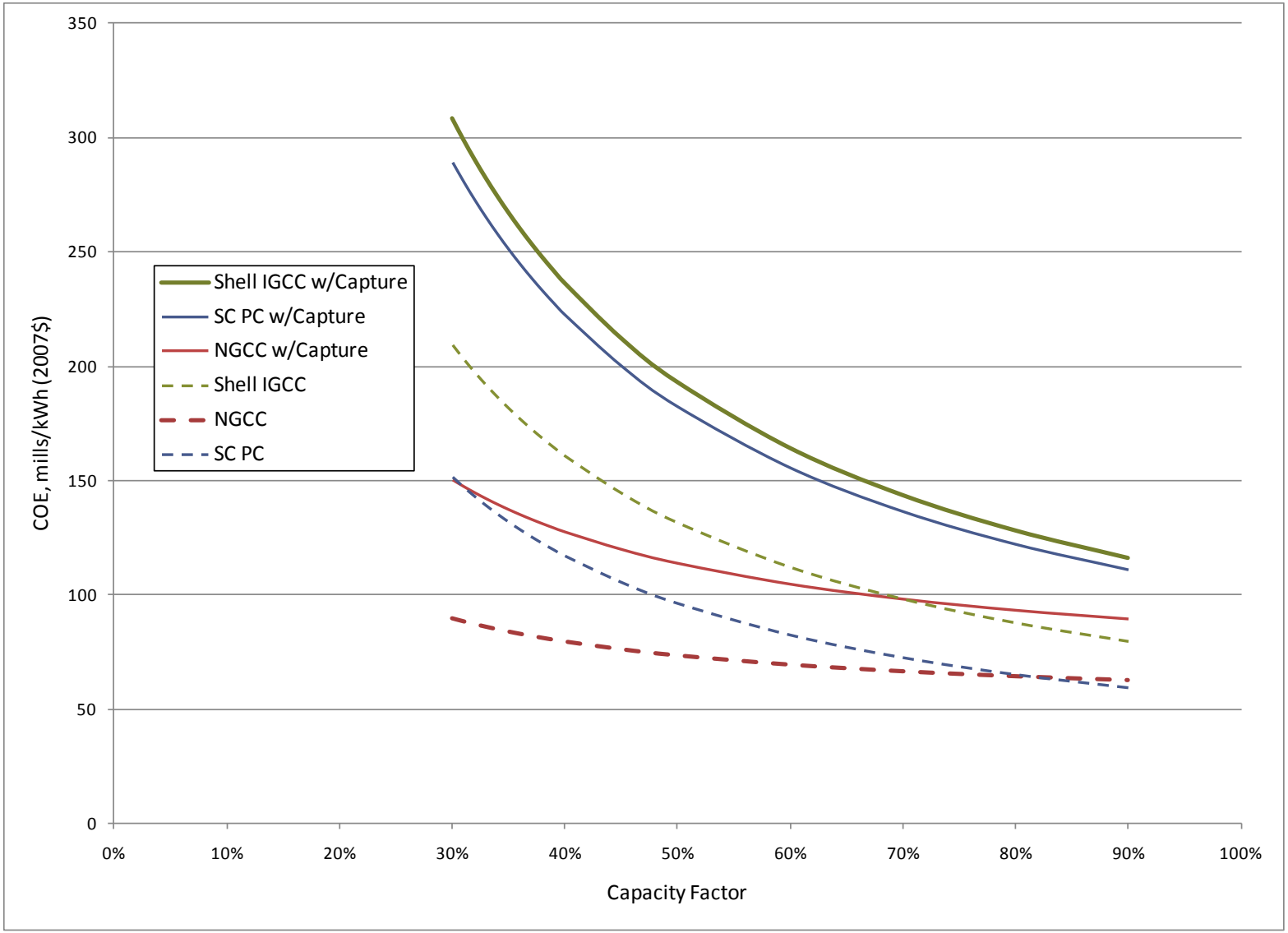
Natural Gas Price Sensitivity, ND Site



