CEFCO GLOBAL CLEAN ENERGY, LLC

McIlvaine Hot Topic Hour

High-Value Beneficial By-Products
from Coal Combustion and Gasification
at Ultra-Low Cost Inputs
through Innovative Technology

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Five Major Groups of Beneficial Products from Capture and Conversion

- Trace Metals and Fine Particulates —
  - Very valuable when captured and neutralized for Industrial Use by Metal Refiners, Steel Makers and Electronic Component Makers
- Sulfur (SO_3, SO_2, SO and H_2S) —
  - Conversion into High Value Potassium Sulfate Fertilizer
- NO, NO_2 and NOx —
  - Conversion into High Value Potassium Nitrate Fertilizer
- CO, CO_2 and THC (Complex Hydrocarbons) —
  - CO_2 can be captured as "pure CO_2" via Bicarbonate for EOR, CCS, and Conversion into High Value Plastics and Liquid Fuels
- Residual Gases, such as N_2, O_2, and the Inerts-Nobles (Argon, Xenon, etc.)

Profit from Valuable End-Product Sale

Sequenced modules selectively capture distinct and Valuable Products from Pollutants.

	CEFCO Module 1: Metals	CEFCO Module 2: SO_2	CEFCO Module 3: NO_X	CEFCO Module 4: CO_2
Final Products	Metal Compounds (Mercury & Trace Metals) Significantly below $PM_{10.0}$	Potassium Sulfate (Fertilizer)	Potassium Nitrate (Fertilizer)	Pure CO_2
Potential Revenue Streams	• Metals Market • Alloy-Steel Users • Industrial Market • Trace Metals for Hi-Tech Electronics Users • Catalysts and Additives for Refining & Petrochemical Sectors	• Fertilizers & Agricultural Applications • Industrial Market • Feedstock for Petrochemical Sector	• Fertilizers & Agricultural Applications • Industrial Market • Feedstock for Petrochemical Sector	• Enhanced Oil Recovery • Sequestration Market • Carbon Credit • Methanol, Ethanol & Diesel Fuels • Feedstock for Petrochemical Sector

CEFCO's Innovative Solution

CO_2 Capture + All-Pollutant Capture = Regulatory Compliance + Renewable & Sustainable Technology + Recovering CAPEX and OPEX

- Use Ewan's shockwave "free-jet collision scrubbing" (recognized by EPA/DOE) to capture CO_2 and all pollutants

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- Cooper Process to convert CO_2 and all "captured pollutants" with Appropriate Reagents into recovered, segregated, valuable, and sellable End-Products

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- Accomplished using Supersonic Shockwave Reaction Mechanism under USPTO Patent issued on November 30, 2010 under: **US 7,842,264B2**

- CEFCO Users:
  - 1) Comply with all EPA's MACT and NESHAPs Requirements
  - 2) Benefit of selling End-Products ≈ no longer "cost-center" ↔ **recover CAPEX+**
  - 3) Providing pure CO_2 gas to Ultimate Users (via Capture in BiCarbonate Solid/Liquid)

