NH_4OH Looping with Membrane CO_2 Absorber and Distributed Stripper for Enhanced Algae Growth

The Presentation will Begin Shortly

University of Kentucky
Center for Applied Energy Research
Lexington, KY
http://www.caer.uky.edu/powergen/home.shtml

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Objective

Unique, integrated CO_2 capture and utilization technology that:

- **Reduces the cost of CO_2 capture**
- **Boots algae production**

UK CAER Cyclic Flow Photobioreactor
East Bend Station, KY

UK CAER Small Pilot CO_2 Capture Unit
Kentucky Utilities EW Brown Station, KY
0.7 MWe, equilavent

Aqueous Post-combustion CO_2 Capture Research since 2008

Algae Utilization Research since 2008

Five Challenges Addressed

1) High cost of capturing CO_2 using aqueous solvents due to high energy consumption and solvent make-up and large capital investment

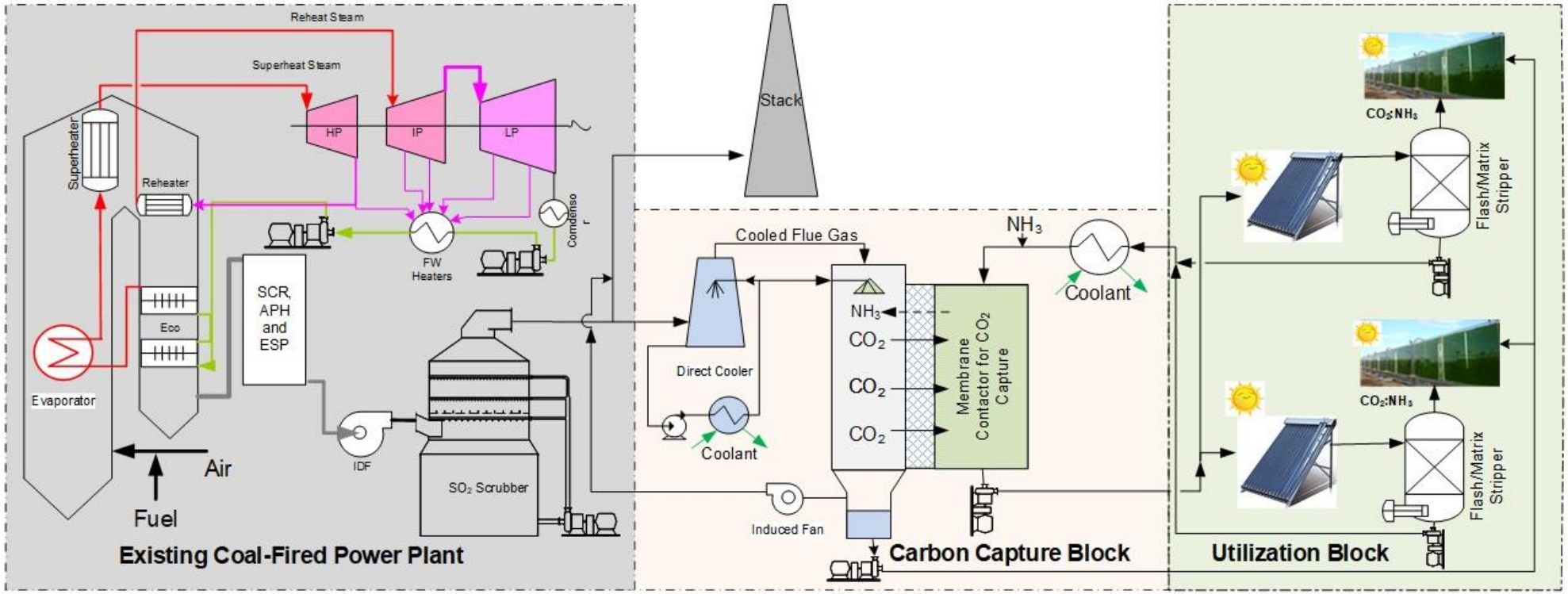
2) CO_2 delivery and feed, due to the large footprint (1000s of acres) of the algae bioreactor and the high pressure drop across the gas spargers required for high CO_2 utilization efficiency