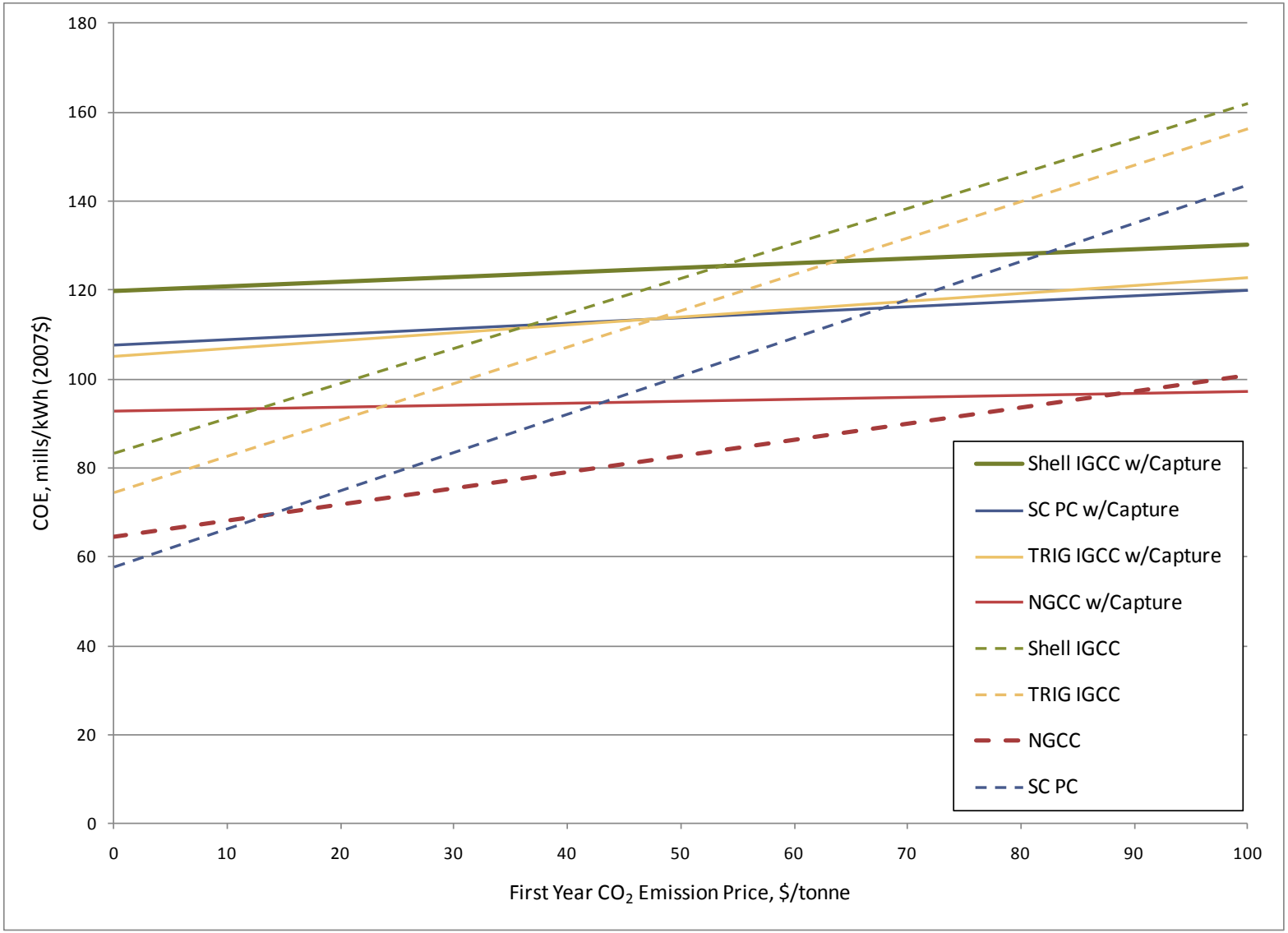
Capacity Factor Sensitivity, Montana Site