Ewan Technology: EPA MACT Compliant

Date	Reference No.	Report Title	Emissions Targets	Description of Tests	Performance Conclusion
April 1, 1974	EPA-650/2-74-028 (Dale L. Harmon, EPA-NERC-RTP)	Steam-Hydro Air Cleaning System Evaluation	0.03 micron to 5.0 micron (EPA Method 5)	Steam-Hydro Patent invented by T.K. Ewan sold and assigned to Lone Star Steel (Div. of US Steel)	"90.0% at 0.01 micron . . . . 99.9% at 0.5 micron and 99.99% at 1.0 micron"
Oct. 1976	NCASI — Special RTP	Kraft Recovery of TRS Emissions	Total Reduced Sulfur, H_2S, CO_2	". . . near instantaneous . . . tremendous surface area for gas-liquid contact . . . 50 x 10^{-3} sec."	"TRS emissions were reduced to less than 2 ppm during total run", "quite successful . . . it is recommended to test for SO_2 removal also"
Sept. 1977	EPA- 600/2-77 -193 under Dennis C. Drehmel, EPA, Research Triangle Park	EPA/600/13 Code	Contract 68-02-2190: Particulates, H_2S, SO_2	"High performance with low energy requirement is achieved by the use of free-	". . . well below the 0.0052 grains /SCF...effective removal of hydrophobic fumed silica having article diameter s. This material Analysis of the rial shows the t wetted, but e film of water."
July, 1986	EPA- 600/S2-86 -011 [this is a head-to-head test vs. equipment and technology provided by ETS, Inc. and Vulcan Engineering]	EPA Hazardous Waste Engineering Research Lab, Cincinnati, OH	APCD, PM, HCl, SO_2, SO_3	"supersonic tandem nozzle . . .", "most effective of the versions tested for control of submicron particulate matter"	Page 2: "uranium hexafluoride and its hydrolysis products with particulate removal efficiency consistently exceeding 99%"; Page 3: "chloride removal of 99% or better should be expected for any version of this unit [vs. both competitors]."
Sept. 1992	DOE PNL-8281	DE-AC06-76RlO 1830 by Battelle Memorial Institute	Hanford Radioactive Waste Incineration	Performance per Office of Solid Waste Emergency Response (OSWER) Directive 9335.3-01	". . . cesium-137 was greater than 99.98%"; other metals, acids and organics "greater than 99.99%"
August 1993	DE-AC01-EW300-30				
1993	WSRC-TR-93-00623				
Feb. 1996	EPA Contract No. 68-D2-0164				
1997	**CERCLIS #**: MOD980685226 EPA Remedial Project Manager: Robert W. Field U.S. EPA Region 7 Kansas City, KS 66101	On-Site Incineration at the Times Beach Superfund Site (Times Beach, Missouri)	Dioxins, TCDD ("Agent Orange")	CEMS measures: O2, CO2, NOx, CO, and SO2. Acids, metals and minerals. Continuous recording.	MACT Compliance. "Resource Conservation and Recovery Act (RCRA): DRE of 99.9999% for TCDD. Stack gas monitoring was conducted for oxygen and carbon monoxide in accordance with 40 CFR Part 264, Subpart O."
July 1998	DOE/ID-10651, Rev.1	Hazardous and Radioactive Waste Treatment Technologies Handbook	PM, Hg, ROW (Radioactive Organic Waste), BRW (Blended Radioactive Waste)	Consolidated Incineration under SVM (Semi-Volatile Metals) + LVM (Low Volatile Metals) Standards	MACT Compliance, and Toxic Substances Control Act Incinerator (TSCAI)
May 22, 2002	40 CFR §63.1209 (m) and §63.1209 (o)	A Guide to Phase I MACT Compliance — May 22, 2002	PM, acids, HCl and Chlorine Gas		"hydrosonic, collision, or free-jet wet scrubber"
unspecified	DOD/DOE docs		controlled	At National Labs	Internal GOV official and formal EPA request

- EPA published its "Guide to Phase I MACT Compliance" for Hazardous Waste Combustors MACT — May 22, 2002
- Ewan's Technology was Federally recognized and codified in 40 CFR §63.1209

et al.

"Renewable + Sustainable" = Providing "Pure CO_2" Gas to Makers of Advanced Fuels or Bio-Fuels or Algae Growers

- **Shockwave "reaction mechanism" —** pin-point delivery by "collision physics" (molecule-on-molecule impact) of all requisite Energy, Pressure at the "point-of-use" (molecular surface interaction chemistry: target + reagent) and serves as Catalyst to make Endothermic-then-Exothermic Reactions happen in a "split-second", in lieu of Conventional Thermo-Chemistry and long "residence time" which inputs unnecessary Energy and Pressure at vast spaces in between molecules (not at the "point-of-use") → ultra-low usage of Energy and Costs

- Shockwave Mechanism avoids High Cost and Energy Penalty associated with Heating and Cooling in conventional Capture of **CO_2** — uses the aerospace phenomenon of rapid "Adiabatic Cooling" under the Shockwave

- Avoids Current Methods of **CO_2** Capture that become contaminated by Traces of Amine or Ammonia

- Removes Energy Penalty and Stainless Pipeline Cost Burden to Compression and Transmission of Liquid **CO_2**

