

# Retrofitting NGCC and PC Power Plants with Carbon Capture Technology

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Research & Innovation Center



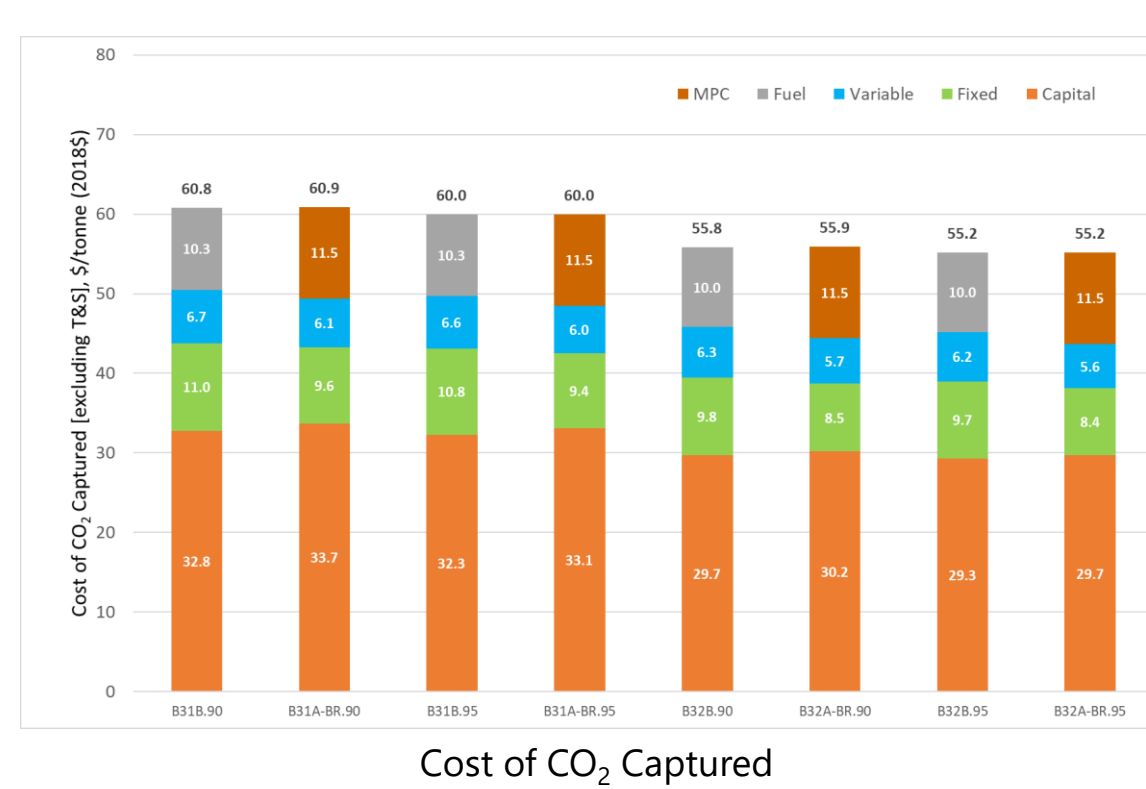
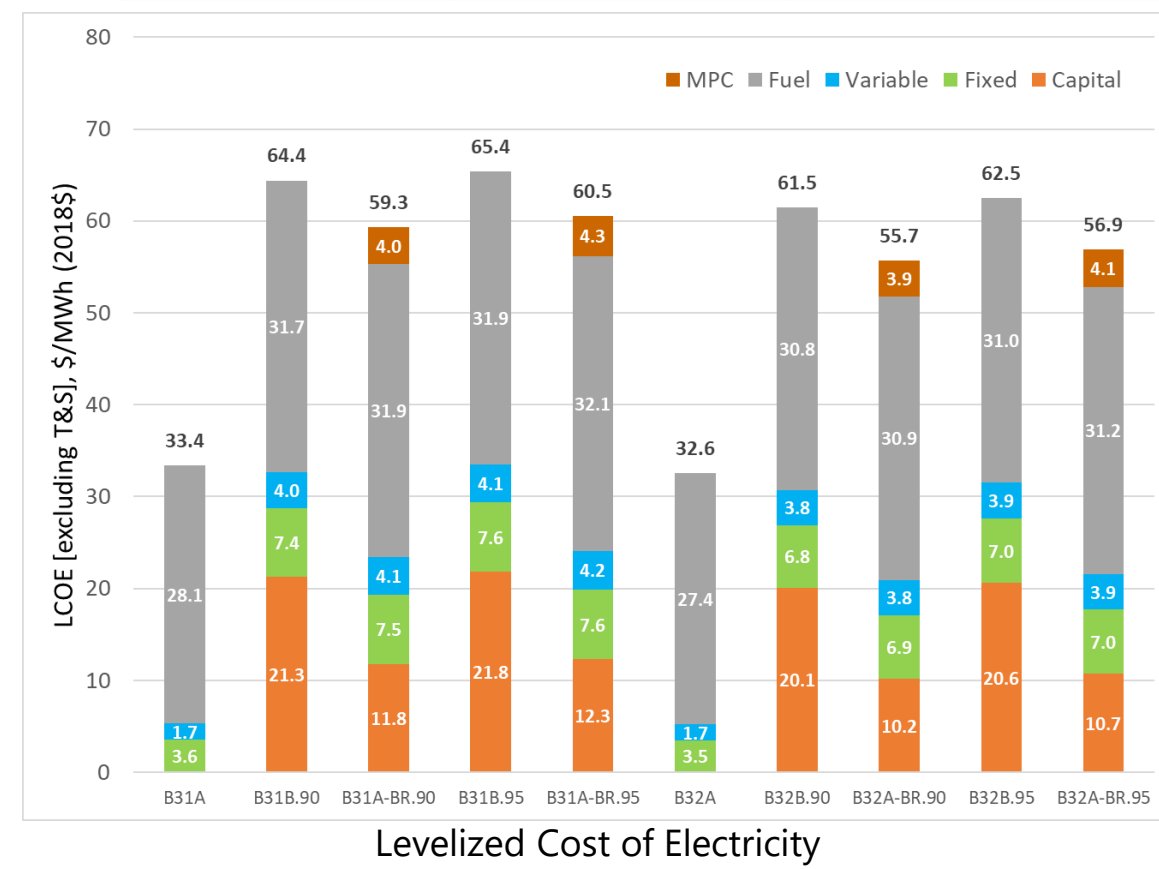
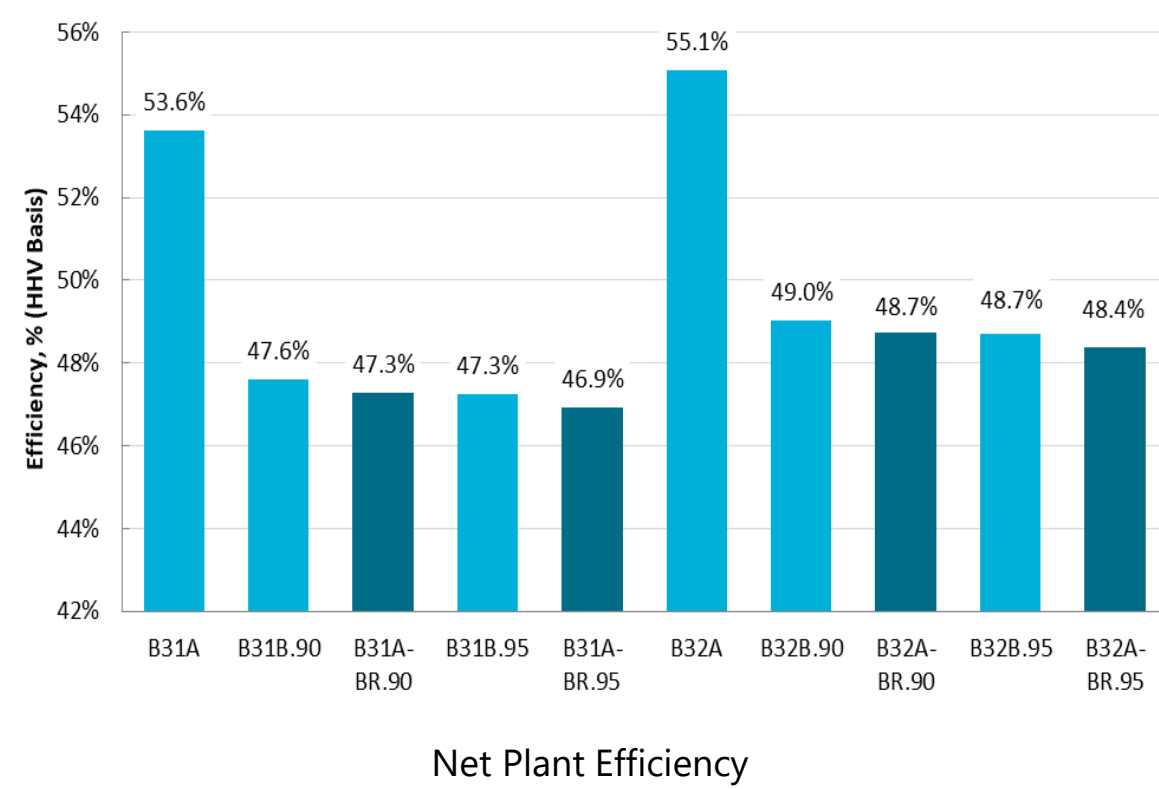
Objective: To update the cost and performance results for retrofitting existing NGCC and PC plants with solvent-based (Shell CANSOLV) carbon capture to be consistent with the NETL Fossil Energy Baseline Study, Revision 4A

