Advanced Generation & Carbon Capture and Storage

Abhoyjit S. Bhowm, Ph.D.
Program Manager
Advanced Generation & Carbon Capture and Storage
Palo Alto, California

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About The Electric Power Research Institute

• Mission: Advancing **safe, reliable, affordable** and **environmentally responsible** electricity for society through global collaboration, thought leadership and science and technology innovation

• Established 1973 as independent, not-for-profit research center

• Major locations in Palo Alto, CA; Charlotte, NC; Knoxville, TN. ~1000 staff

• ~$420 million/year revenue (25% international)

• 450+ participants in more than 30 countries

• EPRI members generate approximately 90% of the electricity in the United States
Large-Scale CCS

- Boundary Dam, Saskatchewan, Canada
- Petra Nova, Thompsons, Texas, USA

(Recently Announced Suspension due to low oil prices)

Figure from GCCSI, Global Status of CCS, 2020
Options for CO$_2$ Capture in Fossil Power Systems

Almost all fossil-fuel power generated today

- **Postcombustion (PC)**
  - Fossil
  - Air
  - Power & Heat
  - CO$_2$ Separation
  - N$_2$
  - O$_2$
  - CO$_2$

- **Precombustion (IGCC)**
  - Fossil
  - Air/O$_2$
  - Steam
  - Gasification
  - Shift, Gas Cleanup + CO$_2$ Separation
  - H$_2$
  - Power & Heat
  - CO$_2$

- **Oxyfuel Combustion**
  - Air
  - Fossil
  - O$_2$
  - Power & Heat
  - Air Separation
  - N$_2$
  - CO$_2$
Post-Combustion CO₂ Capture

Coal Flue Gas ~12-15% CO₂

Fresh Water

PC Boiler → Selective Catalytic Reduction → Electro-Static Precipitation → Flue Gas Desulfurization → CO₂ Capture

Flue Gas to Stack

Fly Ash

Gypsum/Waste

Coal Flue Gas ~3-4% CO₂ (Higher concentrations with CO₂ recycle)

NGCC Flue Gas

Solvent

CO₂ Stripper

Lean adsorbent

Rich adsorbent

Cooling

Flue Gas

CO₂

Heating

Membrane
Post-Combustion CCS

EPRI’s R&D objective is to reduce cost of CCS and mitigate risk

<table>
<thead>
<tr>
<th></th>
<th>Supercritical Coal Plant</th>
<th>Natural Gas Combined Cycle</th>
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<tbody>
<tr>
<td>CO₂ Concentration</td>
<td>12-15%</td>
<td>3-4%</td>
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<tr>
<td>t CO₂/MWh (w/o CCS)</td>
<td>~0.86</td>
<td>~0.38</td>
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<td>Efficiency Reduction with CCS, %</td>
<td>~22%</td>
<td>~11%</td>
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<td>Breakeven CO₂ Sales Price, $/t CO₂</td>
<td>~$46</td>
<td>~$80</td>
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<td>LCOE increase</td>
<td>~77%</td>
<td>~72%</td>
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Source: NETL-PUB-226383 September 24, 2019
Allam-Fetvedt Cycle Overview

- CO₂ as working fluid improves efficiency
- Heat provided by in-situ oxy-combustion
- CO₂ removed at pipeline pressure
- Oxy-gas combustor is novel, operating at pressures 10 times greater than a natural gas combustion turbine
- Reduced turbine size / cost and potentially improved flexibility
- CO₂ and other byproducts (Ar, H₂O, and N₂) generate revenue
- Projected efficiency with CCS for NG: up to 59% LHV*
- Projected low capital costs: $900–1200/kW*

* Values provided by NET Power

NET Power is the developer of the natural gas version
Together...Shaping the Future of Electricity