- Solution: **CO_2** can be Captured as a Bicarbonate Solid/Liquid and Transported by Rail or Truck or Barge, and Released as "Pure" Gas by Ultimate Industrial User

Innovation: CEFCO's Supersonic Collision Reaction Mechanism can be Developed for the Petro-Chemical & Refinery Industry

- Using the Supersonic Collision Reaction Mechanism to make Chemicals, such as Fuels and Plastics from Coal, Asphaltenes, or any Hydrocarbon Feedstock. This method could be a significant Energy-Reduction, Time-Reduction, Equipment and Steps Reduction, and overall Cost-Reduction application

- Colliding any gas with another gas/vapor or liquid reagent at Supersonic Speeds: colliding **$CO + H_2$** or **$CH_4 + H_2$** with any combination of **Carbon, CO or CO_2, O_2** with or without **H_2O re-combination** can form Polyethylene (PE) and Polypropylene (PP), and can add **HCl** or **Cl_2** to form Ethylene Dichloride (EDC) to make PVC Plastic, etc.

$2\ CO + 4\ H_2 \rightarrow C_2H_4 + 2\ H_2O$ [Ethylene]

$2\ CO + 4\ H_2 + Cl_2 \rightarrow C_2H_4Cl_2 + 2\ H_2O$ [EDC]

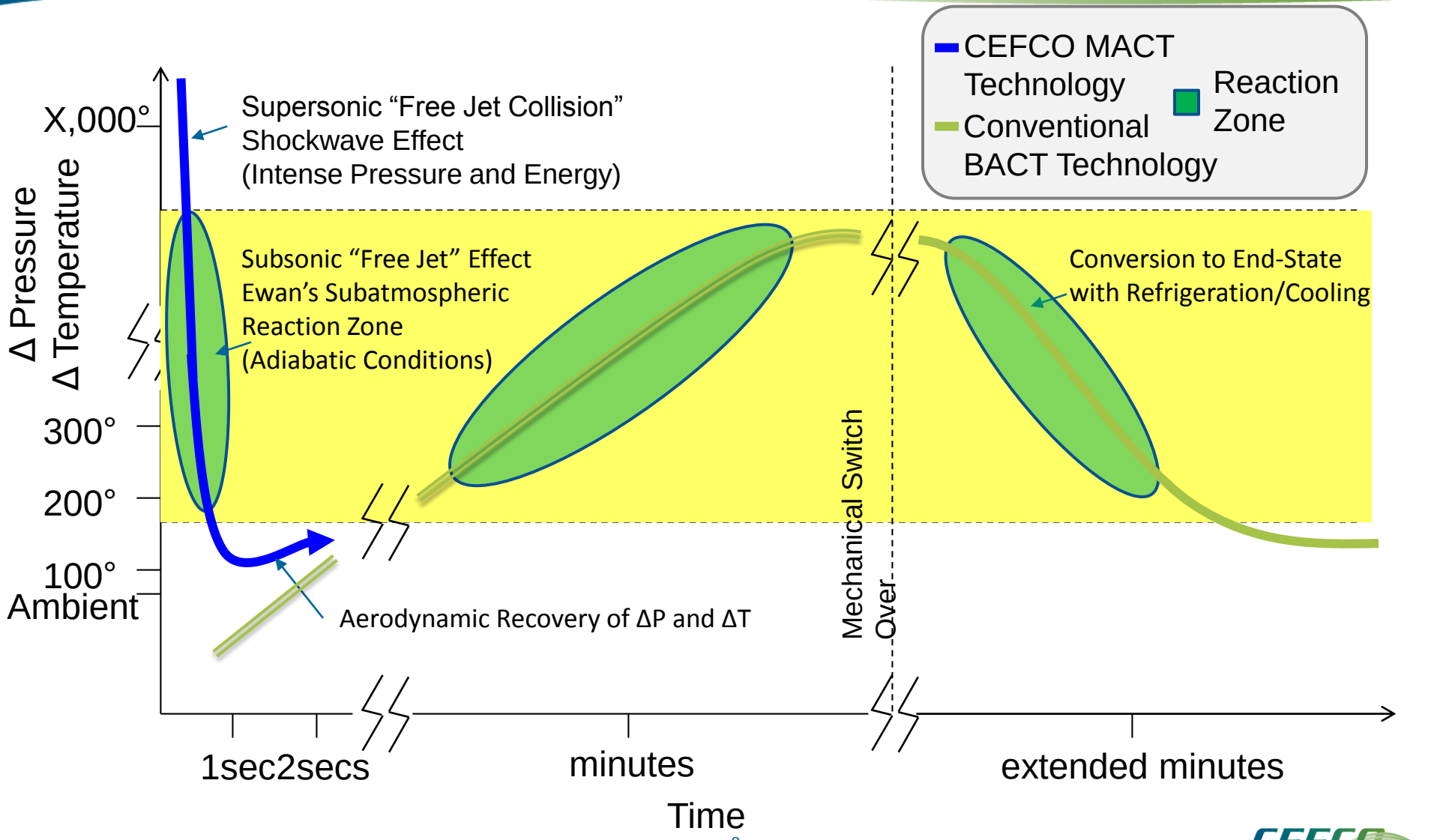
$EDC_o + EDC_n \rightarrow$ PVC Plastics