## Retrofit Cost and Performance Reports

### Natural Gas Combined Cycle (NGCC)

- Base Cases: New build plants with and without capture (90% and 95%), F-Frame and H-frame NGCC technology
- Retrofit Cases: Shell CANSOLV based CO<sub>2</sub> Capture Process at 90% and 95% capture
- Higher capture rate (97%) information available in report appendix

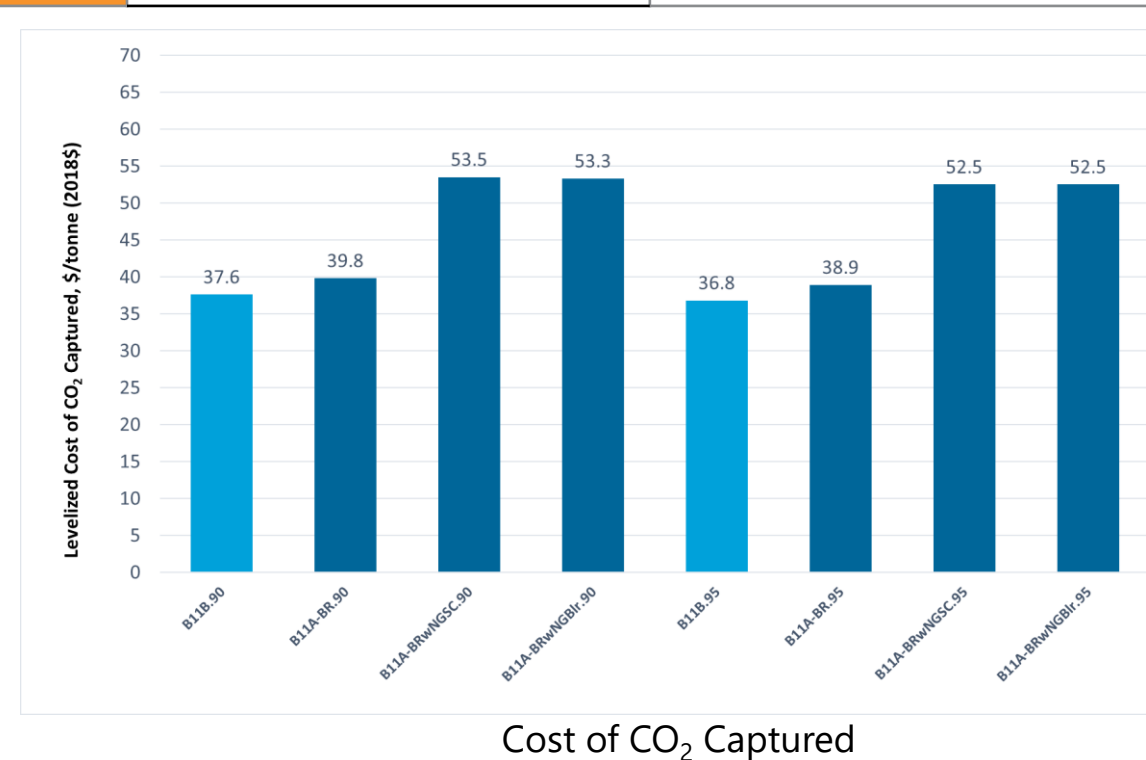
