Optimized Solvent for Energy-Efficient, Environmentally-Friendly Capture of CO$_2$ at Coal-Fired Power Plants (DE-FE0007716)

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Power Generation Systems Segment

Fossil and Renewables
- Coal-fired power generation
- Service, operation and maintenance
- Construction and EPC
- Environmental systems (FDG, SCR, mercury, carbon)
- Renewables (Biomass, solar, waste-to-energy)

Nuclear Energy
- Field services
- Plant modifications
- Component manufacturing and installation
- Fuel design, enrichment and fabrication
- B&W mPower

Government Operations Segment

Nuclear Operations
- Virginia-Class submarine program
- Ford-Class carrier program
- Refueling
- Fuel processing and fabrication

Management & Operations
- Nuclear material handling, storage and security
- Nuclear laboratories
- Weapons complex
- Decontamination and decommissioning
- Strategic Petroleum Reserve

Leading technology innovator in power generation and a specialty manufacturer of nuclear components with legacy spanning 140 years
# Project Overview

**Funding:**

- US DOE: 2,835,680
- B&W: 708,920
- Total: 3,544,600

**Period of Performance:**

- Oct 1, 2011 to May 31, 2015

**Participants:**

- B&W Power Generation Group
- University of Cincinnati
- First Energy

**Objective:**

To optimize and fully characterize a novel solvent formulation as a critical enabler for cost-effective, energy-efficient CO\textsubscript{2} capture while minimizing environmental impact and maximizing reliability.
CO₂ Scrubbing Process
Impacts of Solvent

- Capital Cost
- Operability
- Corrosion
- Physical Properties
- Solubility
- Solvent
- Solubility
- Degradation
- Environmental Impact
- Operating Cost
- ΔH_{ABS}
- Volatility
- Capacity

- Kinetics

- Environmental Impact
- Operating Cost
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Wetted-Wall Column

Key Features:

- Gas/liquid contactor
- Differential reactor
  - “Slice” of absorber or regenerator
- Known process conditions
  - Contact area
  - $T$, $p$, compositions, flow rates
Bench-Scale Simulator

Key Features:

- 1 kg/hr CO₂ capture
- Fully-integrated process
- Flexible, modular design
- Multiple modes of operation
Key Features:

- High quality, representative data
- Coal flue gas
Simulation Modeling

- Complicated process
  - Multiple components, multiple phases
  - Thermodynamics, chemical reactions, mass & heat transfer
  - Non-ideal solution (aqueous electrolytes)

- Evaluation of process concepts
- Performance prediction
- Support pilot/demo testing
- Facilitate full-scale plant design
Candidate Formulations

Better Solvents (B&W’s Downselect Process)

Carbonates
  - Ammonia
  - Alkali
    - Promoted Carbonates
      - Primary Amines
        - ≥30% MEA (Fluor EFG+)
        - Conc Pz
      - CCA
        - CCA, Hindered/Tert Blends
        - Novel Conc Pz Salt/Blend
        - Proposed B&W Candidate
  - Pri/Sec Amines
    - Cyclic Amines
      - ≥20% Cyclic Amines (CCA)
      - CCA, Hindered/Tert Amines
        - Promoted Cyclic Amines (CCA)
        - CCA, Hindered/Tert Amines
          - Promoted Amino Acid Salts
            - CCA, AAS Blends
            - Proposed B&W Candidate
  - Hindered/Tert Amines
    - Organic AAS
      - Organic AAS
      - Inorganic AAS
        - Promoted Amino Acid Salts
          - Proposed B&W Candidate

B&W’s 5-Year Solvent Development Effort

Current State-of-the-Art

Most Promising Developmental

Proposed B&W Candidate
B&W’s Approach

Current State-of-the-Art

>30% MEA (Fluor EFG+)

Fluor/B&W strategic alliance

Most Promising Developmental

Conc Pz

OptiCap™ test at NCCC

Proposed B&W Candidate

Novel Conc PZ Salt/Blend

Current Project
Project Plan / Status

Solvent Formulation
  Engineering Analysis
  Performance Calculations
  Laboratory Data
  Lab Degradation Apparatus

Preliminary Feasibility Study

Solvent Characterization
  Calorimetry
  Solubility
  Volatility
  Process Simulator Tests
  Degradation Testing
  Corrosion Testing
  Performance Calculations

Budget Period 1

Solvent Performance
  Performance Calculations
  Lab-Pilot Performance

Budget Period 2

Process Performance
  Performance Calculations
  EH&S Risk Assessment

Final Feasibility Study

Budget Period 3

Budget Period 4
Program Goals

- Approaching aggressive US DOE goals will require
  - Advanced solvent (this project)
  - Innovative design (equipment size, materials of construction, etc.)
  - Innovative process heat integration
  - Optimal integration with power plant

- Advanced solvent expected to provide
  - Low reboiler heat duty
  - Smaller absorber / high removal efficiency
  - Lower compression costs
  - Reduced material cost
  - Reduced emissions / waste
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- **Project Partners**
  - B&W project team: Purusha Bonnin-Nartker, Lei Ji, Mike Klidas, Lisa Rimpf, Victoria Wilson, Ruyu Zhang
  - University of Cincinnati (Prof. Stephen W. Thiel, et.al.)
  - First Energy (Elizabeth Shaw, Director, FE Technologies & Corporate METT)