MIT Carbon Sequestration Forum IX

September 16, 2008

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ECO_2 Technology – Basin Electric Power Cooperative's 120 MWe CCS Demonstration

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Powerspan Corp.

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Company Description

- Founded in 1994, privately-held
- ECO® technology development began in 1998, ECO_2® development began in 2004
- Nine years and over $120 million raised to bring company and technology to this point
- Management Team has experience in large-scale projects, including design, project management, and construction:
  - Nuclear submarine construction and repair (both public and private shipyards)
  - Hamon Research Cottrell
  - URS Washington Group International, Inc

Powerspan Products

- Multi-pollutant control system for coal-fired power plants – ECO (Electro-Catalytic Oxidation)
- Sulfur dioxide scrubber, including fine particulate matter and oxidized mercury control – ECO-SO_2
- CO_2 control in conjunction with ECO (in development) – ECO_2

Competitive Advantage: Lower cost, higher performance, aimed at future requirements, not those of the past

Post Combustion CO_2 Capture with ECO® and ECO_2® Technology

- **Approach: Design CO_2 removal as an ECO add-on feature that could be deployed later**
- **Produces a carbon dioxide stream that is "sequestration ready"**
- **Use of ammonia in ECO makes incorporating CO_2 removal feasible**
  - **Provides the ability to absorb ammonia vapor and use dilute ammonia streams**
  - **Ammonia is not consumed in the CO_2 capture process**
  - **Management of ammonia vapor is key to process success and economics**
- **Reduced energy due to lower heat of reaction and solution capacity**

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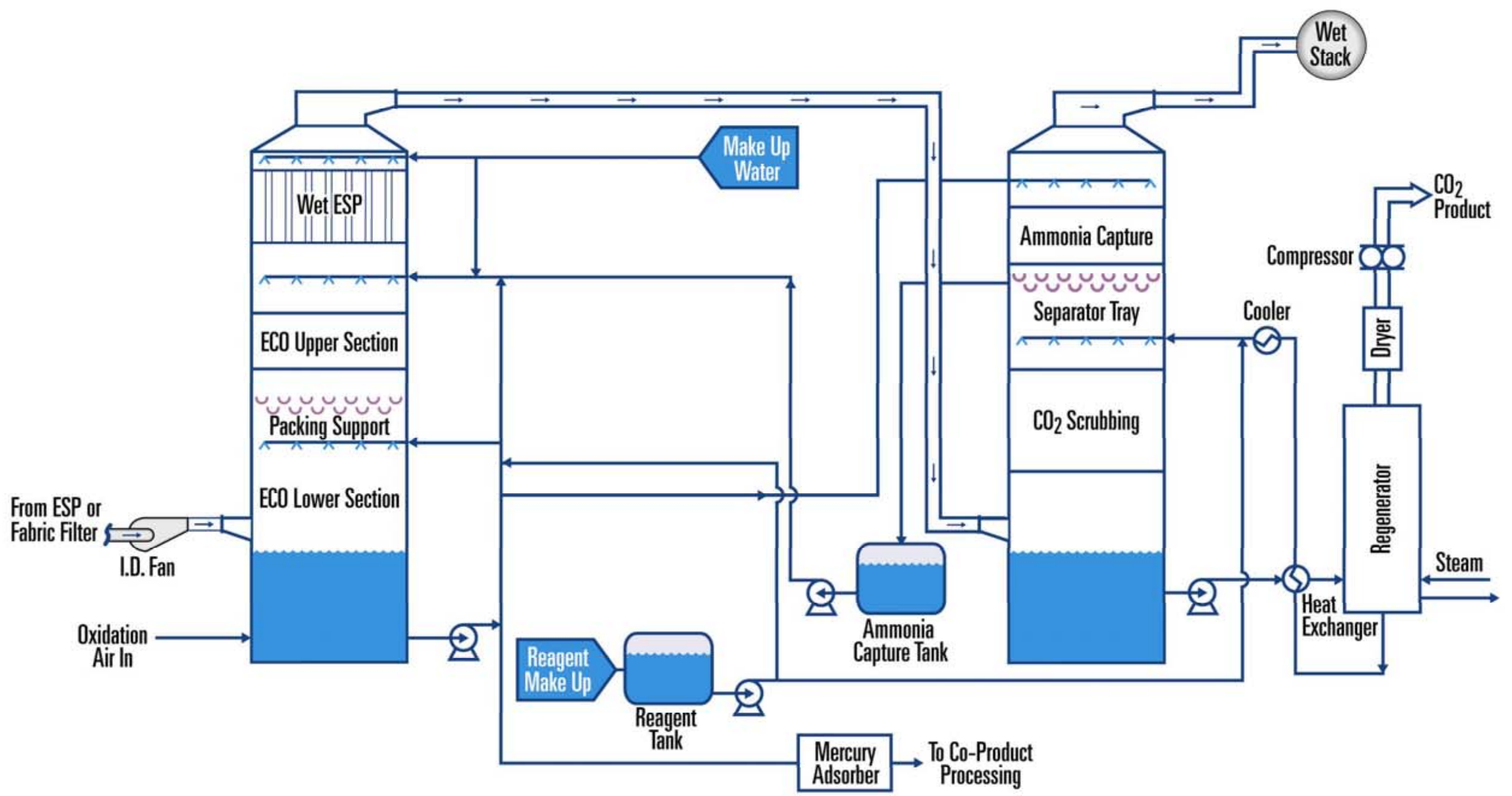
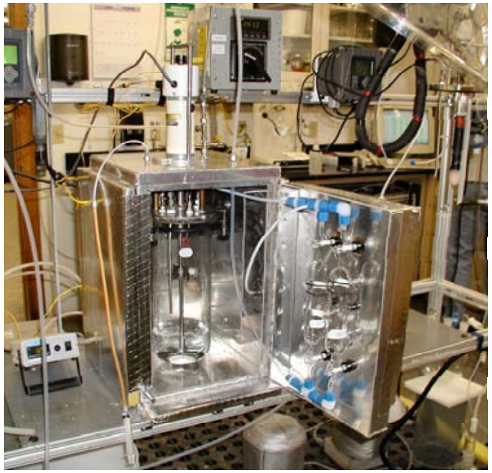
Integrated ECO-SO_2 - ECO_2 Process Flow