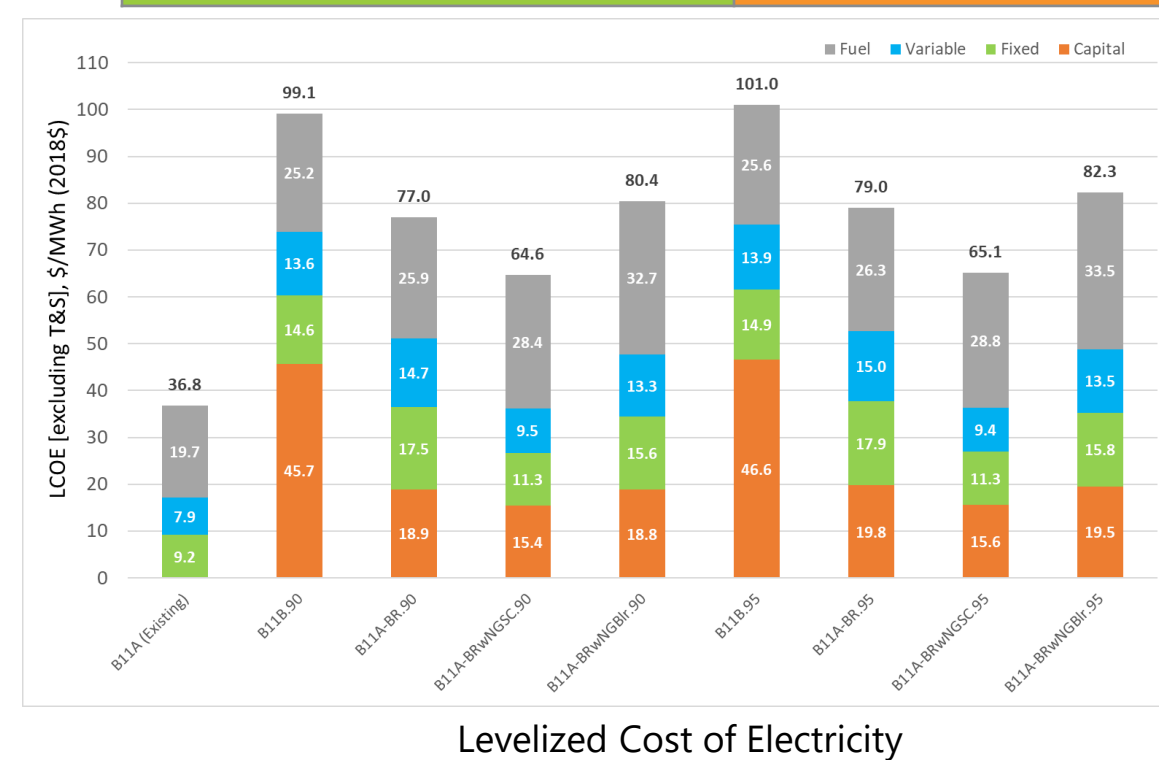
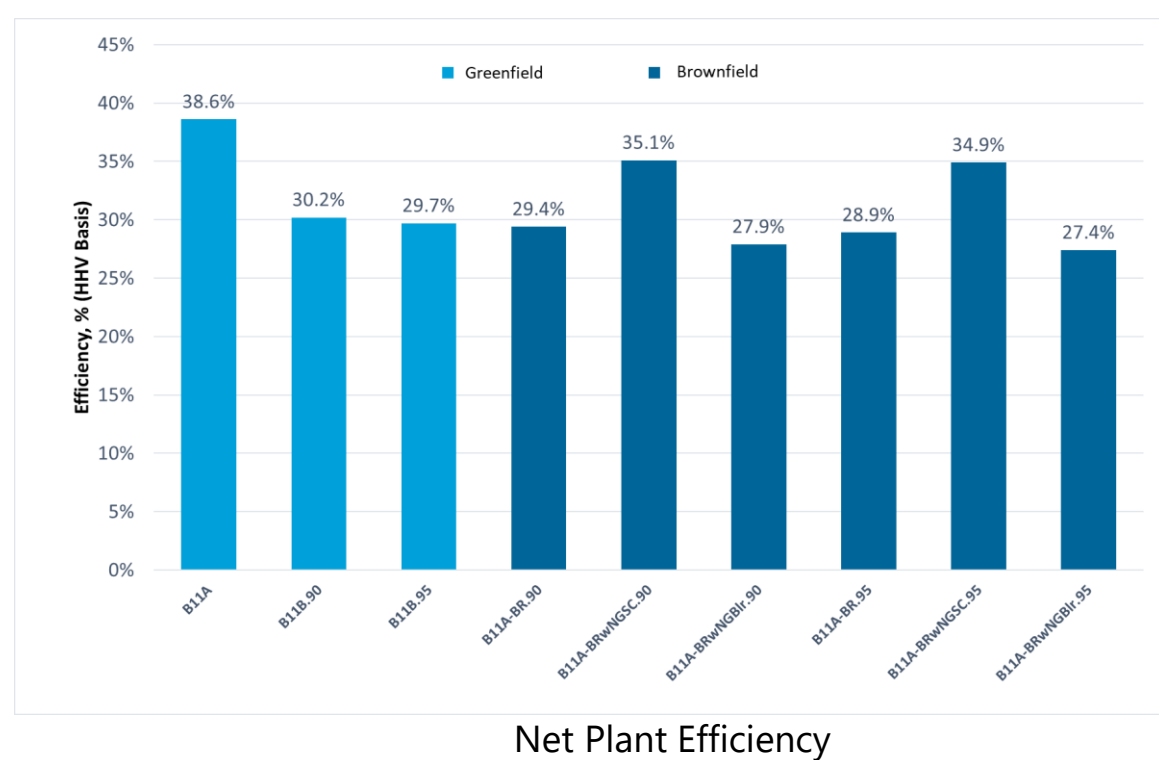
Case	Plant Type	Steam Cycle, psig/°F/°F	Combustion Turbine	Capture Rate
B31A	F-frame NGCC	2378/1085/1084	2x-State-of-the-art 2017 F-frame	N/A
B31B.90				90%
B31B.95				95%
B31A-BR.90				90%
B31A-BR.95	95%			
B32A	H-frame NGCC	2668/1085/1044	2x-State-of-the-art 2017 H-frame	N/A
B32B.90				90%
B32B.95				95%
B32A-BR.90				90%
B32A-BR.95	95%			



