

Comparison of IGCC and Pulverized Coal Technologies in a BACT Analysis

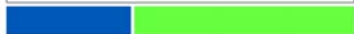
Workshop on Gasification Technologies

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Clean Air Task Force



Outline

- **Clean Air Task Force (CATF) in Brief**
- **The Changing Context for IGCC in “best available control technology” (BACT) review**
- **CATF Illustration of BACT Cost Comparison**
- **Sensitivity Analysis for CATF Illustration**
- **Key Results**



Clean Air Task Force in Brief

- **The Clean Air Task Force (CATF)**

- National non-profit environmental organization founded in 1996
- Major focus has been on controlling power plant air pollution
 - Legal advocacy
 - Scientific research
 - Public education
- Related projects to support cleaner technology, including support for IGCC projects such as
 - Duke Energy Edwardsport, Indiana IGCC
 - AEP Mason County, WV IGCC
 - Tenaska Taylorville, IL IGCC

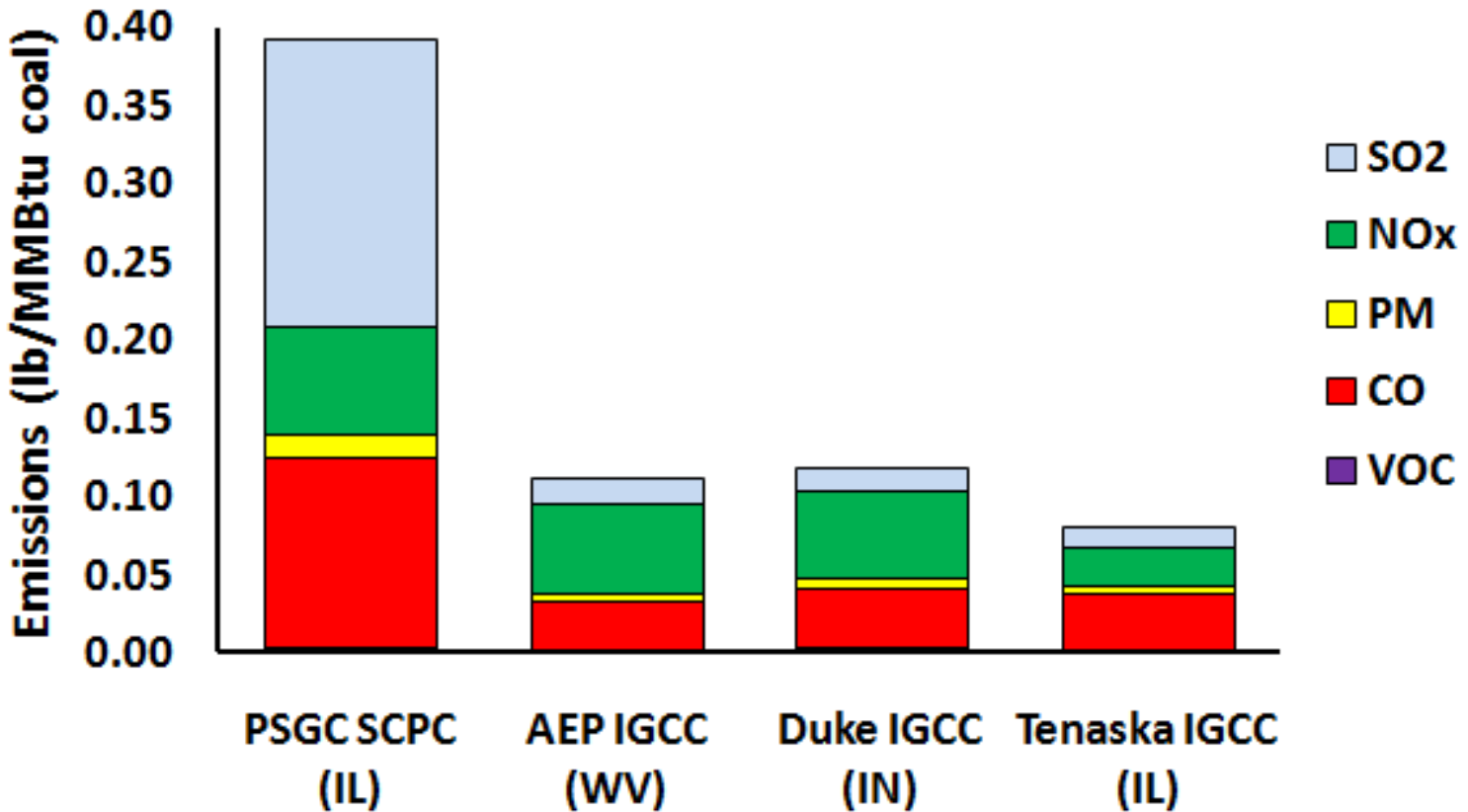
Some IGCC Are Moving Forward

- **Recent examples**

- Tenaska IGCC, Taylorville, Illinois
 - Air permit issued June, 2007
 - EAB order supporting air permit issued January, 2008
- Duke Energy IGCC, Edwardsport, Indiana
 - IURC approval November, 2007
 - Air Permit issued January, 2008
 - Breaking ground soon
- AEP IGCC, Mason County, West Virginia
 - WV PSC approval March, 2008
 - VA corporation commission action expected in April, 2008
 - WV air permit expected soon

Emissions Profile for New Coal

Air Emissions of Recently Approved Plants



Policy Context for Coal is Changing

- **CO2 emission restrictions, in some form, are highly likely**
 - Federal legislation (e.g., Lieberman-Warner)
 - State and regional actions (e.g., RGGI)
 - Frequent new developments (e.g., Waxman-Markey this week)
 - Legal challenges (e.g., Mass v. EPA, etc.)
- **A new administration will be coming to Washington**
 - Likely to change the CO2 discussion
 - Major climate bills sponsored by McCain, Clinton, and Obama
 - Could change historical practices with respect to IGCC and BACT for criteria pollutants
- **In any event, the energy, coal, IGCC, and BACT future is likely to be quite different from the recent past**

A (Short) History of IGCC in BACT Analyses