3) Inhibition of algae growth resulting from frequent pH swings in the bioreactor due to unbalanced (intermittent) feeding systems for CO_2 and N

4) Fouling on the algae interface in the CO_2 absorber if the algae culture is used to capture CO_2 directly from flue gas

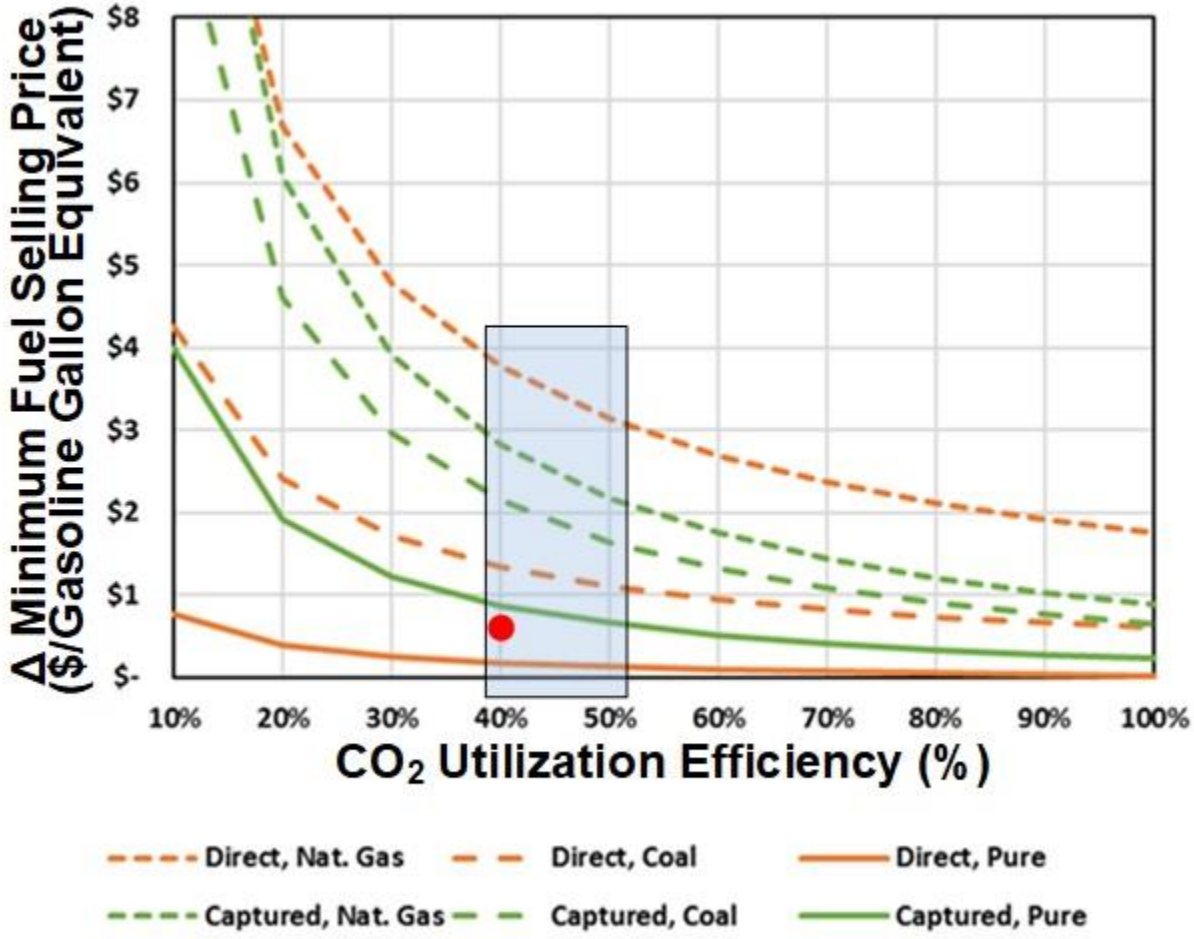
5) Short-term planned or unplanned disruptions in flue gas/CO_2 supply to the algae bioreactor

Technology Overview



Favorable Economics

A 50% reduction of reselling price for CO_2 from coal-fired power plants is achievable, as indicated by the red dot (< $1/GGE).



