

Employment and Other Economic Benefits from Advanced Coal Electric Generation with Carbon Capture and Storage (Preliminary Results)

Prepared for:

- **Industrial Union Council, AFL-CIO**
- **International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers, and Helpers**
- **International Brotherhood of Electrical Workers**
- **United Mine Workers of America**
- **American Coalition for Clean Coal Electricity**

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Introduction

- The development and broad deployment of CCS technologies can be a key part of a national strategy to reduce CO₂ emissions and address climate change concerns.
- Initiatives to reduce greenhouse gas emissions are likely to stimulate the deployment of new, advanced coal generation facilities with carbon capture and storage (CCS), provided CCS technology development is successful and timely.
- In addition to environmental benefits, this study also shows that the development and deployment of CCS technologies can serve as an economic stimulus.
- This study estimates the capital, operating and maintenance costs (O&M), jobs and other economic benefits associated with the deployment of advanced coal generation with CCS.

Purpose and Caveats

- The purpose of this study is to illustrate the potential job and other economic benefits from the deployment of advanced coal-fueled electric generation using carbon capture and storage technologies (“CCS-only benefits”).
- ***The study does not take into account adverse economic impacts that may result from proposals to reduce greenhouse gas emissions.***
- Numerous analyses by EIA, DOE, and NGO’s have shown that complying with emission reduction targets is likely to have adverse economic impacts on the coal and electric generation sectors, along with other industries and sectors.
- Study results are presented at the national level to illustrate the potential magnitude of job, GDP and income benefits associated with the construction and operation of these new advanced coal-fueled electric generation technologies.
- ***This study is not intended to imply support for any policy position regarding climate change legislation, or to endorse assumptions regarding the level of future deployment of Advanced Coal facilities with CCS.***