- **Some have argued that IGCC should not be part of a coal-fueled power plant BACT analysis because to do so impermissibly “redefines” the source proposed by a permit applicant**
- **Others have argued that IGCC must be part of the BACT analysis because evaluation of cleaner “production processes”, “clean fuels”, and other approaches is required by the Clean Air Act**
- **Ultimately the disagreement concerns the proper scope of BACT with respect to a facility’s fundamental nature**
- **Different regulatory agencies (e.g., NM, MI, IL, US EPA) and different actors have offered different perspectives**

Given the Changing Terrain, What Does a Fresh Look at IGCC in BACT Reveal?

- **CATF has developed an illustrative comparison based on an EPA method and EPA data**
- **The method: 5-Step “Top-Down” BACT per EPA’s 1990 New Source Review Manual (“NSRM”)**
 - A method is described for consideration of production processes for “identical or similar products from identical or similar raw materials or fuels” (NSRM at B.10)
 - NSRM available at <http://www.epa.gov/ttn/nsr/gen/wkshpman.pdf>
- **The data: EPA report from 2006**
- **Even with guidance and data, challenges remain**
 - Each process of producing electricity from coal is itself a control technology, and overall costs of production and emission reduction must be properly allocated to environmental benefits

4 Study Plants in CATF Illustration

- **CATF illustration built on EPA “Footprints Report” data**
 - EPA 2006 study; emissions based on recent permits; performance and cost based on published studies
 - EPA’s 4thQ 2004 capital costs adjusted +33%
- **CATF developed 4 study plants based on EPA’s data**
 - Study plants are 500 MW net output with bituminous coal feed
 - “PC-1”, direct per EPA data, w/SCPC with SCR, wet FGD, and FF
 - “IGCC-0”, direct per EPA data, O₂-blown IGCC with MDEA for AGR and Claus SRU, syngas dilution for NO_x control
 - “PC-NSPS”, adapted from “PC-1” by CATF, with control only as necessary to meet NSPS Subpart Da levels
 - “IGCC-1”, adapted from “IGCC-0” by CATF, but with Selexol for syngas sulfur removal, and SCR for NO_x control
 - Heat rates of PC and IGCC units have not been adjusted