$3\ CO + 7\ H_2 \rightarrow C_3H_8 + 3\ H_2O$ [Propane, etc.]

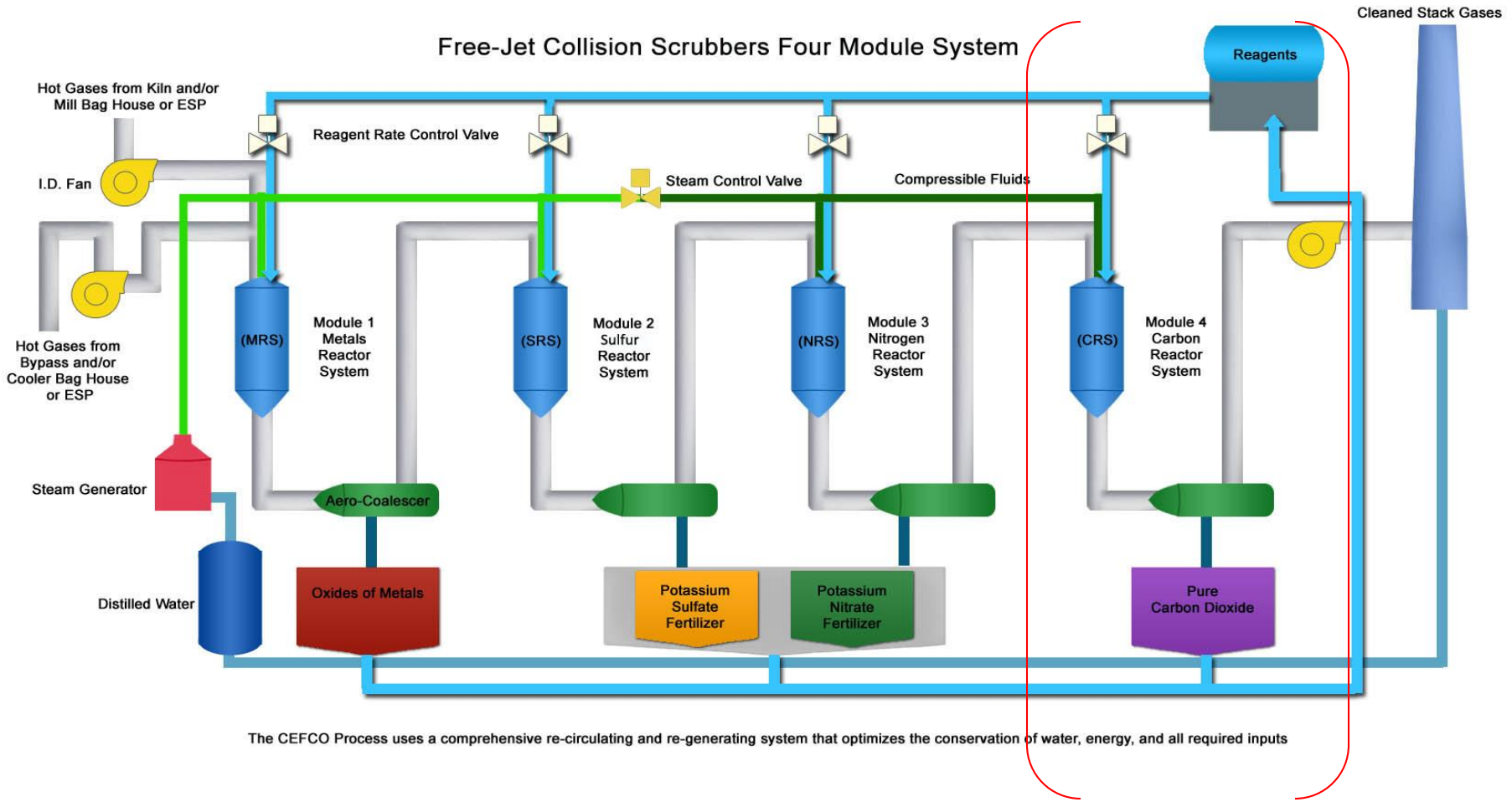
$C_nH_x + C_nH_x +$ etc. → Any Long-Chain Hydrocarbons or Fuels