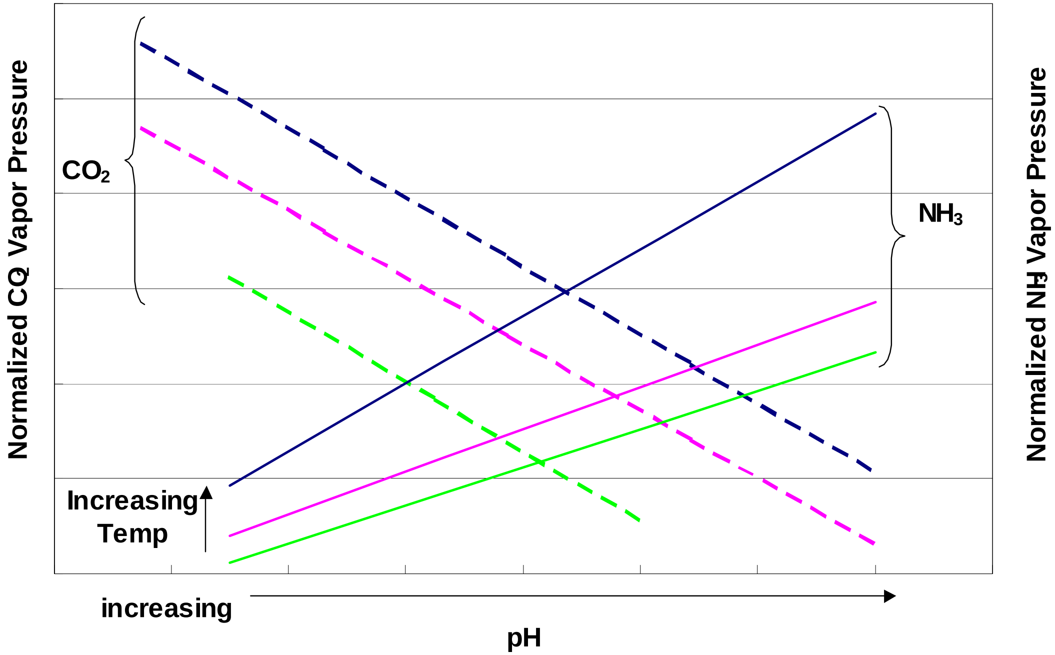
Equilibrium Testing for ECO_2

Benchtop testing to define equilibrium conditions for absorption and regeneration

- Solution concentration, pH
- Solution temperature, pressure
- Construction of chemical model – existing model results do not agree with experimental measurements



Atmospheric Equilibrium Still



Lower temperature → reduced CO_2 and ammonia vapor pressure

Higher pH → reduced CO_2 but increasing ammonia vapor pressure

Higher concentration → increased CO_2 and ammonia vapor pressure

Laboratory Testing for ECO_2

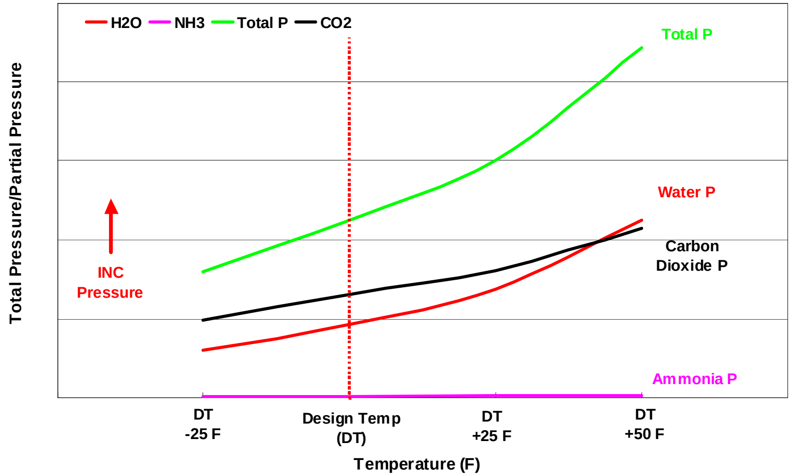
Rate testing for absorber and regenerator mass transfer requirements