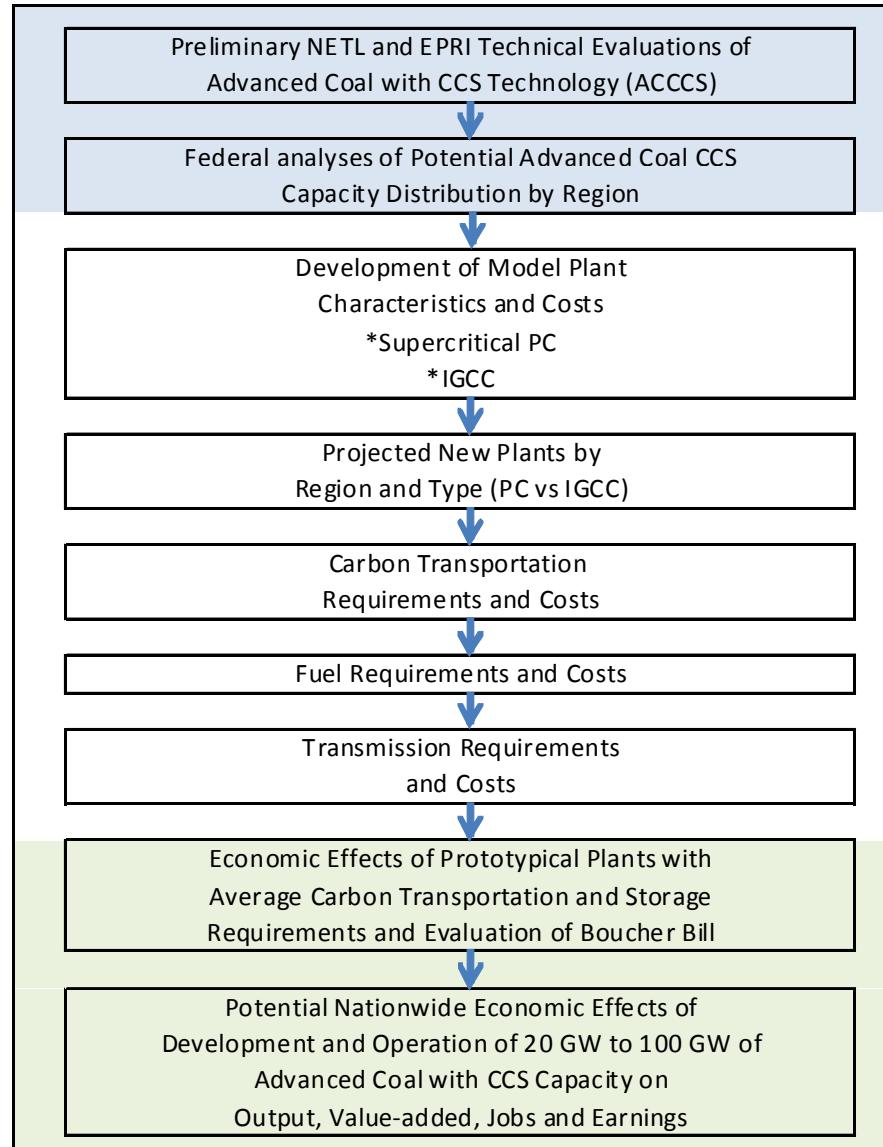


Part 1: **Background and Study Approach**

Overview of Study Approach

- The study team:
 - Analyzed recent studies from the U.S. Department of Energy's National Energy Technology Laboratory (NETL) and the Electric Power Research Institute (EPRI) to estimate the costs and operating characteristics of typical Advanced Coal CCS facilities.
 - Estimated the infrastructure and operating requirements for carbon capture and storage by examining regional projections of future Advanced Coal CCS capacity from EPA analyses of climate change proposals to determine possible plant locations relative to potential CO₂ storage locations.
 - Estimated the coal mining and fuel transportation requirements, and likely sources, for new Advanced Coal CCS facilities based on the potential regional distribution of Advanced Coal CCS facilities from the EPA analyses.
- Construction and operating expenditures were incorporated into the IMPLAN input-output model to estimate the national effects of construction and ongoing operations on economic output, value-added, jobs and labor earnings.
- The flow chart on the following page illustrates the study approach.

Study Approach



Advanced Coal Plant Technology

- Based on recent NETL and EPRI research, this study focuses on two technologies: Advanced Supercritical Pulverized Coal (PC) with CCS and Integrated Gasification Combined Cycle (IGCC) with CCS.
 - PC – Pulverized coal is used in a boiler designed to deliver "supercritical" steam conditions, generating power with high plant generating efficiency. Combustion products, after removal of nitrogen oxides, particulate matter, mercury and sulfur dioxide, are processed in a post-combustion scrubber to remove approximately 90% of the CO₂.
 - IGCC – Coal is partially oxidized in oxygen, generating a synthetic gas (syngas). Steam is injected into the syngas to "shift" most of the chemical energy in the CO to H₂, producing mostly CO₂ and H₂. After cooling, the CO₂, mercury and SO₂ are removed, leaving H₂ to fuel a combined cycle generating plant, and the byproducts include sulfur compounds and highly concentrated CO₂. As envisioned for this study, IGCC designs remove approximately 90% of the CO₂.

Terminology

- **Direct economic effects** – Output, jobs and other economic measures at electric generating plants, sites manufacturing the equipment used in the plants, coal mines, carbon transportation and storage facilities and for firms transporting coal to plants.
- **Indirect economic effects** – Output, jobs and other economic activity stimulated by purchases of goods and services by directly affected industries from other firms. Purchases of equipment or consulting services by coal mines would be examples of indirect effects.
- **Induced economic effects** – Output, jobs and other economic activity stimulated by purchases by employees of directly and indirectly affected businesses. Purchases of groceries and home rental expenditures would be examples of induced effects.
- **Multiplier effects** – Sum of indirect and induced economic effects.
- **Output** – Generally equivalent to sales.
- **Value-added** – Sales net of the costs of inputs. When summed across all industries, generally equivalent to gross domestic product (GDP).
- **Job-year** – One job for a one-year period.

Notes

- Monetary economic effects (e.g., output, value-added and labor income) are reported in year 2007 dollars.
- Expenditures for plant construction, operations and maintenance were estimated and are reported in year 2007 dollars.
- All other capital and operating expenditures (e.g., coal costs, pipeline construction costs) were estimated and are reported in year 2006 dollars. The IMPLAN model was used to update these costs to year 2007 dollars prior to estimating economic effects.



Part 2:
Expenditures, Jobs and Other Economic Benefits from an Individual Advanced Coal Plant with CCS

Summary of Benefits from an Individual Advanced Coal Unit with CCS

- Advanced coal units with CCS are assumed to have net generating capacities of 520 megawatts (MW) for IGCC and 540 MW for PC.
- Construction expenditures for either a Supercritical PC unit with CCS or an IGCC unit with CCS are approximately \$2.0 to \$2.1 billion.
- Annual O&M expenditures are \$137 million for an IGCC unit with CCS and \$127 million for a Supercritical PC unit.
- Construction of either type of facility is expected to support about 13,000 to 14,000 direct job-years and about 36,000 to 38,000 total job-years (including indirect and induced effects throughout the economy).
- Ongoing annual employment from O&M activity at an individual unit, including coal purchases and transportation, is projected at between 250 and 270 direct jobs. Including multiplier effects, between 1,200 and 1,300 total jobs would be supported throughout the economy.