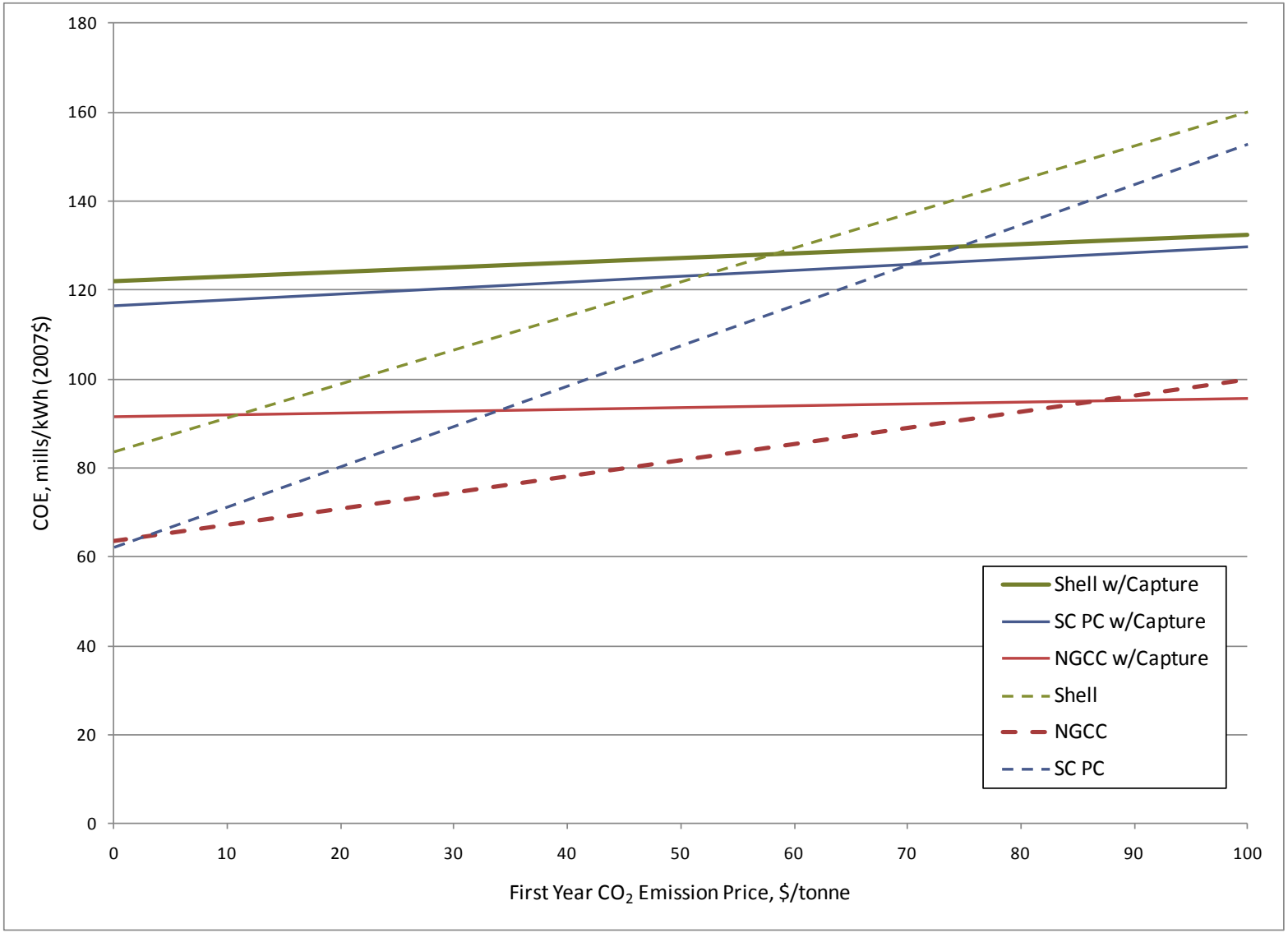
Capacity Factor Sensitivity, ND Site



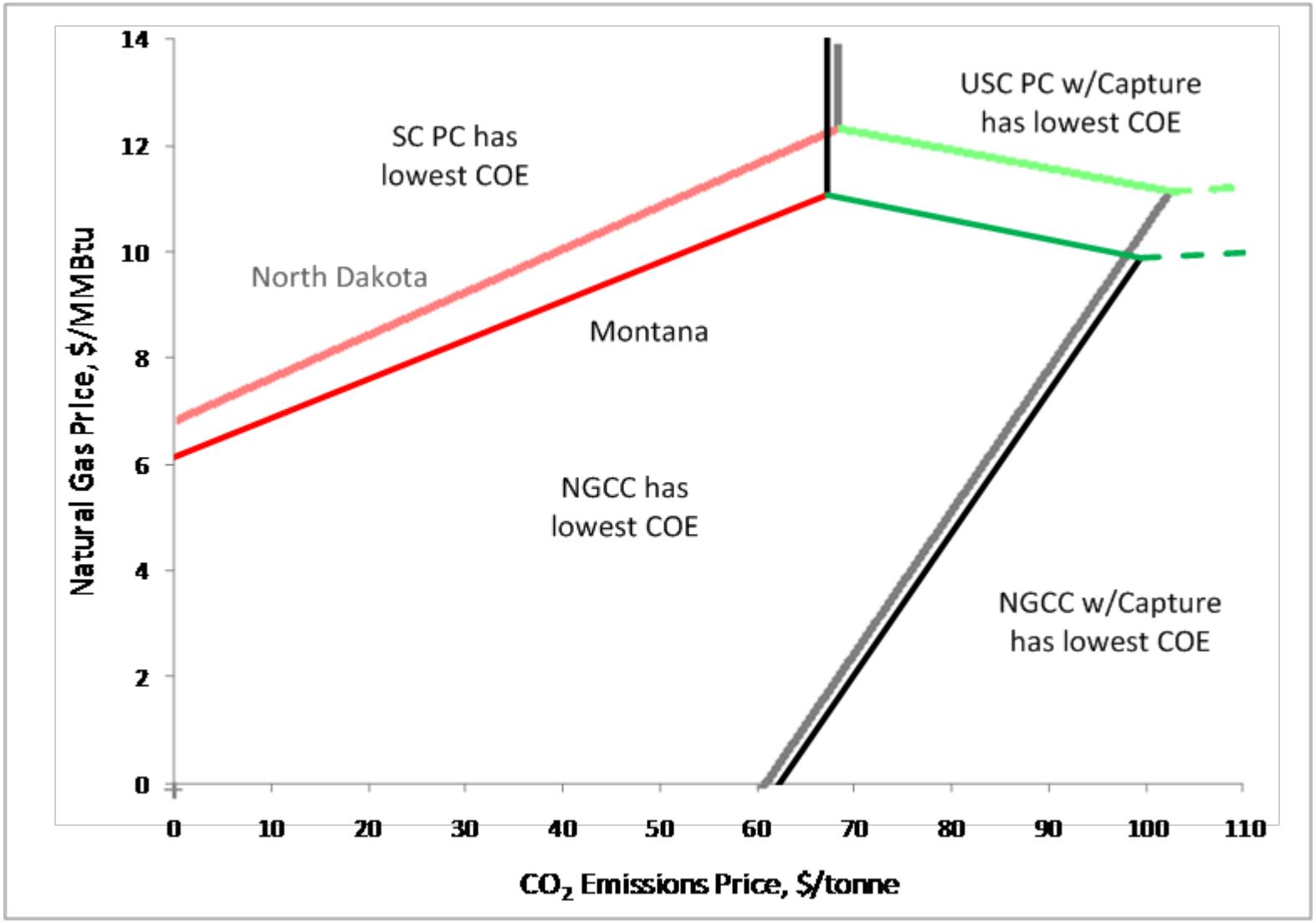
Carbon Emission Price Sensitivity, Montana



Carbon Emission Price Sensitivity, ND



Tech Parity for Varying CO_2 and NG Cost



NETL Viewpoint

- **Most up-to-date performance and costs available in public literature to date**
- **Establishes baseline performance and cost estimates for current state of technology**
- **Improved efficiencies and reduced costs are required to improve competitiveness of advanced coal-based systems**
  - In today's market and regulatory environment
  - Also in a carbon constrained scenario
- **Fossil Energy RD&D aimed at improving performance and cost of clean coal power systems including development of new approaches to capture and sequester greenhouse gases**