Cyclic operation – absorption with regeneration

4” absorber, flue gas flow of 20 scfm

Lab Scale Scrubber/Regenerator

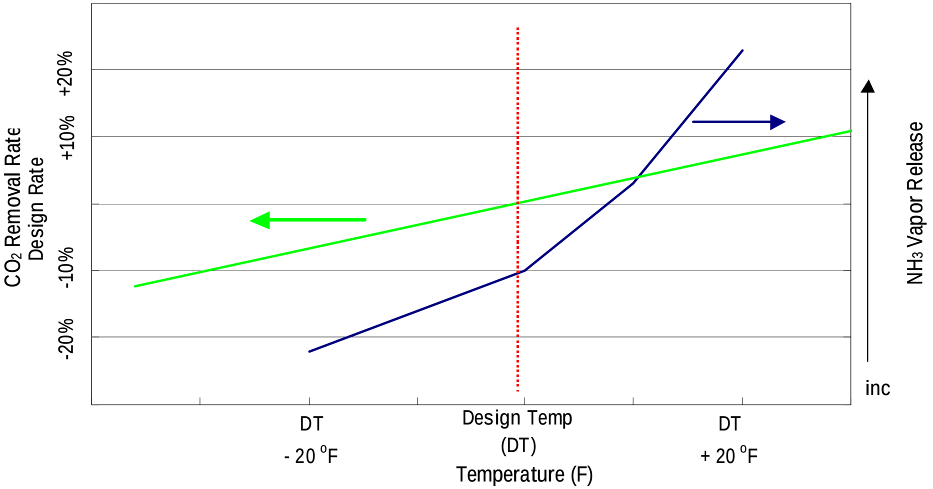
Effect of Temperature and Pressure on Solution Regeneration



Higher temp → increased pressure, reduces compression costs

Higher temp → increased water and ammonia content in product CO_2, increasing heating requirements and water/ammonia recovery costs

Effect of Temperature on Scrubbing



Lower temp → reduced ammonia release

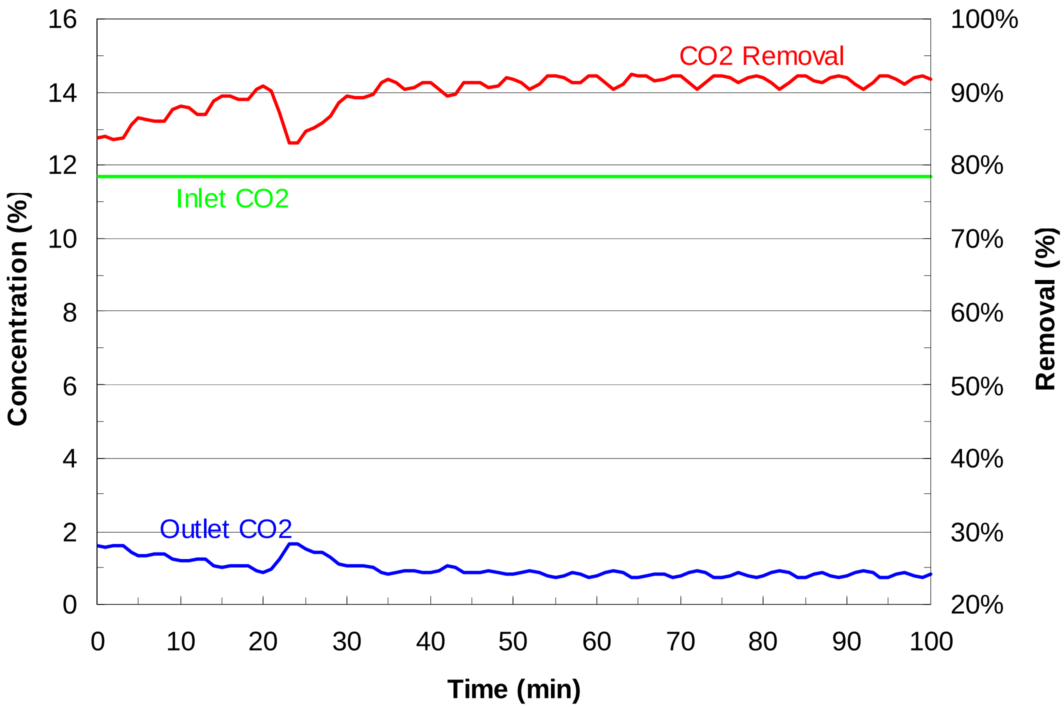
Lower temp → reduced scrubbing rate, increases mass transfer