Construction and Operating Expenditures for an Advanced Coal Facility with CCS

Expenditure Category	Advanced Coal Facility Type		
	Supercritical Puverized Coal	Integrated Gasification Combined Cycle	
Net Generating Capacity	540 MW	520 MW	
Capital Costs for Construction (\$ Millions)			
Plant	\$2,090	\$1,976	
Transmission Upgrades	\$32	\$32	
Pipelines and Compressors	\$21	\$21	
Carbon Storage Site	<u>\$2</u>	<u>\$2</u>	
Total Construction Costs	\$2,145	\$2,031	
Annual Operating & Maintenance Costs (\$ Millions)			
Plant	\$50.0	\$61.8	
Coal (minemouth cost)	\$29.3	\$54.9	
Coal (transportation)	\$39.3	\$12.6	
Pipeline and Compressor Stations	\$7.4	\$7.4	
Storage Site	<u>\$0.6</u>	<u>\$0.6</u>	
Total Annual O&M Costs	\$126.6	\$137.2	

Benefits from a Supercritical PC Plant with CCS

Economic Benefits from Construction (one-time)

Economic Measure	Direct Benefit	Total Benefit
Output	\$2.1 Billion	\$6.0 Billion
Value-added	\$0.9 Billion	\$2.9 Billion
Employment	13,952 Job-years	37,878 Job-years
Labor Income	\$0.8 Billion	\$2.0 Billion

Economic Benefits from Operations & Maintenance (annual)

Economic Measure	Direct Benefit	Total Benefit
Output	\$126.6 Million	\$285.4 Million
Value-added	\$73.6 Million	\$157.0 Million
Employment	251 Jobs	1,225 Jobs
Labor Income	\$30.7 Million	\$81.9 Million

Benefits from an IGCC Plant with CCS

Economic Benefits from Construction (one-time)

Economic Measure	Direct Benefit	Total Benefit
Output	\$2.0 Billion	\$5.7 Billion
Value-added	\$0.9 Billion	\$2.7 Billion
Employment	13,219 Job-years	35,893 Job-years
Labor Income	\$0.8 Billion	\$1.9 Billion

Economic Benefits from Operations & Maintenance (annual)

Economic Measure	Direct Benefit	Total Benefit
Output	\$135.6 Million	\$299.6 Million
Value-added	\$81.5 Million	\$168.2 Million
Employment	269 Jobs	1,260 Jobs
Labor Income	\$34.0 Million	\$86.5 Million

Benefits from Rep. Boucher's Bill (HR 6258)

- HR 6258, the "Early Carbon Capture and Storage Commercial Demonstration Act of 2008," is designed to advance the commercial deployment of Advanced Coal CCS facilities.
- If the proposed \$10 billion in funding under HR 6258 for early commercial deployment of CCS technology leads to development and operation of six (6) plants:
 - Including multiplier effects, construction would stimulate between \$33 billion and \$36 billion in total economic output, about 225,000 total job-years of employment, and about \$12 billion in labor income.
 - Ongoing operations and maintenance would support about 7,500 permanent jobs throughout the economy and about \$500 million in annual labor income.
 - Economic benefits would occur in virtually all sectors of the economy. The largest number of jobs from new facility development would be in the construction, manufacturing and professional services sectors. The largest number of jobs supported by ongoing operations would be in mining, transportation and utilities.



Part 3:
**Benefits From Future
Deployment of a Fleet of
Advanced Coal CCS Facilities**

Potential Extent of Advanced Coal CCS Development

- This study illustrates the potential magnitude of CCS-only benefits under three alternative levels of deployment: 20 gigawatts (GW), 65 GW and 100 GW. The study assumes an equal mix of PC plants with CCS and IGCC plants with CCS.
- The study is not intended to imply any policy endorsement of these levels of deployment; rather, the study simply assumes these levels for purposes of analysis. Moreover, these results do not consider any potential economic impacts of emission reduction requirements.
- 20 GW of advanced capacity would require deployment of about 38 plants, based on the generating capacities for typical plants (540 MW for PC and 520 MW for IGCC). 65 GW of advanced capacity would require development of approximately 122 plants, and 100 GW of advanced capacity would require approximately 188 plants.
- The following pages summarize projected expenditures for construction and O&M for Advanced Coal facilities with CCS under this assumed range of future deployment, as well as projected nationwide economic benefits from construction and O&M.