Key Findings

- **Utilizing western coals close to their source of origin (e.g., high elevation, limited water availability) can result in technology selection factors very different than the same plant at an alternate location, i.e., one size does not fit all**
- **Even with low rank coals, IGCC technologies take less of an efficiency hit when adding CCS compared to combustion technologies**
- **Using COE as the metric for comparison, there is no clear advantage for either IGCC or combustion plants fueled by low rank coal equipped with CCS**

Overall Accomplishments

- **Twenty-eight techno-economic systems analyses completed**
- **Three additional technologies (CFBC, TRIG and Siemens) added to NETL OPPA modeling library**
- **First public study with results directly applicable to western coal states, fills a previous void**
- **Significantly improved OPPA/vendor relationships that are expected to provide added credibility to these studies as well as provide future opportunities for collaborative work**

Lessons Learned

- **Do not initially rule out technologies that intuitively seem non-competitive, e.g., slurry fed IGCC with PRB**
  - Introduction of water (slurry + coal moisture) into the gasifier appears preferable to introduction of MP steam upstream of the WGS reactors
- **Substantial vendor involvement adds significant technical credibility with the trade-off of uncertain and likely schedule delays**
- **Learning associated with the execution of multiple "atypical" systems studies can result in unanticipated additional iterations of systems engineering**
  - Learning on later cases requires revision to previously completed early cases