Laboratory Testing for ECO_2

Parametric testing of absorption and regeneration conditions

Steady state operation of absorption with regeneration

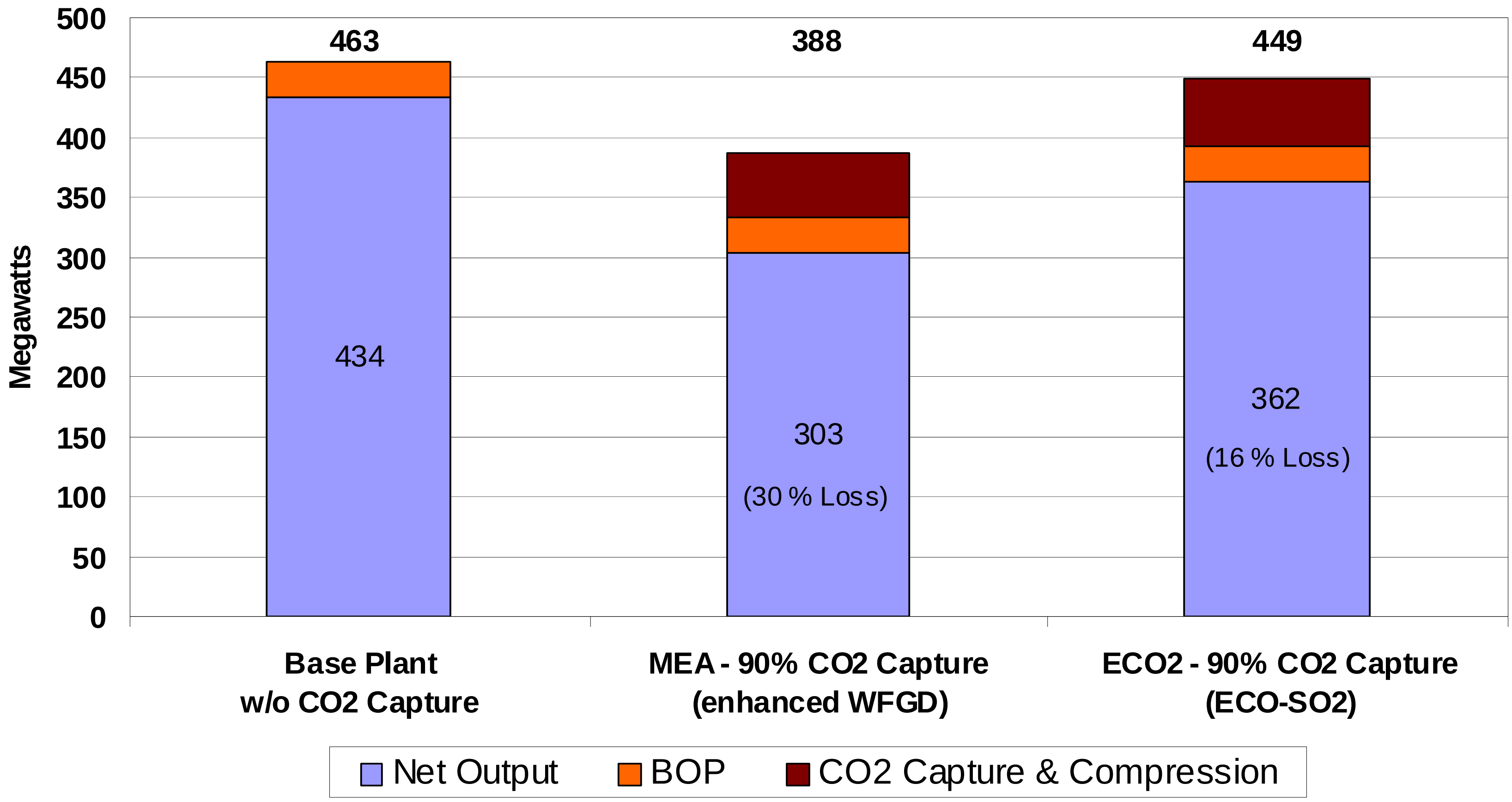
Experimental energy measurements confirm design values



Scrubber with Regeneration

92% CO_2 removal under simulated flue gas conditions

CO_2 Capture Performance Comparison



Source Data for Base Plant and MEA cases: "Carbon Dioxide Capture from Existing Coal-Fired Power Plants", DOE/NETL-401/110907, Revision Date, November 2007