### Pulverized Coal (PC)

- Base Cases: New build plants with and without capture (90% and 95%), subcritical PC technology
- Retrofit Cases: Shell CANSOLV based CO<sub>2</sub> Capture Process at 90% and 95% capture
- Higher capture rate (99%) information available in report appendix

Case	Plant Type	Steam Cycle, psig/°F/°F	Capture Rate
B11A	Baseline w/o Capture	2400/1050/1050	N/A
B11B.90	Baseline w/ Capture		90%
B11B.95	95%		
B11A-BR.90	Fully Integrated Retrofit		90%
B11A-BR.95	95%		
B11A-BRwNGSC.90	Retrofit with NGSC for CHP	90%	
B11A-BRwNGSC.95	95%		
B11A-BRwNGBlr.90	Retrofit with NG Boiler Steam Generation	90%	
B11A-BRwNGBlr.95	95%		



## Carbon Capture Retrofit Databases

- Public-facing carbon capture retrofit databases (CCRD) are being released in tandem with the technical reports
- Macro-based spreadsheet tool calculates emissions, incremental cost of electricity, and cost of carbon capture broken down into sub-categories (i.e. capital, variable, make-up power, etc.)
- Tool is customizable, allowing the end user to apply retrofit calculations to specific plant(s) of interest (user defined plant characteristics)
- A similar tool is already available for industrial capture
- Includes "User Guide for the Public Power Generation CO<sub>2</sub> Capture Retrofit Database Models"

#### Basic User Input

Parameter	Units	Value
CO <sub>2</sub> Capture Rate	Choose Option	Default
CO <sub>2</sub> Capture Technology	Choose Option	90% Cansolv
Pre-Retrofit Capacity Factor	Choose Option	Varies
Post-Retrofit Capacity Factor	Choose Option	Delta
Retrofit Unit Capacity Applicability Limit	Choose Option	Default
Retrofit Cost Factor	Choose Option	1.10
Capital Charge Factor	Choose Option	0.077

#### Advanced User Input

Parameter	Units	Value
CO <sub>2</sub> Emissions Rate	Choose Option	Unit Actual
Maximum CO <sub>2</sub> Capture Rate Per Train	Choose Option	Default
Plant Capacity Metric	Choose Option	Nameplate
Install CO <sub>2</sub> Capture System per CT	Choose Option	No
Cost Year Basis	Choose Option	Year
Cooling Preference?	Choose Option	State
Projected Sales Price of Electricity	Choose Option	N/A
Include SCR with Retrofit?	Choose Option	Yes
Include FGD with Retrofit?	Choose Option	Yes
Additional Heat Rate Penalty	Choose Option	None
CO <sub>2</sub> Transport and Storage Costs	Choose Option	None

#### Plant Data

Column Title	Description
Plant ID	A unique numeric designation for this data row
Plant Name	A unique designation for the plant associated with this data row
Plant State	The state of location for the plant
Plant NERC Region	The NERC location for the plant
Gross to Net Factor	A factor for converting Gross MW generation to Net MW (i.e., MW <sub>Net</sub> /MW <sub>Gross</sub> )
Nameplate Capacity, MW	The nameplate capacity of this unit
Net Summer Capacity, MW	The summer net capacity of this unit
Net Winter Capacity, MW	The winter capacity of this unit
Heat Rate, Btu/kWh	The heat rate for this unit (usually based on HHV)
CO <sub>2</sub> Annual Rate, lb/MMBtu	The annual CO <sub>2</sub> emissions rate for this unit
NOx Summer Rate, lb/MMBtu	The NOx emissions rate for this unit
NOx Control Equipment	Existing NOx Control Systems (e.g., Low NOx Burners, Overfire Air, Selective Catalytic Reduction, Selective Non-catalytic Reduction)
Number of Combustion Turbines (NGCC version only)	The number of combustion turbines listed as included in the capacity
SO <sub>2</sub> Annual Rate, lb/MMBtu (PC version only)	The annual SO <sub>2</sub> emissions rate for this unit
SO <sub>2</sub> Control Equipment (PC version only)	Existing SO <sub>2</sub> Control Systems (e.g., Wet Limestone FGD, Lime Spray Dryer, Fluidized Bed Limestone Injection)
Weighted Average Variable O&M Costs, \$/MWh	Current existing plant variable O&M rate
Weighted Average Fixed O&M Costs, \$/MWh	Current existing plant fixed O&M rate
Fuel Costs (12-month weighted average), \$/MWh	Current existing plant fuel cost rate
Cooling System Type	Existing plant cooling systems (e.g., Recirculating with induced draft cooling towers), Recirculating with natural draft cooling towers), Once through with cooling pond(s) or canal(s), Once through without cooling pond(s) or canal(s)
Capacity Factor 2021, %	Existing plant capacity factor for current year
Capacity Factor 2020, %	Existing plant capacity factor for previous year
Capacity Factor 2019, %	Existing plant capacity factor for previous year