Details of the CATF Illustration

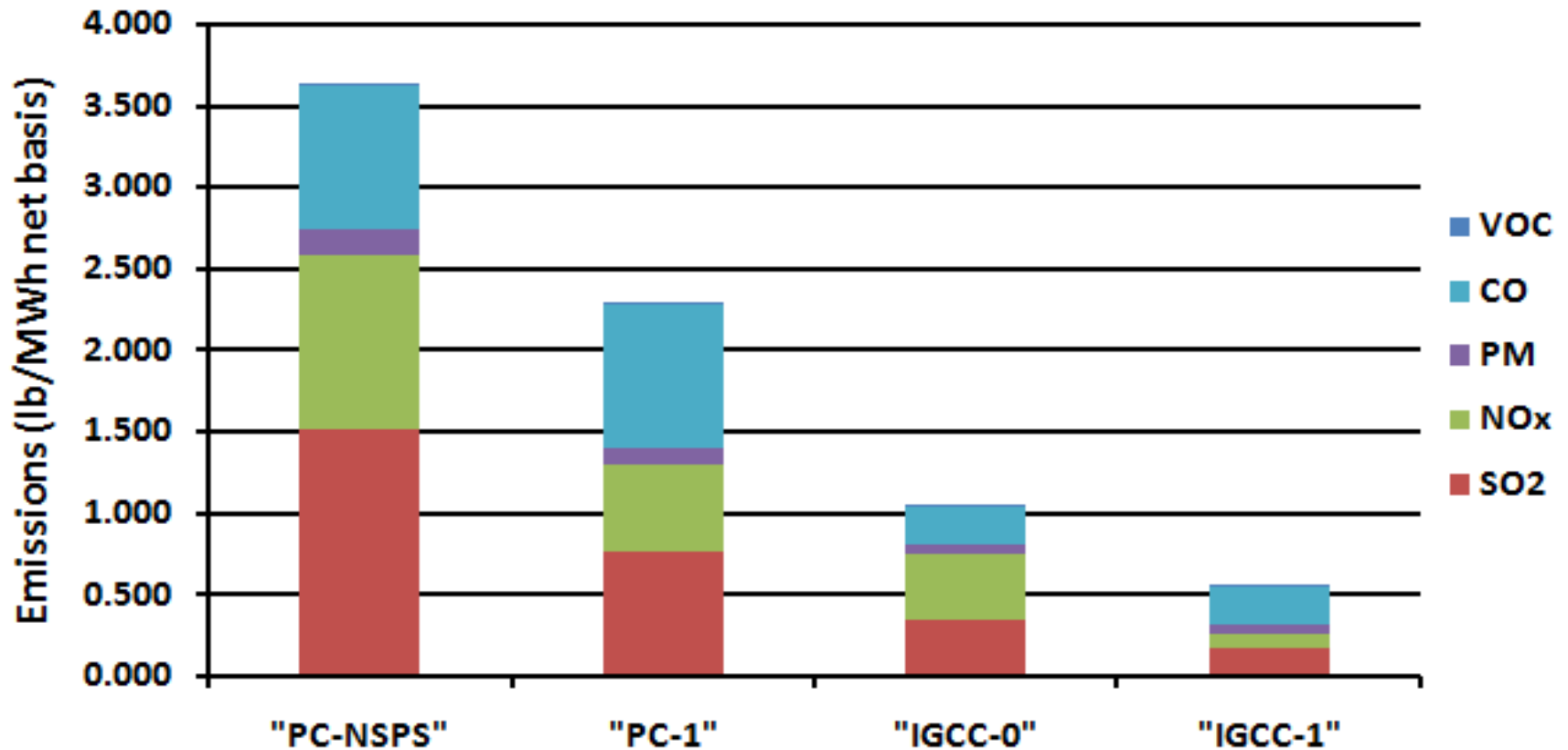
- **In the CATF reference case comparison**
 - SO₂ allowances are included at \$500/ton; NO_x at \$2500/ton
 - CO₂ allowances are included at \$5/ton
 - Fuel costs are included at \$1.80/MMBtu
 - A consistent cost of capital is used (10% annual CRF)
 - Total annual cost (“TAC”) is cost of producing electricity from each plant, calculated using an equivalent uniform annual cost (EUAC) method, considering capital cost repayment, fixed and variable O&M, fuel costs, and costs of emission allowances
 - TAC is 100% allocated to criteria pollutant emissions; for simplicity allocation to other effluents/impacts is ignored
 - Costs and emissions are based on 85% capacity factor