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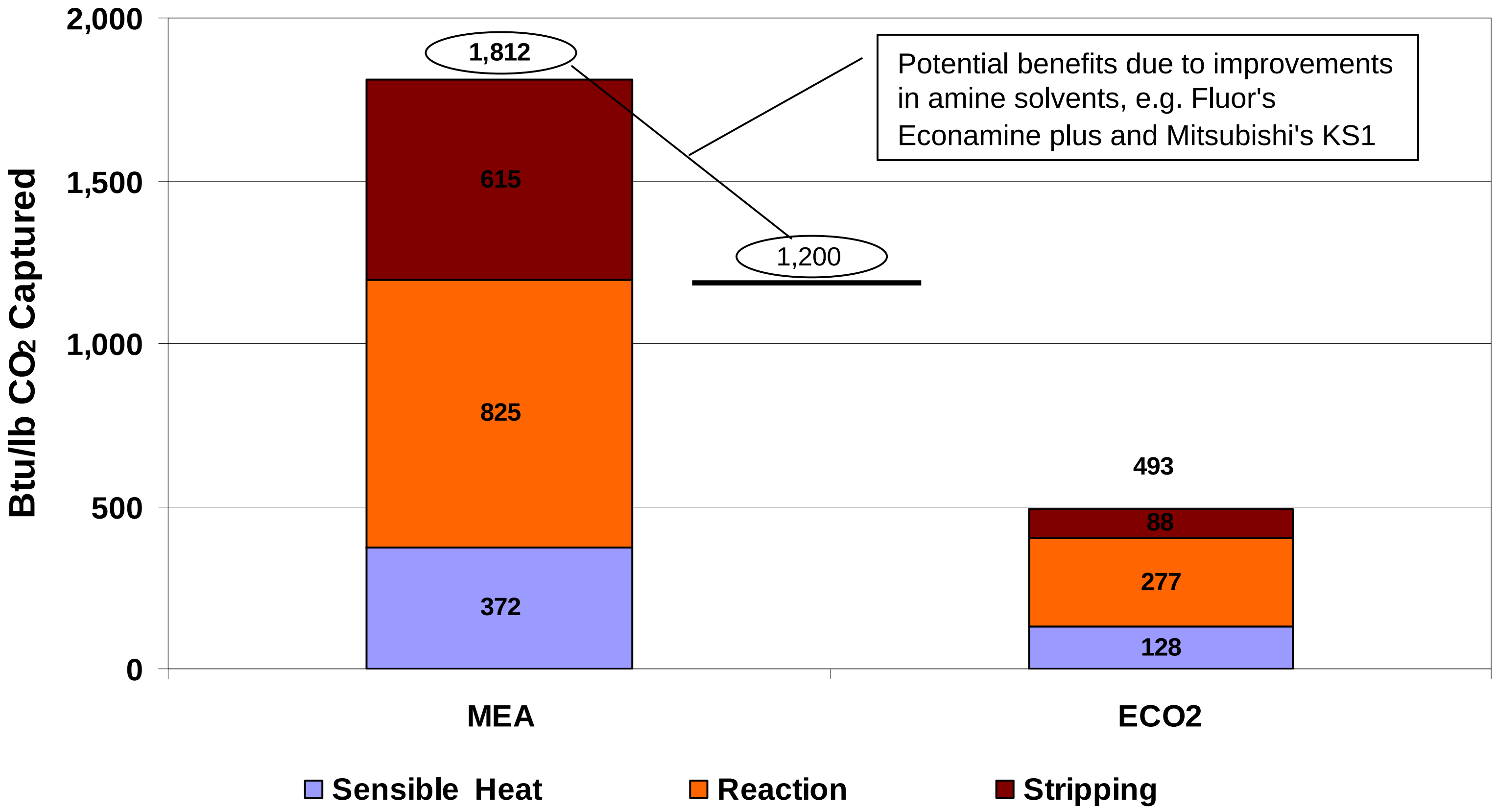
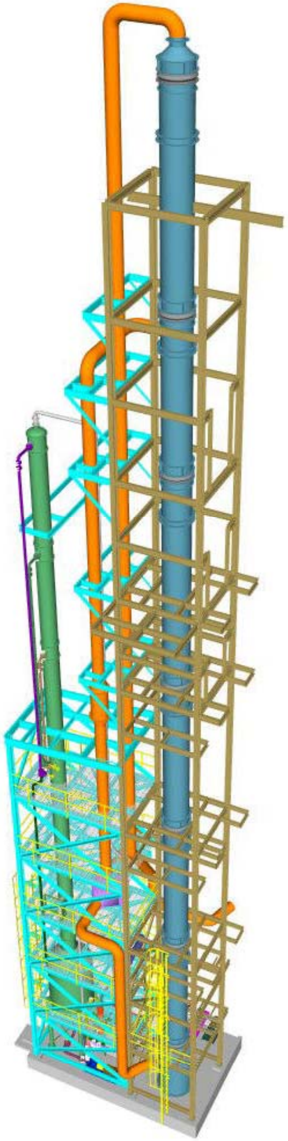
Energy Usage in CO_2 Capture



Source Data for MEA case: "An Economic Scoping Study for CO_2 Capture Using Aqueous Ammonia", DOE/NETL Final Report, Revised, February 2005

ECO_2 Pilot

- **Pilot scale tests of CO_2 removal**
  - **Integrated with ECO at FirstEnergy's R.E. Burger Plant**
  - **~20 ton/day CO_2 / ~ 1 MWe equivalent**
- **Evaluate process performance and economics for scale-up**
- **Demonstrate ammonia vapor control**
- **Verify process control under varying conditions**
- **Operating in October 2008**



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ECO_2 Commercial Demonstration Plans

- NRG selected Powerspan for 125-MW CCS commercial demonstration at NRG's Parish plant near Houston, Texas
- Designed to capture 90% of incoming CO_2 (~1 million tons/yr CO_2); operational in 2012
- Captured CO_2 to be used for EOR in the Houston area
- Feasibility study in progress

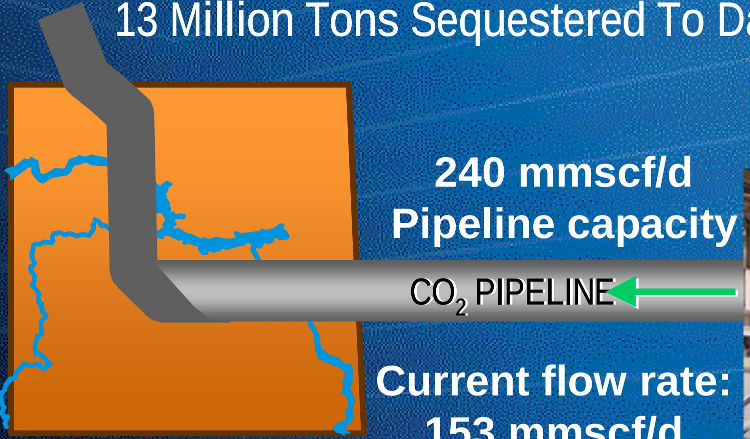
- Basin Electric competitive solicitation selected Powerspan for 120-MW CCS demonstration at Antelope Valley Station; feasibility study completed
- Designed to capture 90% of incoming CO_2 (~1 million tons/yr CO_2); operational in 2011
- Captured CO_2 to be sold into EOR market, used in DOE sequestration test

Dakota Gasification Company (DGC)

