

# Novel Low Grade Waste Heat Recovery System with Simultaneous Electricity Generation, Carbon Sequestration and Urea Production

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Over 60% of energy generated during electricity production is discarded as low-grade waste heat. Concurrently, modern power plants are reluctant to capture and sequester flue-gas CO<sub>2</sub>, due to high cost and significant efficiency reductions. The novel system invented in this research converts untapped low grade waste heat into valuable byproducts including electricity, captured CO<sub>2</sub>, and Urea. The system generates electricity by engineering a concentration gradient using CO<sub>2</sub> emissions and recycled NH<sub>3</sub>(aq) in an Osmotic Heat Engine. An NH<sub>4</sub>HCO<sub>3</sub> solution then selectively decomposes into pure CO<sub>2</sub> and NH<sub>3</sub> gas streams for carbon capture and Urea production. The performance of each component was separately evaluated, and integrated to determine viability of the complete process. In electricity generation, a high concentration solution was created through NH<sub>3</sub>(g) (recycled) and CO<sub>2</sub>(g) absorption with pH 8.6 and NH<sub>3</sub>:CO<sub>2</sub> 1.3:1, parameters exceeding draw solution requirements. 14.4Wh electricity was produced per kg CO<sub>2</sub> scrubbed, translating to 180 MWh per day from a 500 MW power plant. The Pressurization-Depressurization CO<sub>2</sub>(g) capture at 45°C produced 98% NH<sub>3</sub>(g), 1.02atm; 99% CO<sub>2</sub>(g), 2.1atm and was 85.5% more efficient than current carbon-capture systems. Ammonium Carbamate/Urea production achieved conversion efficiencies of up to 99% and was carbon negative, net sequestering 770 kg CO<sub>2</sub>/ton Urea. Based on the CO<sub>2</sub> emissions of 500MW coal power plant, the system will produce 335 metric tons of Urea/hour respectively. The proposed integrated system dramatically lowers the cost of carbon capture/sequestration and converts otherwise waste products into valuable Urea, while simultaneously improving the efficiency of power plants and industrial facilities.

## Awards Won:

First Award of \$5,000