CATF Study Plant Matrix for Reference Case

Output/Assumption	"PC-NSPS"	"PC-1"	"IGCC-0"	"IGCC-1"
Output, Net, MWe	500	500	500	500
Heat Rate, HHV, Btu/kWh	8900	8900	8167	8167
Total heat input rate, MMBtu/hr	4450	4450	4083.5	4083.5
SO ₂ , lb/MMBtu	0.170	0.086	0.043	0.021
NO _x , lb/MMBtu	0.121	0.060	0.049	0.010
PM (Filterable), lb/MMBtu	0.017	0.012	0.007	0.007
CO, lb/MMBtu	0.100	0.100	0.030	0.030
VOC, lb/MMBtu	0.0024	0.0024	0.0017	0.0017
Total Criteria Emissions, ton/yr	6803	4316	1986	1061
CO₂, ton/yr	3347349	3347349	3025771	3025771
Total Capital Requirement, \$/kW (net)	1739.65	1902.74	2221.10	2294.25
Capital Recovery Factor, %/yr	10.00	10.00	10.00	10.00
Annual Capital Charge, M\$/yr	86.982	95.137	111.055	114.713
Total Annual Non-Fuel O &M, M\$/yr	25.822	29.000	27.310	30.990
Fuel Cost, M\$/yr	59.642	59.642	54.730	54.730
Sub-Total, Annual Production Costs, M\$/yr	172.447	183.780	193.095	200.433
CO ₂ Allowance Cost, M\$/yr	16.737	16.737	15.129	15.129
Sub-Total, Annual Allowance Costs, M\$/yr	23.170	19.932	17.319	15.660
Total Annual Cost, M\$/yr	195.617	203.712	210.414	216.092