World's Largest Carbon Sequestration Project

Weyburn, Saskatchewan

13 Million Tons Sequestered To Date



240 mmscf/d
Pipeline capacity

Current flow rate:
153 mmscf/d

Compressors

CO_2

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Carbon Capture – Antelope Valley Station (AVS)

- Dakota Gasification Company (DGC) – experience
- Infrastructure – Additional pipeline capacity
- AVS close proximity to DGC
- Demand/market for CO_2
- Plains CO_2 Reduction Partnership (PCOR) – CO_2 source for Phase III
- Building future coal generation – Demonstrating Carbon Capture and Storage (CCS) is vital

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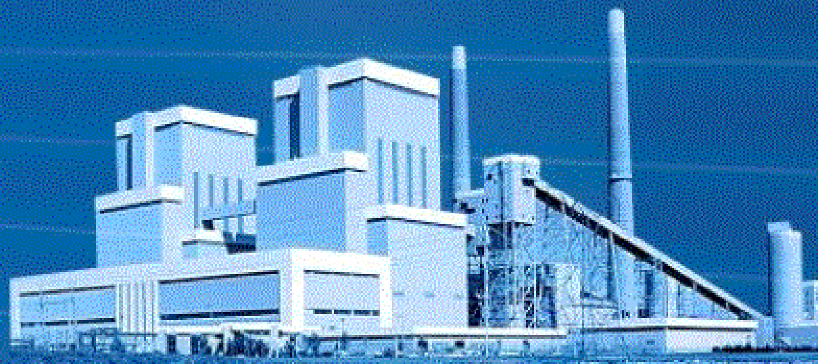
Carbon Capture – AVS

- Request For Proposal (RFP) released on June 1, 2007
- Sent to 10 companies, RFP placed on website
- Plant site visit encouraged in RFP
- Proposals from 6 companies received - September 2007
- Basin Electric's selection of Powerspan – January 2008



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Carbon Capture – AVS

[Companies that were sent AVS RFP]

- Cansolv Technologies Inc.
- Carbozyme, Inc.
- Powerspan
- Babcock & Wilcox
- HTC Purenergy
- ALSTOM
- Mitsubishi Heavy Industries
- Fluor
- GE Global Research
- ConocoPhillips

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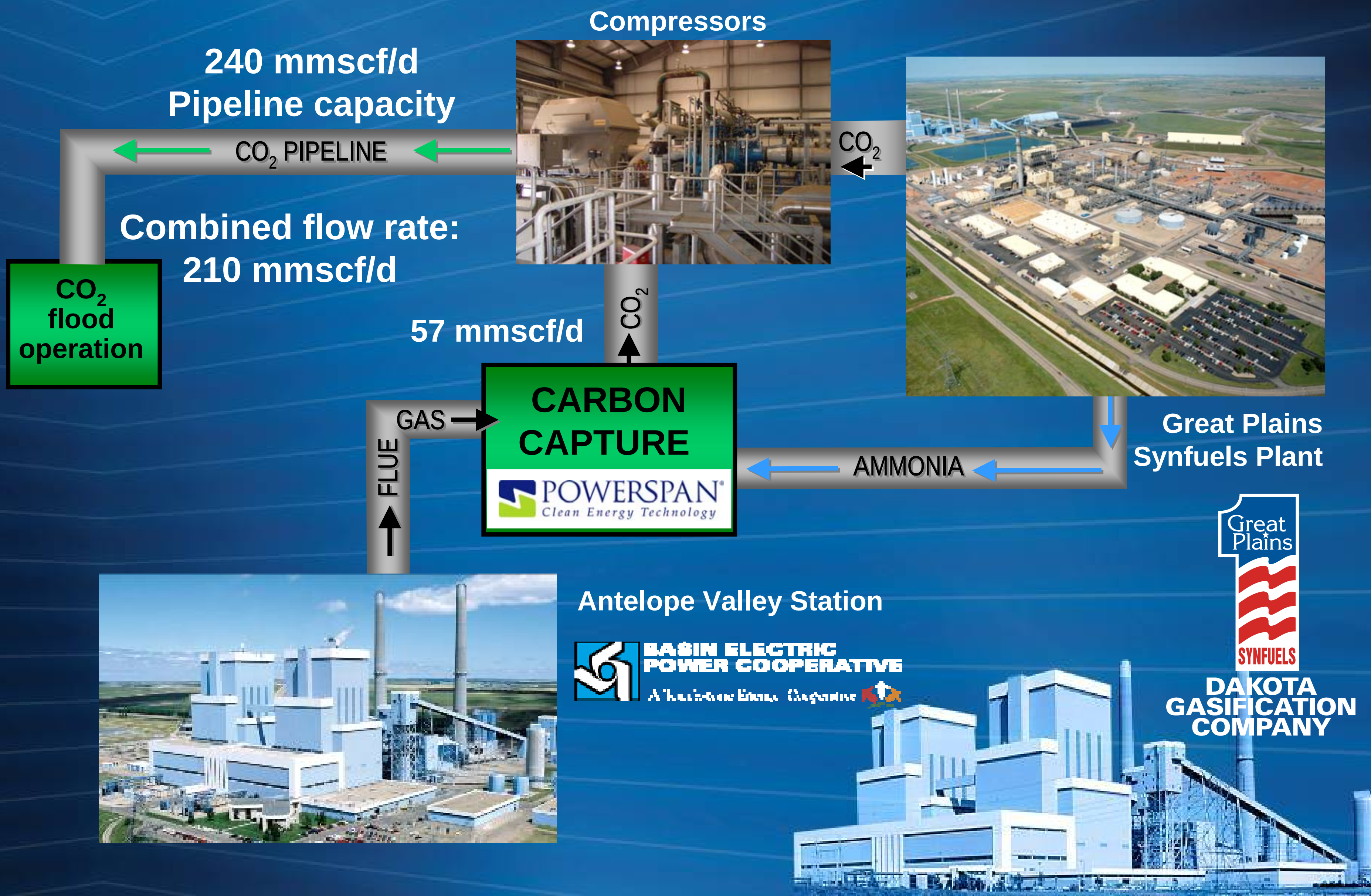
Carbon Capture Optimization Project



