CO_2 Capture with ECO

ECO Commercial Demonstration
Open House
R.E. Burger Plant

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Powerspan CRADA with DOE

- Joint research and development program on CO_2 capture with ammonia (NH_3)
- Lab tests show NH_3 has several advantages over commercially available amine (MEA) process:
  - higher CO_2 loading capacity
  - lower energy consumption for regeneration
  - lower cost reagent
- By comparison, MEA process suffers from:
  - higher equipment corrosion rate
  - amine degradation by flue gas requiring higher makeup

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Lab Results for CO_2 Removal

- 88% CO_2 removal achieved with 10% ammonium carbonate solution
  - Gas and liquid at 130°F
  - 7 second residence time
  - Liquid to gas ratio of 65 gpm/kacfm
  - Simulated flue gas with
    - CO_2 (12%)
    - O_2 (6%)
    - N2 (Balance)

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CO_2 Capture with ECO

- CO_2 capture incorporated into ECO process
- Approach – Design CO_2 removal as an ECO add-on feature that could be deployed later
- Benefits –
  - Use of ammonia in ECO process makes incorporating CO_2 removal feasible
  - Ability to absorb ammonia vapor and use dilute ammonia stream is key to process efficiency
  - Climate change concerns could result in CO_2 emission caps – requiring capture/sequestration

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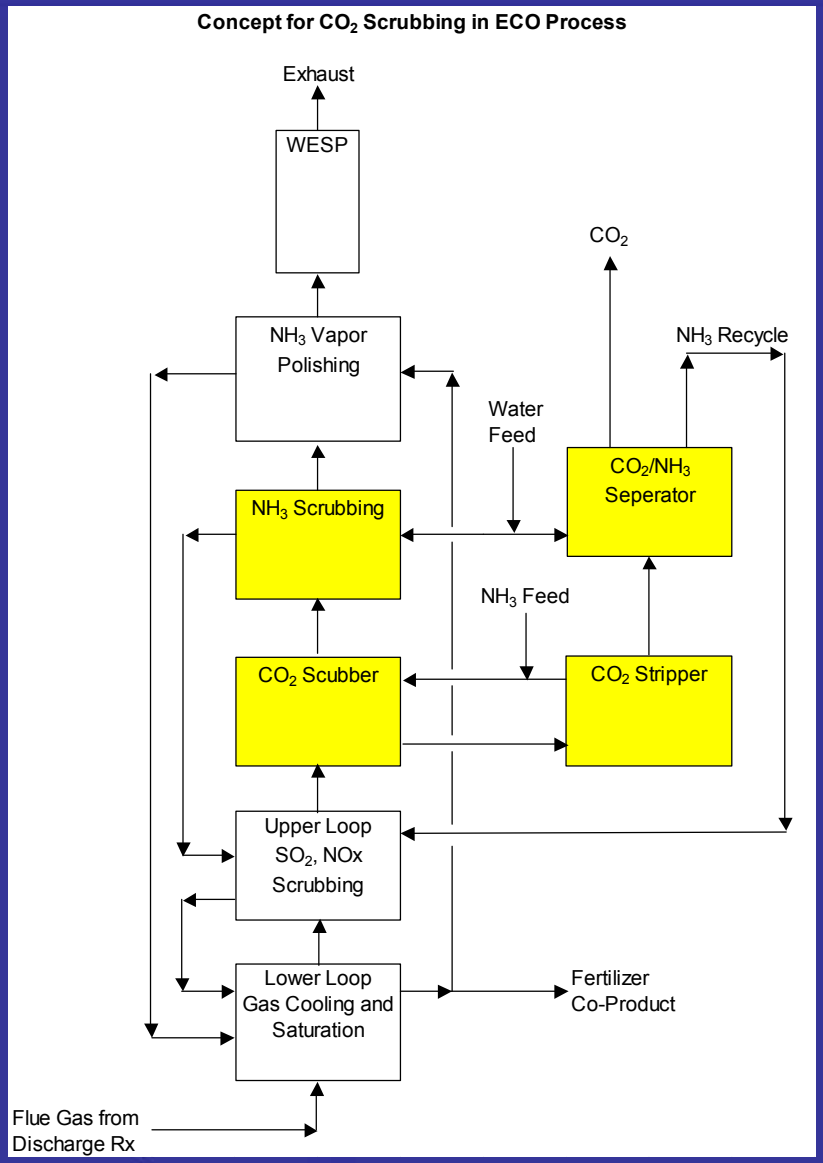
Conceptual Process Flow Diagram



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Estimated CO_2 Capture Costs with ECO

DOE analysis indicates:

- Plant capital cost approximately $295/kW
- Energy use approximately 10% of plant capacity
- Total energy costs (to release CO_2 from solution and compress) is ~$3.50/ton
- Incremental power costs of <$0.01/kWh
- Cost per ton of CO_2 emissions avoided $14.00 - includes $3.00/ton charge for transportation and underground sequestration

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Estimated CO_2 Capture Costs with MEA

EPRI-Parsons Study on CO_2 removal from a 500MW plant using MEA concludes:

- Plant capital cost approximately $838/kW
- Energy use approximately 27% of plant capacity
- Thermal efficiency decreases from 40.5% to 28.9%
- Incremental power costs of $0.04/kWh
- Cost per ton of CO_2 emission avoided - $47

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Estimated ECO Cost Compared to IGCC

EPRI-DOE Study on IGCC with CO_2 Capture:

- IGCC plant capital costs increase $350-550/kW
- Cost of electricity (COE) increases 25-36%
- IGCC COE with CO_2 capture is ~$0.054/kWh

DOE Study on CO_2 Capture with Ammonia on Super Critical PC Plants estimates:

- SCPC COE of ~$0.054/kWh, which <u>includes</u> $3/ton of CO2 for sequestration

<u>Key Points</u>: ECO_2 could be applied to current PC plants and be economically preferable over IGCC for new plants with CO_2 capture

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"ECO_2" Development Plans

- Perform parametric tests in lab to characterize process limits and optimize efficiency - 2005
- Compare Powerspan test results with DOE/NETL
- Conduct pilot scale tests of CO_2 removal integrated with ECO process at FirstEnergy's Burger Plant beginning in 2006 – teaming with Fluor (~20 ton/day CO_2 / ~ 1 MW equivalent)
- Conduct commercial scale test of ECO_2 beginning in 2008 with CO_2 sold for enhanced oil recovery (500 ton/day CO_2 / ~25 MW equivalent)