CATF Illustration - Plant Emissions Levels

Study Cases Emissions

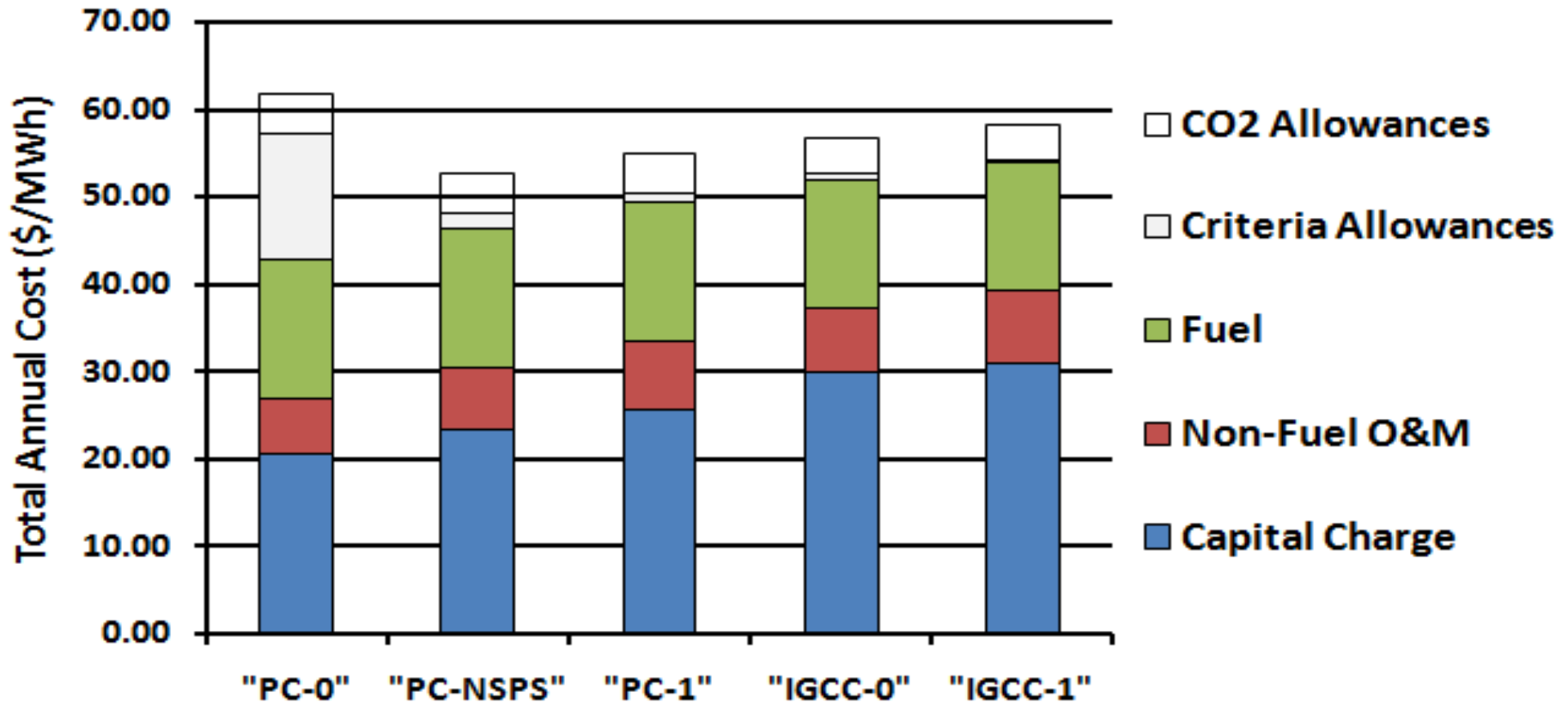


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CATF Illustration – Cost of Electricity