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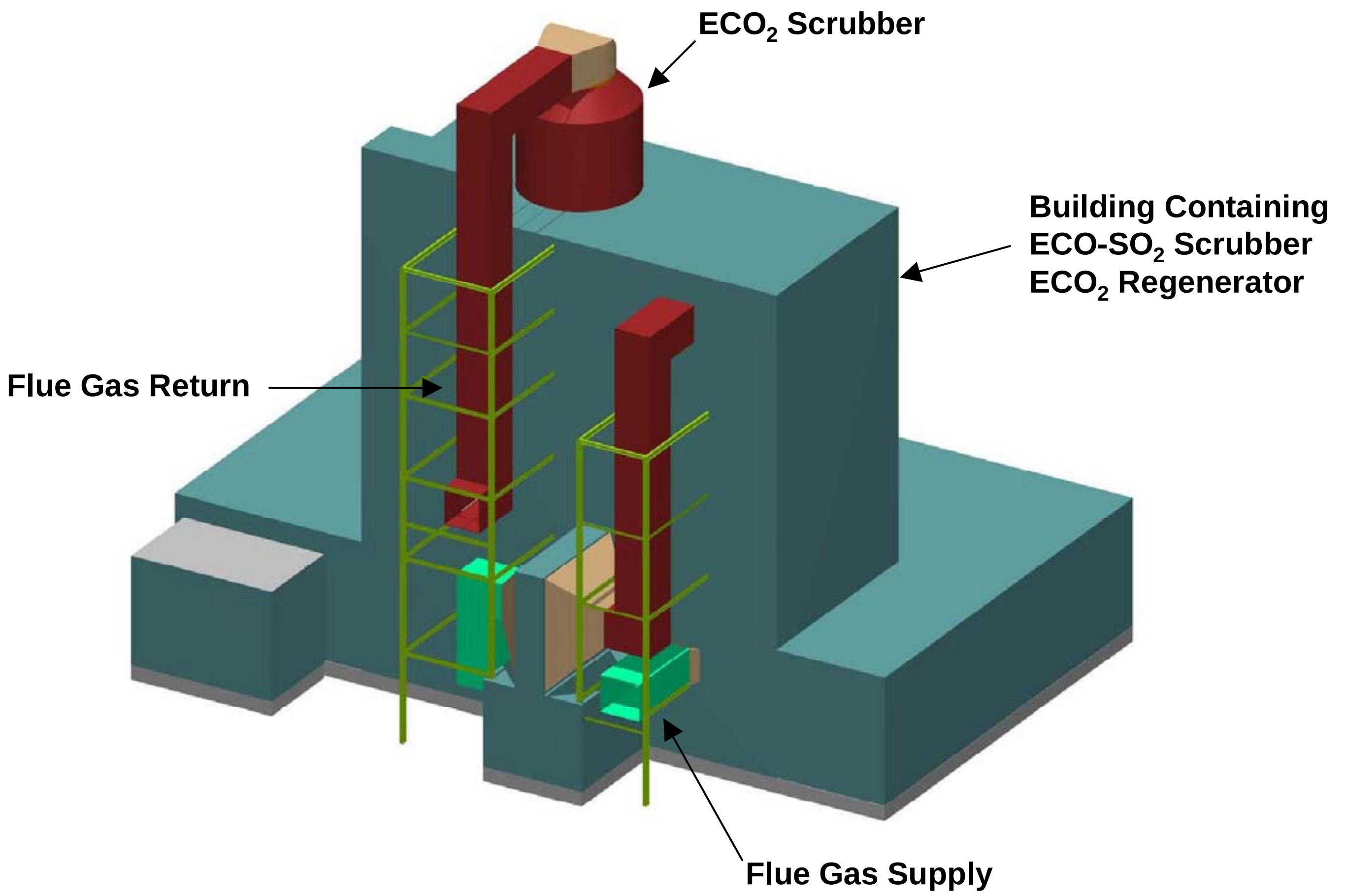
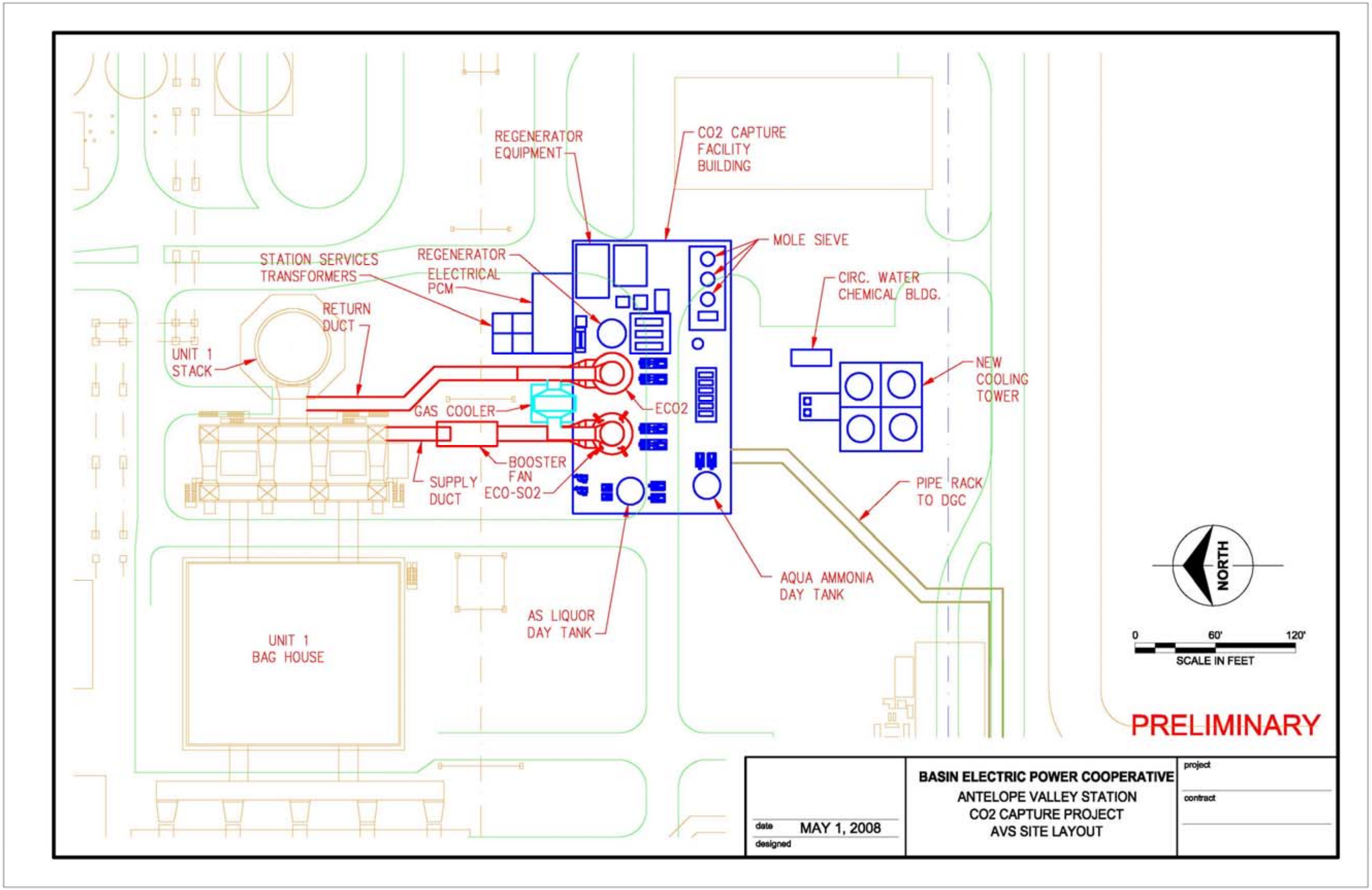
AVS Carbon Capture Milestones

