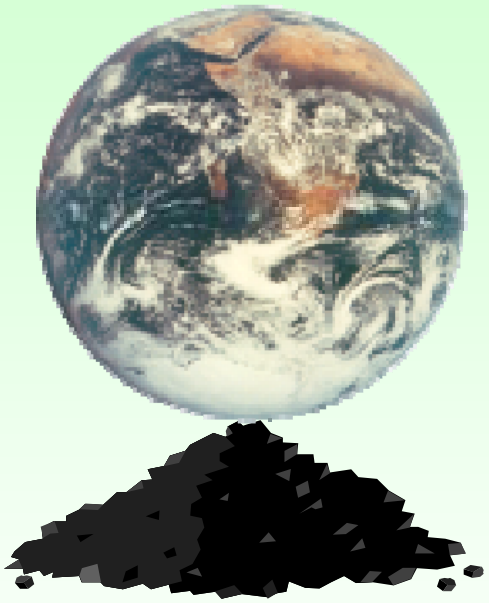
Coal Biotechnology: A Creative Approach for Carbon Reduction, Environmental Foot Print, While Moving Coal Up the Value Chain



Invited Plenum Presentation at:

32nd Int. Pittsburgh Coal Conference
Pittsburgh, Pennsylvania USA

By : Dr. Daman S. Walia
President/CEO

October 8, 2015

ARCTECH, Inc.

14100 Park Meadow Drive
Chantilly, VA 20151
Tel. (703) 222-0280
www.arctech.com

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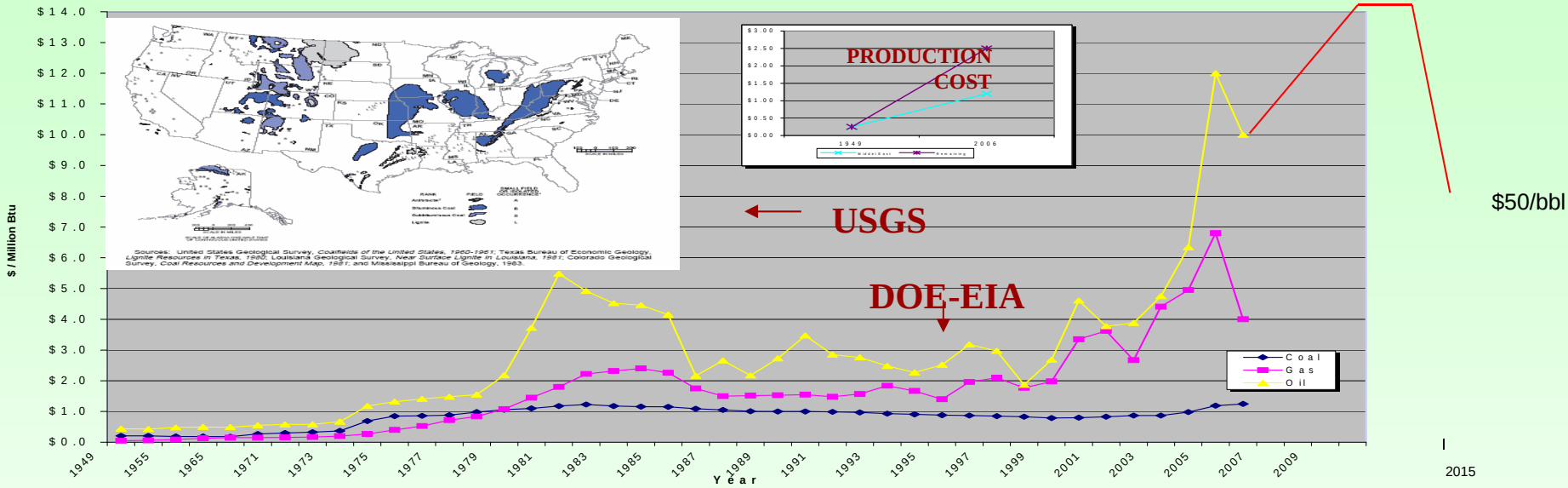
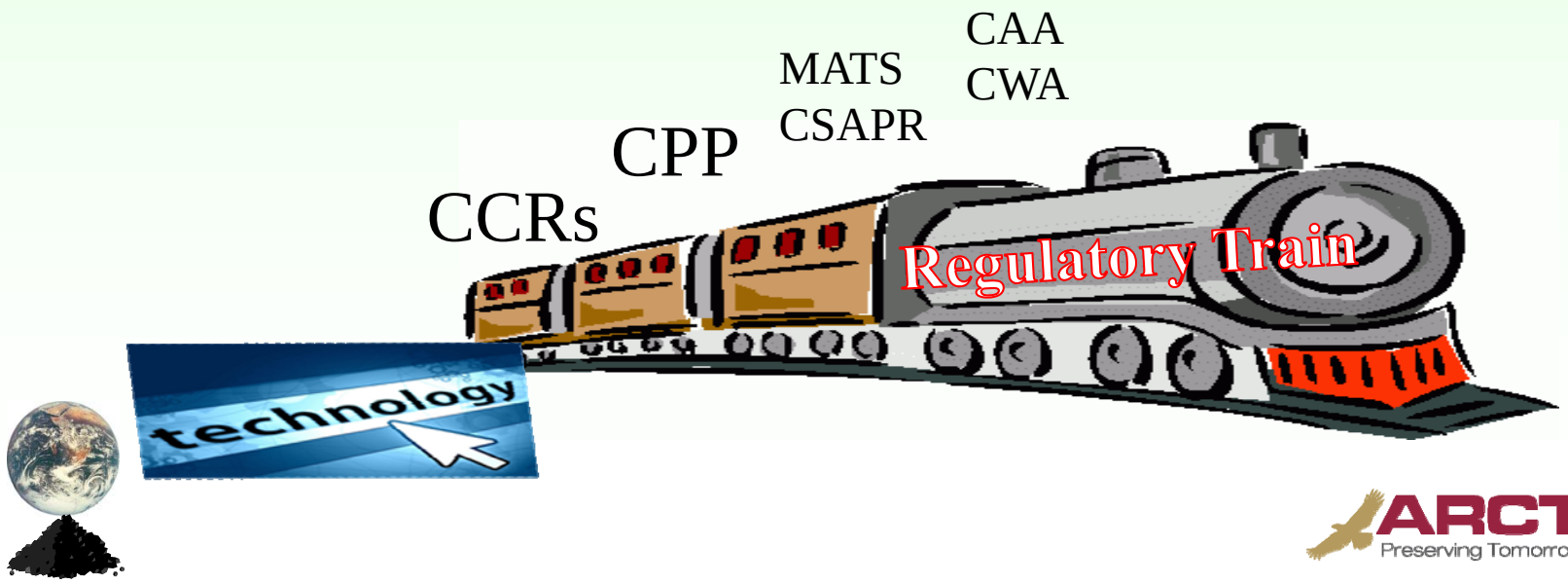
Challenges Coal Continues to Face