Study Cases Cost Breakdown



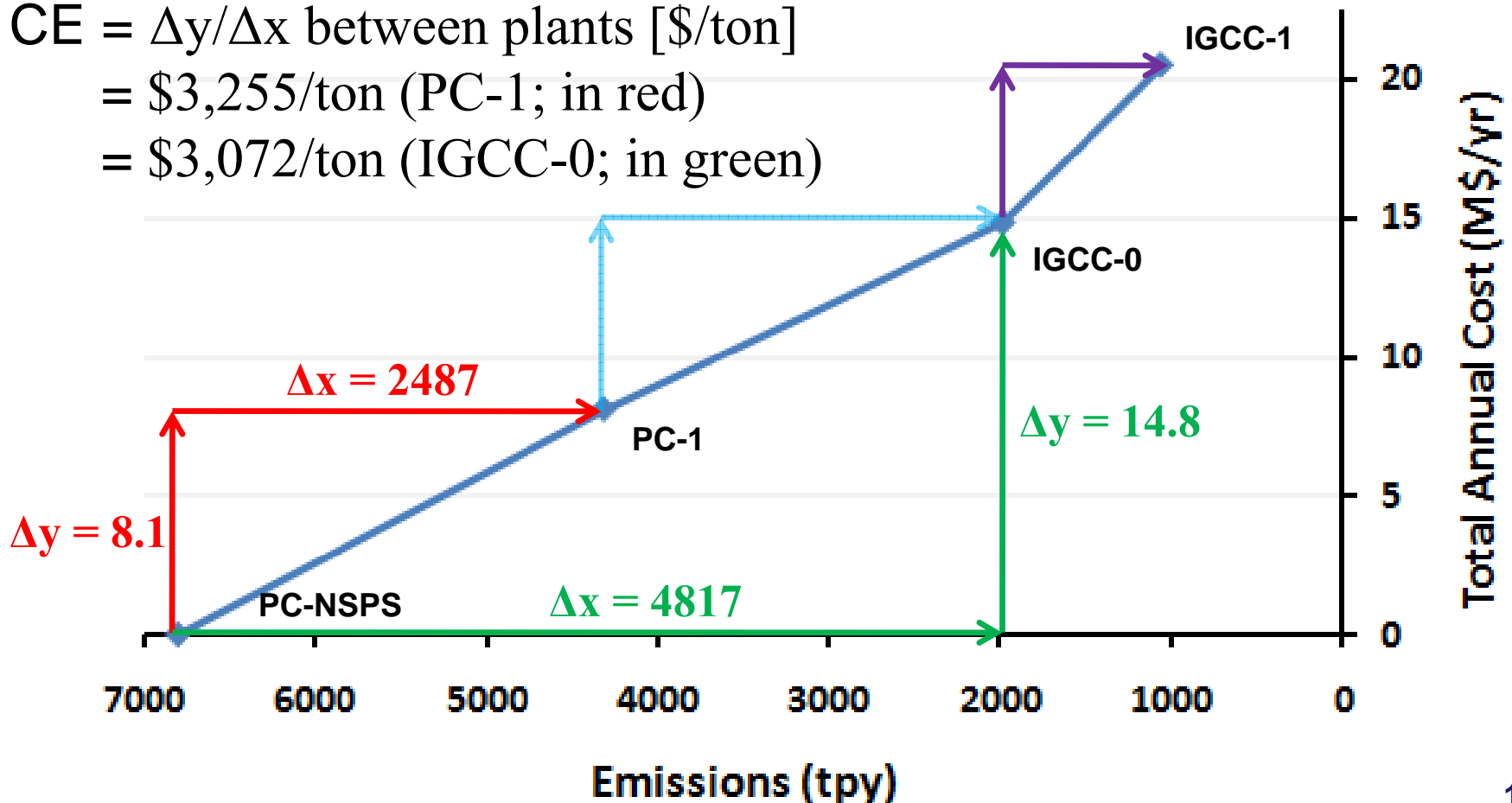
Calculating Control Cost Effectiveness

- **“Cost effectiveness” is the cost of control divided by the quantity of pollution removed, expressed in \$/ton**
- **Numerically high CE (high \$/ton) is less desirable**
- **In this comparison:**
 - Cost of control is TAC for the study plant less TAC for the baseline plant (the NSPS-level PC plant)
 - Quantity of pollutant removed is total emissions from the baseline plant (SO₂+NO_x+PM+CO+VOC) less total emissions from the study plant
 - Both average and incremental cost effectiveness are calculated; the difference is the choice of baseline
- **Total costs also can be apportioned to individual pollutants based on the baseline plant emissions profile**

CATF Illustration – Calculation of Cost Effectiveness

Least Cost Envelope, All Criteria Pollutants

CE = $\Delta y / \Delta x$ between plants [\$/ton]
= \$3,255/ton (PC-1; in red)
= \$3,072/ton (IGCC-0; in green)



CATF Illustration - Cost Effectiveness Results

- **Cost effectiveness of PC-1, IGCC-0, and IGCC-1, for all criteria pollutants combined, is indicated below**

Cost Effectiveness (CE)	PC-1	IGCC-0	IGCC-1
Average CE v. PC-NSPS Baseline	\$3,255/ton	\$3,072/ton	\$3,566/ton
Incremental CE v. Next Option		\$2,877/ton	\$6,139/ton