- Feasibility study completed – May 2008
  - Results positive; project is viable and can be effectively integrated into AVS and DGC
- Pilot testing at Burger to provide sufficient information to design, build, and guarantee performance for full-scale ECO_2 systems (WorleyParsons study)
- Next phase – Front End Engineering & Design (FEED) study anticipated to begin in late 2008
- Project ready to proceed with construction in 2009, operational in 2012

120 MW ECO_2 Commercial Demonstration



AVS Demonstration Project – GA Dwg



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Estimated Cost per Ton of CO_2 Removed

Includes

- Total project capital cost
  - SO_2 polishing scrubber
  - CO_2 absorber
  - Compressor and support equipment
  - Balance of plant systems and components

- Fixed and variable operating costs
  - Utilities
    - Electricity - pumps, fan power, compression (2,700 psi)
    - Steam - regeneration
    - Cooling
  - Operating personnel
  - Maintenance

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Estimated Cost per Ton of CO_2 Removed

	Total AVS Project ($ECO\text{-}SO_2/ECO_2$)	Portion due to SO_2 Removal
Capital	\$15.47	\$5.16
Variable and Fixed Operating (exclusive of compression)	\$12.25	\$3.25
Compression (2700 psi)	\$7.80	-
Total	\$35.52	\$8.41

(all values are in current dollars)

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Conventional FGD Penalty on CO_2 Capture

- CO_2 capture systems are impacted by incoming SOx, which forms stable salts that must be purged
- The purge stream results in costly sorbent losses and a new waste disposal stream
- CO_2 capture prefers inlet $SO_2 \leq 1$ ppm; conventional wet and dry scrubbers have 40-60 ppm SO_2 outlet
- Cost impact ~$1/ton CO_2 captured per inlet ppm SO_2
- Therefore, CO_2 capture systems require additional SO_2 scrubbing that can be costly; i.e. $3-5/ton CO_2
- ECO/ECO_2 combination avoids this added cost/waste as ECO system achieves $SO_2 \leq 1$ ppm

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For Further Information

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