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Coal is the Most Abundant , Lowest Cost and Concentrated Source of Carbon

Source	$ Ton	% Carbon	$/Ton Carbon
Waste Biomass	-10 + 50	20	-50 + 260
Cultivated Biomass	60	25	240
Corn Grain	120	30	400
Coal	**10-50**	**60**	**17-85**

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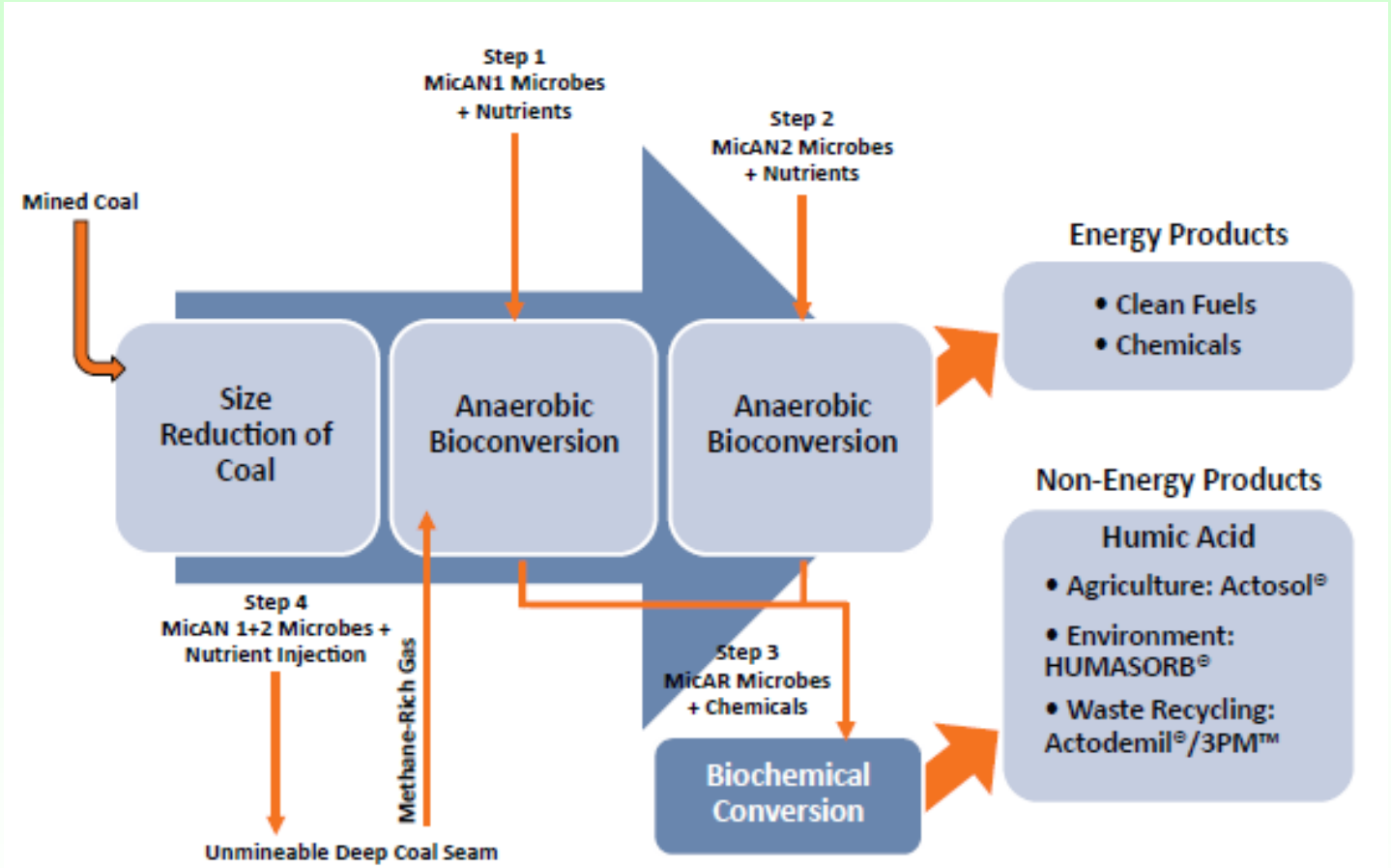
Integrated MicGAS™ biotechnology process flow scheme