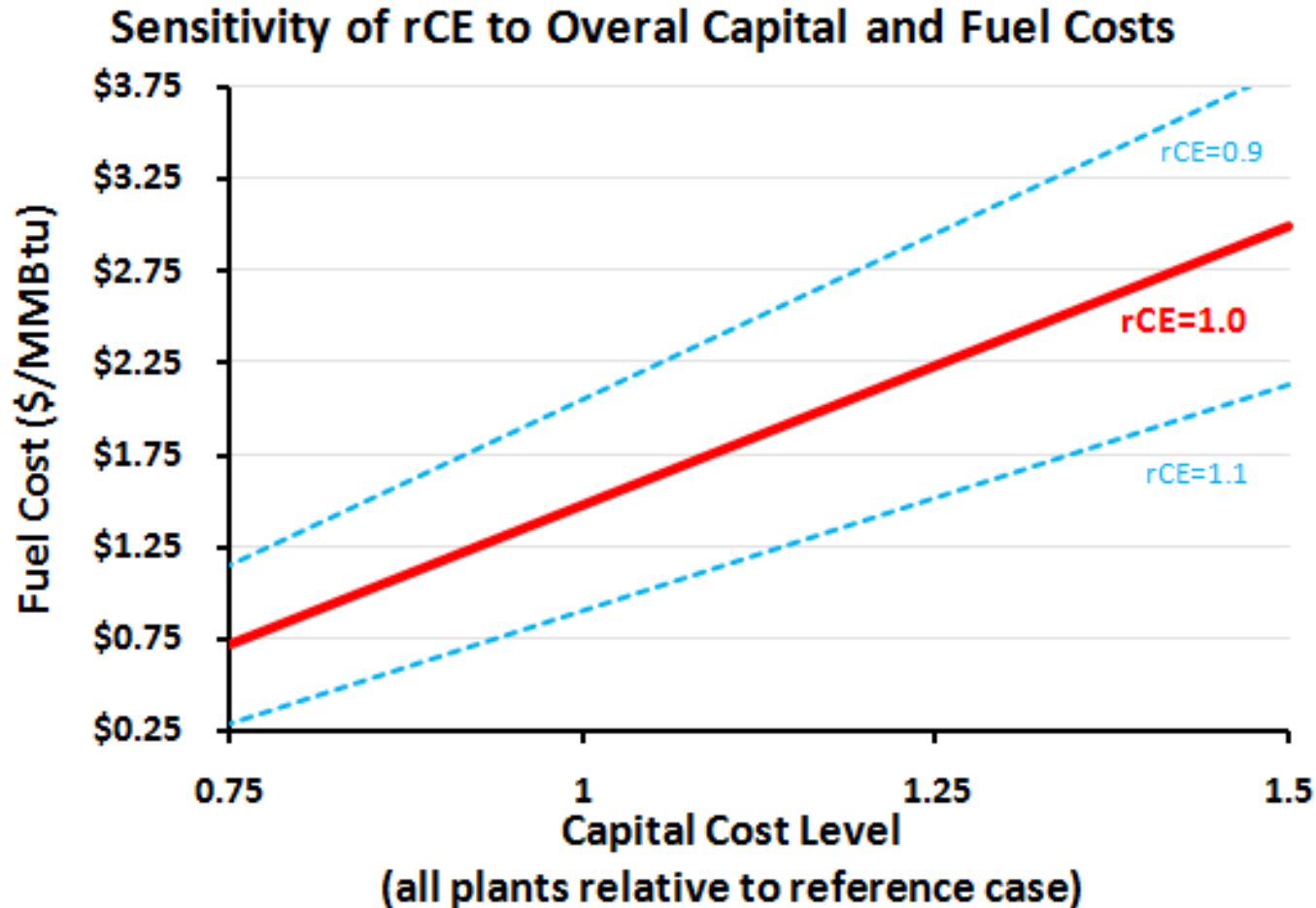
- **Implications:**

- Using the EPA methodology, in the CATF reference case the average cost effectiveness of IGCC is less than that for SCPC
- The incremental cost effectiveness of IGCC, compared to SCPC, is not unacceptable