#### Sample Output

Parameter	SCENARIO #1	
	Fleet Total	Unit Average
Total units, No.	693	-
Units retrofit with CCS, No.	505	-
Units retrofit with dry cooling, No.	106	-
Units retrofit with SCR, No.	343	-
Units retrofit with FGD, No.	246	-
Units retrofit with NGSC or NG Boiler, No.	0	-
Pre-retrofit capacity, MW	226,619	449
Pre-retrofit heat rate, Btu/kWh	-	10,755
Pre-retrofit CO <sub>2</sub> emissions, x1,000 TPY	1,053,535	2,059
Post-retrofit capacity, MW	160,997	319
Post-retrofit heat rate, Btu/kWh	-	14,987
Post-retrofit CO <sub>2</sub> emissions, x1,000 TPY	84,664	165
Retrofit CO <sub>2</sub> capture, x1,000 TPY	761,978	1,484
Retrofit parasitic load, MW	65,622	129.9
Makeup/excess power, x1,000 MW/yr	433,861	859.1
Retrofit capital cost (TOC), \$/10 <sup>6</sup>	593,147	1,175
Retrofit COE, \$/MWh	-	288.5
Cost of CO <sub>2</sub> captured, \$/tonne	-	225.4
Cost of CO <sub>2</sub> avoided, \$/tonne	-	100.4

Scenario Assumptions:	
CO <sub>2</sub> capture rate, %	90%
CO <sub>2</sub> capture technology	90% Cansolv
Average pre-retrofit capacity factor	50%
Average post-retrofit capacity factor	40%
Retrofit unit capacity applicability limit, MW	25
Retrofit cost factor	1.10
Capital charge factor	0.077
CO <sub>2</sub> emissions rate, lb/MMBtu	Varies
Maximum CO <sub>2</sub> capture rate per train, TPD	15,772
Plant capacity metric	Nameplate
Cost year basis	2018
Cooling preference	State
Makeup/excess power costs/credits, \$/MWh	N/A
Include SCR with retrofit	Yes
Include FGD with retrofit	Yes
Additional heat rate penalty, Btu/kWh	N/A
CO <sub>2</sub> transport and storage cost, \$/tonne-CO <sub>2</sub>	N/A

#### PC CCRD Specific Inputs

Parameter	Units	Value		
		SCENARIO #1	SCENARIO #2	SCENARIO #3
Avoid Derate by Installing NGSC or NG Boiler?	Choose Option	No	No	No
Add NGSC or NG Boiler?	Choose Option	None	None	None
Plant Capacity Applicability Minimum for adding NGSC or Boiler Unit	Choose Option	Default	Default	Default
NGSC Design Margin	Choose Option	25	25	25
Natural Gas Price	Choose Option	10%	10%	10%
Use Spray Dryer instead of Wet FGD	Choose Option	Default	Default	Default