Summary of National Economic Benefits from 20-100 GW of Advanced Coal Facilities with CCS

- Construction expenditures for this range of capacity of Advanced Coal facilities with CCS are projected at \$79 billion to \$393 billion.
- Annual O&M expenditures, including coal purchase and transportation, are projected at \$5 billion to \$25 billion for this range of future Advanced Coal with CCS capacity.
- Construction of 20 GW of capacity would require about 0.5 million direct job-years of labor and support about 1.4 million job-years of labor throughout the economy.
- Development of 100 GW of capacity would require about 2.6 million direct job-years for construction and support about 6.9 million total job-years of labor throughout the economy.
- Annual O&M for this range of Advanced Coal with CCS capacity would directly support between 10,000 jobs and 49,000 jobs. Including indirect and induced effects (sometimes referred to as “multiplier effects”), deployment in this range would create between 48,000 and 235,000 permanent jobs throughout the economy.
- Economic benefits would be widely distributed across sectors. The largest benefits from construction would be in the construction, manufacturing and professional services sectors. Mining, utilities and transportation would be among the sectors most benefited by ongoing operations and maintenance activities.

Nationwide Expenditures for Construction of 20-100 GW of Advanced Coal Facilities with CCS

	20 GW	65 GW	100 GW
New Supercritical PC Plants (540 MW)	19 plants	61 plants	94 plants
New IGCC Plants (520 MW)	19 plants	61 plants	94 plants
Total Capital Cost for New Plants	\$78.5 Billion	\$251.9 Billion	\$388.2 Billion
Total Capital Cost for Transportation & Storage Infrastructure	\$0.9 Billion	\$2.8 Billion	\$4.4 Billion
Total Overall Capital Investment	\$79.4 Billion	\$254.8 Billion	\$392.6 Billion

Nationwide Expenditures for Annual O&M for 20-100 GW of Advanced Coal Facilities with CCS

	20 GW	65 GW	100 GW
New Supercritical PC Plants (540 MW)	19 plants	61 plants	94 plants
New IGCC Plants (520 MW)	19 plants	61 plants	94 plants
Plant Fixed and Variable O&M	\$2.1 Billion	\$6.8 Billion	\$10.5 Billion
Coal Costs (minemouth)	\$1.6 Billion	\$5.1 Billion	\$7.9 Billion
Coal Transportation Costs	<u>\$1.0 Billion</u>	<u>\$3.2 Billion</u>	<u>\$4.9 Billion</u>
Total Fuel Costs	\$2.6 Billion	\$8.3 Billion	\$12.8 Billion
Power and O&M for Transportation & Storage	<u>\$0.3 Billion</u>	<u>\$1.0 Billion</u>	<u>\$1.5 Billion</u>
Total Annual Costs	\$5.0 Billion	\$16.0 Billion	\$24.7 Billion

Economic Benefits from Construction and O&M for 20 GW of Advanced Coal Facilities with CCS

Economic Benefits from Construction (one-time)

Economic Measure	Direct Benefit	Total Benefit
Output	\$79.4 Billion	\$221.7 Billion
Value-added	\$33.8 Billion	\$107.1 Billion
Employment	0.5 Million Job-years	1.4 Million Job-years
Labor Income	\$29.4 Billion	\$74.8 Billion

Economic Benefits from Operations & Maintenance (annual)

Economic Measure	Direct Benefit	Total Benefit
Output	\$5.0 Billion	\$11.2 Billion
Value-added	\$2.9 Billion	\$6.2 Billion
Employment	9.9 Thousand Jobs	47.5 Thousand Jobs
Labor Income	\$1.2 Billion	\$3.2 Billion

Economic Benefits from Construction and O&M for 65 GW of Advanced Coal Facilities with CCS

Economic Benefits from Construction (one-time)

Economic Measure	Direct Benefit	Total Benefit
Output	\$254.8 Billion	\$711.9 Billion
Value-added	\$108.6 Billion	\$343.9 Billion
Employment	1.7 Million Job-years	4.5 Million Job-years
Labor Income	\$94.5 Billion	\$240.1 Billion

Economic Benefits from Operations & Maintenance (annual)

Economic Measure	Direct Benefit	Total Benefit
Output	\$16.0 Billion	\$35.9 Billion
Value-added	\$9.5 Billion	\$19.9 Billion
Employment	31.6 Thousand Jobs	152.5 Thousand Jobs
Labor Income	\$4.0 Billion	\$10.4 Billion

Economic Benefits from Construction and O&M for 100 GW of Advanced Coal Facilities with CCS