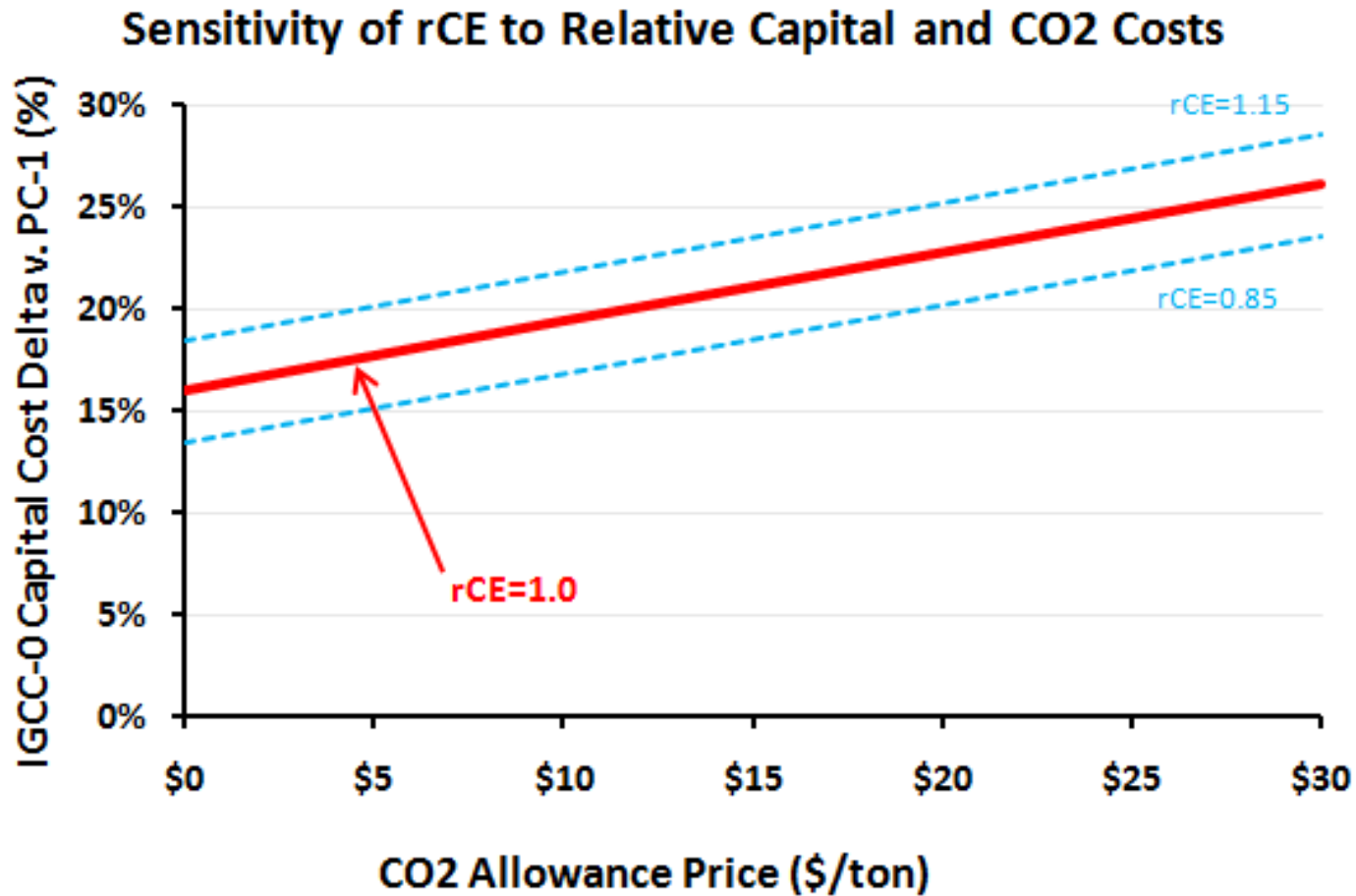
CATF Illustration - Sensitivities

- **CATF evaluated the sensitivity of the BACT cost-effectiveness result by calculating the ratio of the average cost effectiveness (\$/ton) of IGCC-0 to the average cost effectiveness of PC-1 (\$/ton) for a range of input assumptions. This quantity is termed “rCE”**
 - $rCE = [CE \text{ for IGCC-0}] / [CE \text{ for PC-1}]$
- **Sensitivity to various input assumptions are indicated on the next two slides**
 - Uniform capital cost increase (the same factor applied to all plants)
 - Fuel cost increase (same for all plants)
 - CO2 allowance cost (same for all plants)
 - Capital cost differential (capital cost of IGCC-0 relative to PC-1)

CATF Illustration – Sensitivity Analysis



CATF Illustration – Sensitivity Analysis



CATF Illustration - Key Results

- **Criteria pollutant control for IGCC costs slightly more (in \$/ton terms) than for PC under assumptions of “yesterday’s world”**
- **CO2 allowance prices are a key consideration, even for plants without carbon capture and storage (“CCS”)**
- **Criteria pollutant control for IGCC costs less (in \$/ton terms) than PC even under moderate assumptions of “tomorrow’s world” (e.g., CO2 allowances at \$5/ton)**

Thank You

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