#### Visualization Options and Example

CHART 1 = Multiple Comparison

X-AXIS: Cost of CO<sub>2</sub> Captured

Y-AXIS: Cumulative Portion of Capacity

Cost of CO<sub>2</sub> Captured

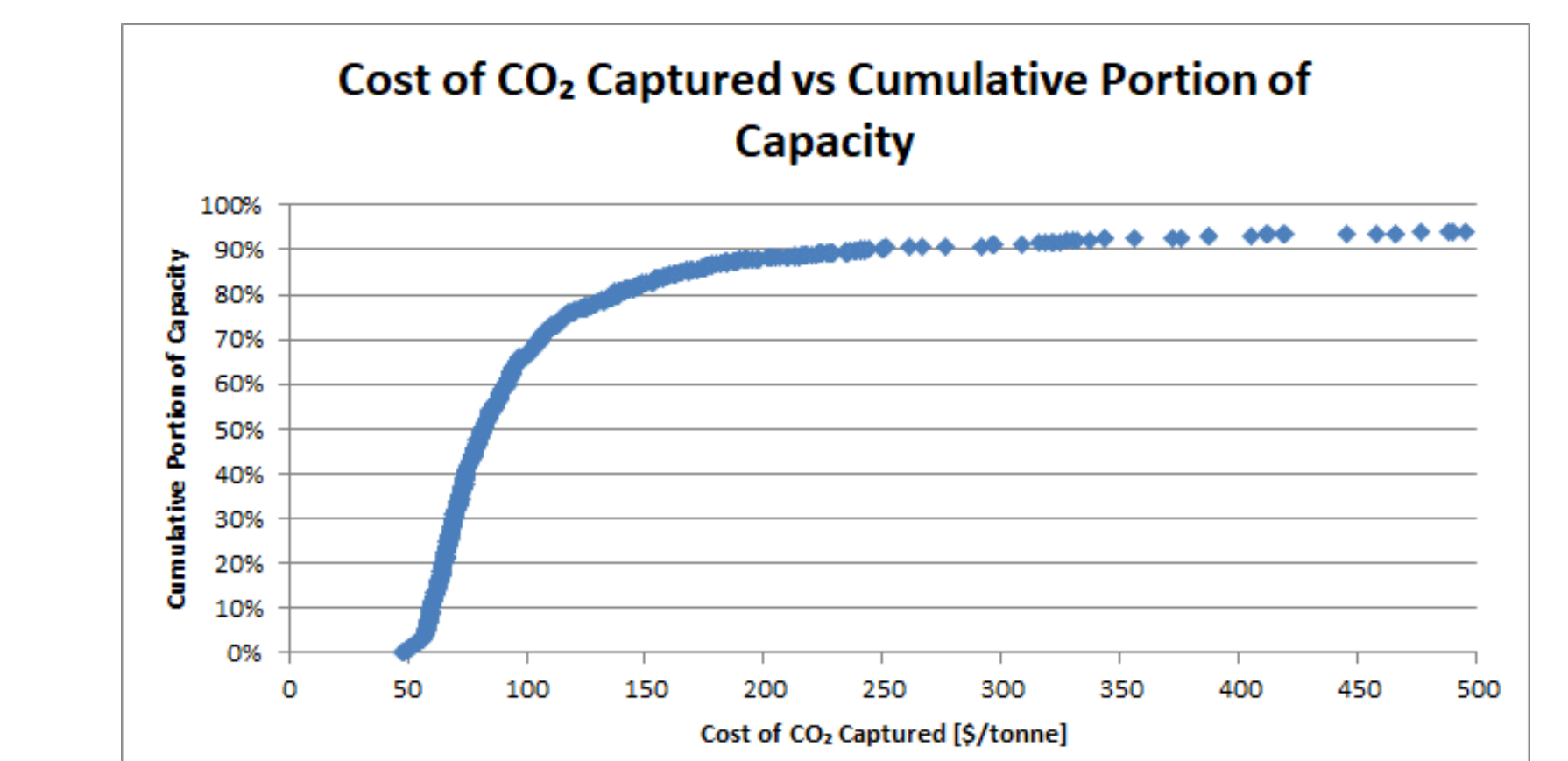
Cumulative Capacity

Cumulative Portion of Capacity

Incremental COE

Cost of CO<sub>2</sub> Avoided

Unit Capacity



References: NETL, "Cost and Performance of Retrofitting NGCC Units for Carbon Capture - Revision 3"; NETL, "Eliminating the Derate of Carbon Capture Retrofits, Revision 2"

References: NETL, "Natural Gas Combined Cycle CO<sub>2</sub> Capture Retrofit Database"; NETL, "Pulverized Coal CO<sub>2</sub> Capture Retrofit Database"