Backup Slides

IGCC Summary Table

	Shell IGCC Cases				TRIG IGCC Cases		Siemens IGCC Cases				CoP IGCC Cases	
PERFORMANCE	**S1A**	**L1A**	**S1B**	**L1B**	**S2A**	**S2B**	**S3A**	**L3A**	**S3B**	**L3B**	**S4A**	**S4B**
CO_2 Capture	0%	90%	0%	90%	0%	83%	0%	90%	0%	90%	0%	90%
Gross Power Output (kW_e)	696,700	752,600	663,400	713,300	652,700	621,300	622,200	678,800	634,700	676,900	738,300	727,200
Auxiliary Power Requirement (kW_e)	124,020	135,900	191,790	213,240	107,280	160,450	117,480	135,680	189,410	210,390	133,460	212,130
Net Power Output (kW_e)	572,680	616,700	471,610	500,060	545,420	460,850	504,720	543,120	445,290	466,510	604,840	515,070
Coal Flowrate (lb/hr)	542,713	760,093	585,970	814,029	545,197	577,946	531,119	743,918	579,796	801,651	656,228	675,058
HHV Thermal Input (kW_{th})	1,362,134	1,474,011	1,470,704	1,578,608	1,368,368	1,450,564	1,333,034	1,442,644	1,455,207	1,554,603	1,647,041	1,694,303
Net Plant HHV Efficiency (%)	42.0%	41.8%	32.1%	31.7%	39.9%	31.8%	37.9%	37.6%	30.6%	30.0%	36.7%	30.4%
Net Plant HHV Heat Rate (Btu/kWh)	8,116	8,156	10,641	10,772	8,560	10,740	9,012	9,063	11,151	11,371	9,292	11,224
Raw Water Withdrawal (gpm/MW_{net})	3.1	3.0	7.2	7.8	3.7	6.5	4.5	4.0	9.0	8.9	5.4	8.4
Process Water Discharge (gpm/MW_{net})	0.8	0.8	1.4	1.6	0.8	1.0	1.1	1.1	1.6	1.7	1.1	1.5
Raw Water Consumption (gpm/MW_{net})	2.3	2.2	5.9	6.2	2.9	5.5	3.4	2.9	7.4	7.2	4.3	6.9
CO_2 Emissions (lb/MMBtu)	214	219	22	22	211	36	214	219	22	22	213	22
CO_2 Emissions (lb/MWh_{gross})	1,426	1,461	165	170	1,507	287	1,563	1,585	172	175	1,620	174
CO_2 Emissions (lb/MWh_{net})	1,735	1,783	233	242	1,803	386	1,927	1,981	246	255	1,977	245
SO_2 Emissions (lb/MMBtu)	0.0023	0.0023	0.0009	0.0010	0.0019	0.0009	0.0039	0.0021	0.0009	0.0010	0.0016	0.0009
SO_2 Emissions (lb/MWh_{gross})	0.015	0.015	0.007	0.007	0.013	0.007	0.029	0.016	0.007	0.008	0.012	0.007
NOx Emissions (lb/MMBtu)	0.062	0.063	0.050	0.049	0.059	0.049	0.061	0.061	0.051	0.050	0.052	0.044
NOx Emissions (lb/MWh_{gross})	0.412	0.418	0.381	0.371	0.422	0.390	0.444	0.445	0.397	0.391	0.398	0.348
PM Emissions (lb/MMBtu)	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
PM Emissions (lb/MWh_{gross})	0.047	0.047	0.054	0.054	0.051	0.057	0.052	0.051	0.056	0.056	0.054	0.056
Hg Emissions (lb/TBtu)	0.351	0.560	0.351	0.560	0.351	0.351	0.351	0.560	0.351	0.560	0.351	0.351
Hg Emissions (lb/MWh_{gross})	2.34E-06	3.74E-06	2.66E-06	4.23E-06	2.51E-06	2.80E-06	2.57E-06	4.06E-06	2.75E-06	4.39E-06	2.67E-06	2.79E-06
COST												
Total Plant Cost (2007$/kW)	2,506	2,539	3,480	3,584	2,236	3,019	2,610	2,656	3,533	3,626	2,265	3,144
Total Overnight Cost (2007$/kW)	3,056	3,094	4,253	4,378	2,728	3,691	3,185	3,239	4,318	4,430	2,771	3,851
Bare Erected Cost	1,914	1,941	2,610	2,692	1,692	2,228	2,006	2,044	2,654	2,730	1,737	2,357
Home Office Expenses	177	179	242	250	157	207	186	189	247	254	162	221
Project Contingency	343	349	486	502	305	421	359	367	493	508	306	431
Process Contingency	72	69	142	141	83	164	60	56	139	135	60	135
Owner's Costs	550	556	773	794	492	672	575	583	785	804	505	706
Total Overnight Cost (2007$x1,000)	1,750,189	1,908,200	2,005,883	2,189,363	1,488,063	1,701,132	1,607,607	1,759,016	1,922,741	2,066,464	1,675,790	1,983,369
Total As Spent Capital (2007$/kW)	3,484	3,527	4,849	4,991	3,110	4,208	3,631	3,692	4,922	5,050	3,159	4,390
COE (mills/kWh, 2007$)[1]	83.2	83.5	119.7	121.9	74.5	105.2	86.8	87.3	121.7	123.7	78.7	112.3
CO_2 TS&M Costs	0.0	0.0	6.0	5.7	0.0	5.9	0.0	0.0	6.3	6.2	0.0	5.8
Fuel Costs	7.2	6.7	9.5	8.9	7.6	9.5	8.0	7.5	9.9	9.4	8.3	10.0
Variable Costs	8.0	8.2	10.6	11.1	6.8	8.8	8.2	8.4	10.6	11.1	8.3	10.9
Fixed Costs	13.7	13.6	18.3	18.6	11.8	15.5	14.1	14.0	18.4	18.6	13.0	17.4
Capital Costs	54.2	54.9	75.4	77.6	48.4	65.4	56.5	57.4	76.6	78.5	49.1	68.3
LCOE (mills/kWh, 2007$)[1]	105.4	105.8	151.8	154.5	94.5	133.3	110.0	110.7	154.3	156.9	99.8	142.4