- Will license this reaction mechanism technology for Innovative Applications Development for Sustainable and Renewable Energy Purposes

Comparison of Parasitic Load or Energy Penalty



CEFCO — System Flow Diagram



MRS — Trace Metal Capture Mechanism

- Analysis of Coal-Fired and Pet-Coke Emissions show ~40 different kinds of metals and minerals → Hg, U, Pd, Cr, V, Ni, Be, Mn, Ge, Ti, Ba, Antimony, etc. can be recovered to reduce Importation from Overseas Countries

- Capture Mechanism: molecular surface area interaction between Pollutant and Reagent
  - Use of Steam: Shockwave shattering Steam's or Reagent's contact surface area to become multiplied thousands and thousands of times
  - Micro-droplets contact and envelope Targeted Pollutant and reform as moisture-encapsulated droplets
  - Capturing Product Reactions completed in split-seconds
- Molecular surface chemistry overcomes conventional mass transfer limitations

CRS (CO_2) Module — Collision Reaction Mechanism made Thermo-Chemistry Simple

Endo-then-Exothermic Reactions inside the Aerodynamic System:

- $CO_2 + KOH_{(reagent)} \rightarrow KHCO_3$ (Carbon Capture)
- $CO_2 + \mathbf{K_2CO_3}_{(reagent)} + H_2O \rightarrow 2\ KHCO_3$ (Carbon Capture)

Transient Reactions (verification of Hess's Law):

- $CO_2 + H_2O \rightarrow H_2CO_3$
- $KOH_{(reagent)} + H_2CO_3 \rightarrow KHCO_3 + H_2O$ (Carbon Capture)

Conventional Reactions after leaving the Aerodynamic Coalescer:

- Decarbonation = Liberation of Carbon Dioxide
- Heat + $2\ KHCO_3 \rightarrow \mathbf{K_2CO_3}_{(regenerated)} + CO_{2\ (liberated\ gas)} + H_2O$

Note: $\mathbf{K_2CO_3}$ re-generation process liberates CO_2 as gas and produces supply of recovered water for many subsequent uses

Any cheaper Alkaline or Alkaline Metal Base Reagent will work for Regulatory Compliance, but Potassium Reagent works faster → Smaller Equipment Size

CO_2 is Captured and Converted into Easily Transportable Solids

Potassium Bicarbonate = $KHCO_3$ (Solid)

Sodium Bicarbonate = $NaHCO_3$ (Solid)

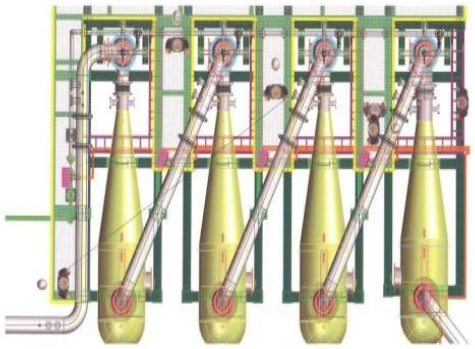
Heat + 2 $KHCO_3$ [or 2 $NaHCO_3$] → **K_2CO_3 (regenerated)** [or Na_2CO_3] + CO_2 **(liberated gas)** + H_2O