Controlled NH_3 Slip and In-situ Antifouling

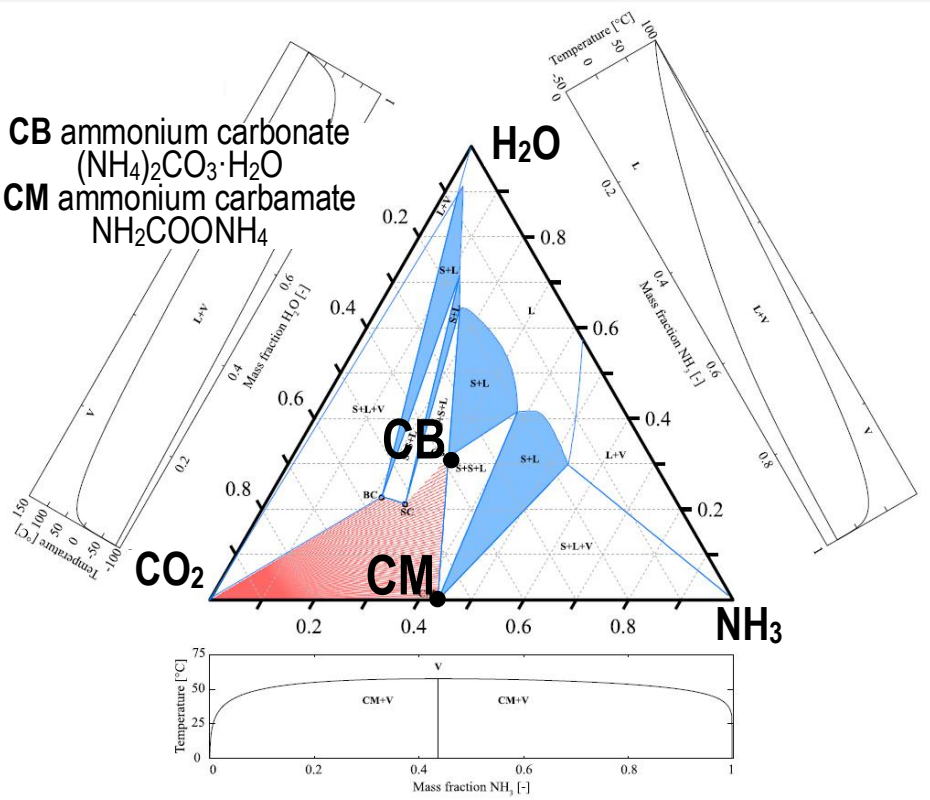
Low NH_3 vapor pressure

- Low concentration NH_3 solvent
- Zn_2^+ chelating additive

$$Zn^{2+} + 4NH_3 \leftrightarrow [Zn(NH_3)_4]^{2+}$$
$$CO_2 + H_2O \leftrightarrow HCO_3^- + H^+$$
$$NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$$
$$[Zn(NH_3)_4]^{2+} + HCO_3^- \leftrightarrow [Zn(NH_2COO)_2]_2 + 2NH_3 + 2H_2O$$
$$2NH_3 + CO_2 + H_2O \leftrightarrow (NH_4)_2CO_3$$

Downflow Glue Gas Configuration

- Flue gas condensate continually washes membrane surface
- In-situ anti-fouling
- NH_3 slip recapture
- Flue gas condensate utilized as makeup water