Combustion Summary Table

	Supercritical Pulverized Coal Boiler				Ultra-supercritical Pulverized Coal Boiler				Supercritical CFB			
PERFORMANCE	**S12A**	**L12A**	**S12B**	**L12B**	**S13A**	**L13A**	**S13B**	**L13B**	**S22A**	**L22A**	**S22B**	**L22B**
CO_2 Capture	0%	0%	90%	90%	0%	0%	90%	90%	0%	0%	90%	90%
Gross Power Output (kW_e)	582,700	584,700	673,000	683,900	581,500	583,200	665,400	675,200	578,400	578,700	664,000	672,900
Auxiliary Power Requirement (kW_e)	32,660	34,640	122,940	133,850	31,430	33,170	115,320	125,170	28,330	28,670	113,990	122,820
Net Power Output (kW_e)	550,040	550,060	550,060	550,050	550,070	550,030	550,080	550,030	550,070	550,030	550,010	550,080
Coal Flowrate (lb/hr)	566,042	755,859	811,486	1,110,668	549,326	731,085	764,212	1,043,879	563,307	745,997	801,270	1,095,812
HHV Thermal Input (kW_{th})	1,420,686	1,465,801	2,036,717	2,153,863	1,378,732	1,417,757	1,918,067	2,024,343	1,413,821	1,446,676	2,011,075	2,125,054
Net Plant HHV Efficiency (%)	38.7%	37.5%	27.0%	25.5%	39.9%	38.8%	28.7%	27.2%	38.9%	38.0%	27.3%	25.9%
Net Plant HHV Heat Rate (Btu/kWh)	8,813	9,093	12,634	13,361	8,552	8,795	11,898	12,558	8,770	8,975	12,476	13,182
Raw Water Withdrawal, gpm	2,649	2,683	7,642	7,817	2,578	2,597	7,117	7,261	2,393	2,379	7,762	7,996
Raw Water Consumption, gpm	2,093	2,125	5,527	5,456	2,035	2,056	5,141	5,060	1,839	1,828	5,713	5,704
CO_2 Emissions (lb/MMBtu)	215	219	21	22	215	219	21	22	213	219	21	22
CO_2 Emissions (lb/MWh_{gross})	1,786	1,877	222	236	1,737	1,820	211	225	1,775	1,865	220	236
CO_2 Emissions (lb/MWh_{net})	1,892	1,996	271	293	1,836	1,930	255	276	1,866	1,963	265	288
SO_2 Emissions (lb/MMBtu)	0.119	0.132	0.002	0.002	0.119	0.132	0.002	0.002	0.102	0.113	0.002	0.002
SO_2 Emissions (lb/MWh_{gross})	0.990	1.130	0.020	0.020	0.960	1.100	0.020	0.020	0.850	0.970	0.020	0.020
NOx Emissions (lb/MMBtu)	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070
NOx Emissions (lb/MWh_{gross})	0.582	0.599	0.723	0.752	0.566	0.581	0.689	0.716	0.584	0.597	0.723	0.754
PM Emissions (lb/MMBtu)	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
PM Emissions (lb/MWh_{gross})	0.108	0.111	0.134	0.140	0.105	0.108	0.128	0.133	0.108	0.111	0.134	0.140
Hg Emissions (lb/TBtu)	0.597	1.121	0.597	1.121	0.597	1.121	0.597	1.121	0.302	0.482	0.302	0.482
Hg Emissions (lb/MWh_{gross})	4.96E-06	9.59E-06	6.16E-06	1.20E-05	4.83E-06	9.29E-06	5.87E-06	1.15E-05	2.52E-06	4.11E-06	3.12E-06	5.19E-06
COST												
Total Plant Cost (2007$/kW)	1,033,301	1,122,438	1,797,852	1,958,416	1,084,716	1,185,901	1,827,095	1,973,559	1,062,836	1,123,412	1,812,415	1,943,572
Total Overnight Cost (2007$/kW)	2,293	2,489	3,987	4,341	2,405	2,628	4,049	4,372	2,357	2,490	4,018	4,307
Bare Erected Cost	1,530	1,663	2,517	2,750	1,577	1,725	2,530	2,738	1,480	1,563	2,424	2,600
Home Office Expenses	145	157	238	261	149	163	239	259	141	149	230	247
Project Contingency	204	220	406	438	213	231	408	437	210	221	407	435
Process Contingency	0	0	107	112	33	37	144	154	102	110	233	251
Owner's Costs	414	448	718	781	433	472	727	783	425	448	722	773
Total Overnight Cost (2007$x1,000)	1,261,175	1,369,100	2,192,877	2,387,887	1,322,909	1,445,367	2,227,086	2,404,506	1,296,474	1,369,642	2,209,764	2,368,935
Total As Spent Capital (2007$/kW)	2,600	2,823	4,545	4,949	2,742	2,996	4,615	4,984	2,687	2,839	4,580	4,909
COE (mills/kWh, 2007$)[1]	57.8	62.2	107.5	116.4	62.2	67.3	107.7	115.4	61.5	64.6	108.0	115.2
CO_2 TS&M Costs	0.0	0.0	6.0	6.2	0.0	0.0	5.8	6.0	0.0	0.0	5.9	6.1
Fuel Costs	7.8	7.5	11.2	11.0	7.6	7.3	10.6	10.4	7.8	7.4	11.1	10.9
Variable Costs	5.1	6.1	9.3	11.0	5.1	6.1	9.0	10.3	5.3	6.1	9.5	11.0
Fixed Costs	9.0	9.7	14.5	15.7	9.3	10.1	14.7	15.8	9.1	9.5	14.5	15.4
Capital Costs	35.9	39.0	66.5	72.4	40.1	43.9	67.6	73.0	39.3	41.6	67.0	71.9
LCOE (mills/kWh, 2007$)[1]	73.3	78.8	136.3	147.5	78.8	85.3	136.5	146.3	78.0	81.9	136.9	146.0