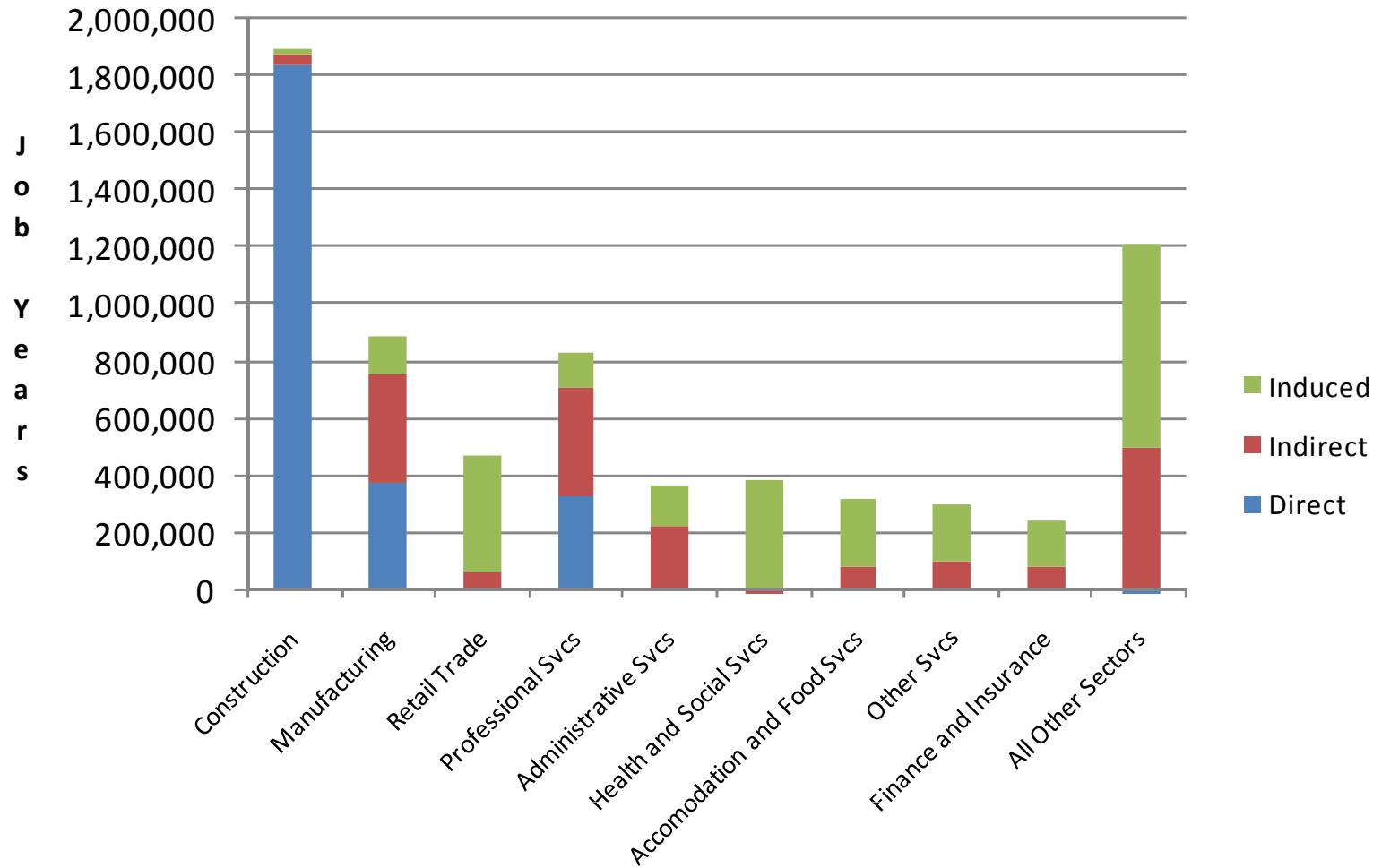
Economic Benefits from Construction (one-time)

Economic Measure	Direct Benefit	Total Benefit
Output	\$392.6 Billion	\$1.1 Trillion
Value-added	\$167.3 Billion	\$529.9 Billion
Employment	2.6 Million Job-years	6.9 Million Job-years
Labor Income	\$145.6 Billion	\$370.0 Billion

Economic Benefits from Operations & Maintenance (annual)

Economic Measure	Direct Benefit	Total Benefit
Output	\$24.7 Billion	\$55.4 Billion
Value-added	\$14.6 Billion	\$30.7 Billion
Employment	48.8 Thousand Jobs	235.0 Thousand Jobs
Labor Income	\$6.1 Billion	\$16.0 Billion

Distribution of Jobs by Sector Due to Construction of 100 GW of Advanced Coal Facilities with CCS



Distribution of Jobs by Sector due to Annual O&M for 100 GW of Advanced Coal Facilities with CCS