Enhanced Algae Growth by up to 50%

Just-in-time C:N Delivery at Appropriate Ratio

- Up to 50% increase in productivity anticipated
- Minimal stress on algae with continuous CO_2/NH_3 feed
- Direct connection between stripper and bioreactor
- Amount of CO_2 and NH_3 in product stream controlled with stripper pressure and temperature
- Thermally compressed CO_2/NH_3 product stream facilitated sparging into bioreactors for high utilization efficiency
- Product stream can continue to be generated for short periods even if flue gas source is disrupted

$\underline{NH_4^+ \text{ consumption - excess } CO_2 \text{ present } (NH_4^+ \text{ limiting}):}$

$$(NH_4)_2CO_3 \rightarrow\rightarrow H_2CO_3$$

$$NH_4HCO_3 \rightarrow\rightarrow H_2CO_3$$

$\underline{CO_2 \text{ consumption - excess } NH_4^+ \text{ present } (CO_2 \text{ limiting}):}$

$$(NH_4)_2CO_3 + H_2O \rightarrow\rightarrow 2NH_4OH$$

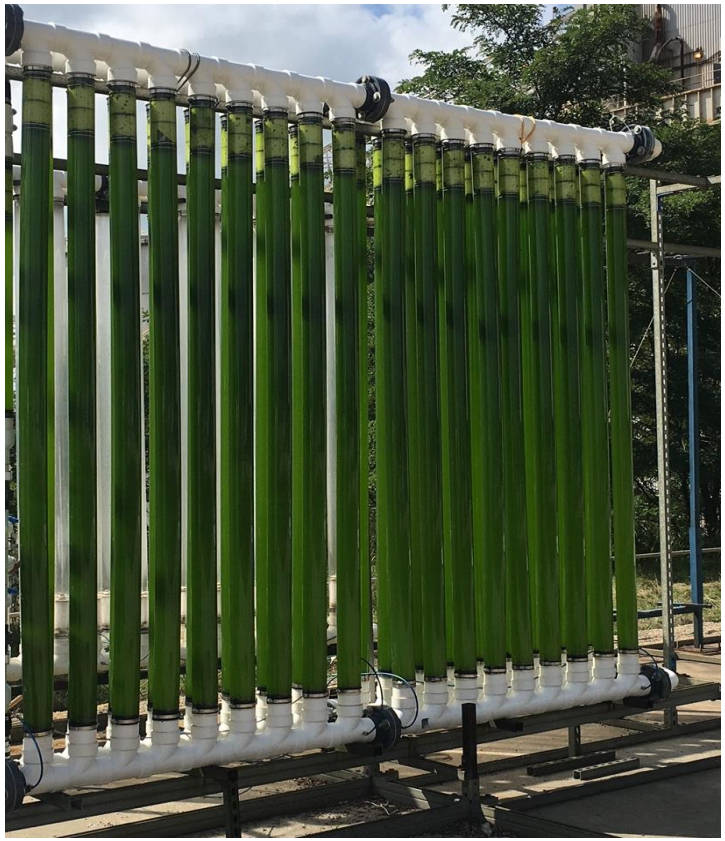
$$NH_4HCO_3 \rightarrow\rightarrow NH_4OH$$

Reduced Costs by up to 50%

- 25% of PCCC cost is from pretreatment, steam extraction for solvent regeneration and CO_2 compression
- Elimination of the parasitic steam extraction and CO_2 compression also eliminates the need for the associated excess generation capacity, which means a smaller boiler, turbine and auxillary equipment of 700kW, or $7 MWh in fuel and fixed costs
- 5% of the overall CO_2 capture cost is from solvent make-up, which will be reduced
- 20-25% of algae production cost is from CO_2 supply and distribution, which are eliminated

Expected Output

Demonstration of a simplified method for CO_2 capture and biofixation for large quantity algae production that can be applied to any source of CO_2, fossil-fueled power generation, cement plants and chemical plants.



Acknowledgements

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Read More at:

https://uknow.uky.edu/research/caer-receives-us-doe-grant-develop-next-generation-carbon-dioxide-capture-technology?j=270051&sfmc_sub=122676171&l=20489_HTML&u=8364228&mid=10966798&jb=0

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