NGCC Summary Table

	NGCC with Advanced F Class			
PERFORMANCE	**Case S31A**	**Case L31A**	**Case S31B**	**Case L31B**
CO_2 Capture	0%	0%	90%	90%
Gross Power Output (kW_e)	522,100	557,000	470,000	501,600
Auxiliary Power Requirement (kW_e)	9,690	10,020	34,940	36,960
Net Power Output (kW_e)	512,410	546,980	435,060	464,640
Fuel Flowrate (lb/hr)	153,559	163,560	153,559	163,560
HHV Thermal Input (kW_{th})	1,014,787	1,080,880	1,014,787	1,080,880
Net Plant HHV Efficiency (%)	50.5%	50.6%	42.9%	43.0%
Net Plant HHV Heat Rate (Btu/kWh)	6,757	6,743	7,959	7,938
Raw Water Withdrawal, gpm	1,084	1,148	3,107	3,309
Raw Water Consumption, gpm	841	890	2,321	2,468
CO_2 Emissions (lb/MMBtu)	118	118	12	12
CO_2 Emissions (lb/MWh_{gross})	784	783	87	87
CO_2 Emissions (lb/MWh_{net})	799	797	94	94
SO_2 Emissions (lb/MMBtu)	Negligible	Negligible	Negligible	Negligible
SO_2 Emissions (lb/MWh_{gross})	Negligible	Negligible	Negligible	Negligible
NOx Emissions (lb/MMBtu)	0.009	0.009	0.009	0.009
NOx Emissions (lb/MWh_{gross})	0.060	0.060	0.067	0.066
PM Emissions (lb/MMBtu)	Negligible	Negligible	Negligible	Negligible
PM Emissions (lb/MWh_{gross})	Negligible	Negligible	Negligible	Negligible
Hg Emissions (lb/TBtu)	Negligible	Negligible	Negligible	Negligible
Hg Emissions (lb/MWh_{gross})	Negligible	Negligible	Negligible	Negligible
COST				
Total Plant Cost (2007$/kW)	341,350	348,275	572,302	588,738
Total Overnight Cost (2007$/kW)	817	782	1,607	1,548
Bare Erected Cost	546	521	994	957
Home Office Expenses	46	44	84	81
Project Contingency	74	71	62	61
Process Contingency	0	0	174	168
Owner's Costs	151	145	291	281
Total Overnight Cost (2007$x1,000)	418,817	427,473	698,949	719,155
Total As Spent Capital (2007$/kW)	879	840	1,732	1,668
COE (mills/kWh, 2007$)[1]	64.4	63.6	92.9	91.4
CO_2 TS&M Costs	0.0	0.0	3.4	3.3
Fuel Costs	48.2	48.1	56.7	56.6
Variable Costs	1.4	1.3	2.7	2.6
Fixed Costs	3.4	3.2	6.1	5.9
Capital Costs	11.5	11.0	24.0	23.1
LCOE (mills/kWh, 2007$)[1]	81.7	80.6	117.8	115.8