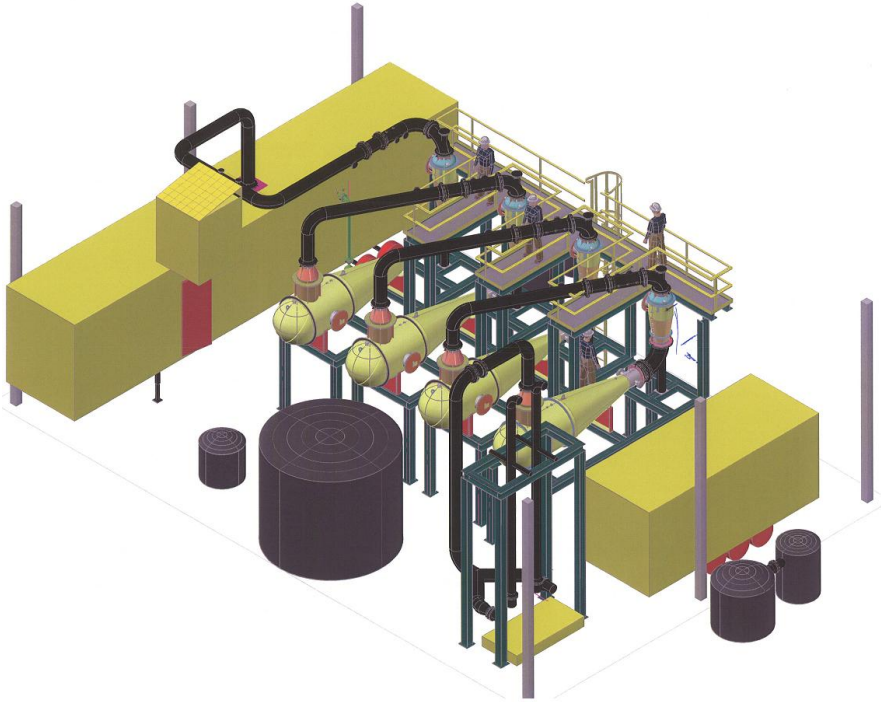
Note: **K_2CO_3** [or Na_2CO_3] re-generation process liberates CO_2 as a pure food-grade gas and produces supply of recovered water for many subsequent uses. The **K_2CO_3** [or Na_2CO_3] can be returned to the CEFCO Process to be re-used as the Reagent in the CRS. Any cheaper Alkaline or Alkaline Metal Base (e.g., Calcium) Reagent will work, but Potassium Reagent works faster.

Successful Capture of Potassium Fertilizer + CO_2

Pilot Plant at Peerless in Wichita Falls, TX

(MRS + SRS → Ready for Commercialization)





- Phase I (MRS + SRS Modules) Success announced in November 9, 2011 Press Release by Peerless Mfg. Co.
- Seeking Demo-Partner for NRS and CRS

Pilot Plant in Wichita Falls, TX

10-Minute Video available in Website: www. cefcoglobal.com

Executive Summary

- Success of Parametric Testing of CEFCO's MRS and SRS Modules was announced by Peerless Mfg. Co. in Press Release dated November 9, 2011
- MRS and SRS Modules are ready for Commercialization → MACT, MATS, CSAPR and NESHAPs Compliance on a timely basis
- Pollution Control = "profit-generation" business; ≠ "cost-center"
- Reliable and affordable "renewable and sustainable" Hydrocarbon Energy:
  - Game-changing "transformative" (described by DOE) reaction mechanism technology = low-cost substitute for traditional thermodynamics and catalysts
- **CO_2** can be Captured as a Bicarbonate Solid/Liquid and Transported by Rail or Truck or Barge, and Released as "Pure" Gas by Industrial User
- "Virtuous Circle for Zero Carbon Footprint" — Repetitively recapturing **CO_2** to make Synthetic Fuel for stationary Co-Generation of Electricity or Process Steam in repeating cycles ("renewable + sustainable")

Questions & Answers

Thank you very much for your attention.

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