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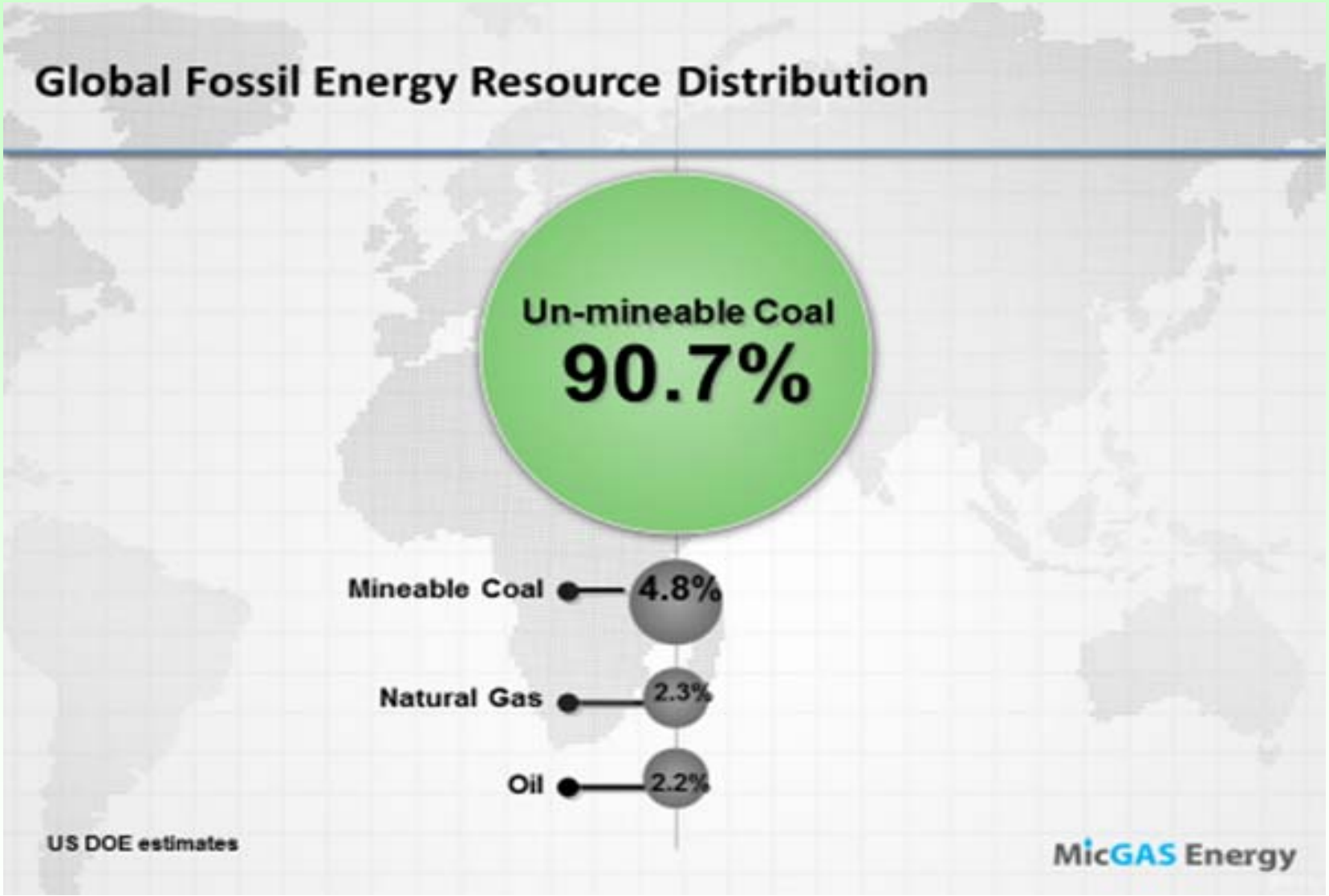
Global Fossil Energy Resource Distribution



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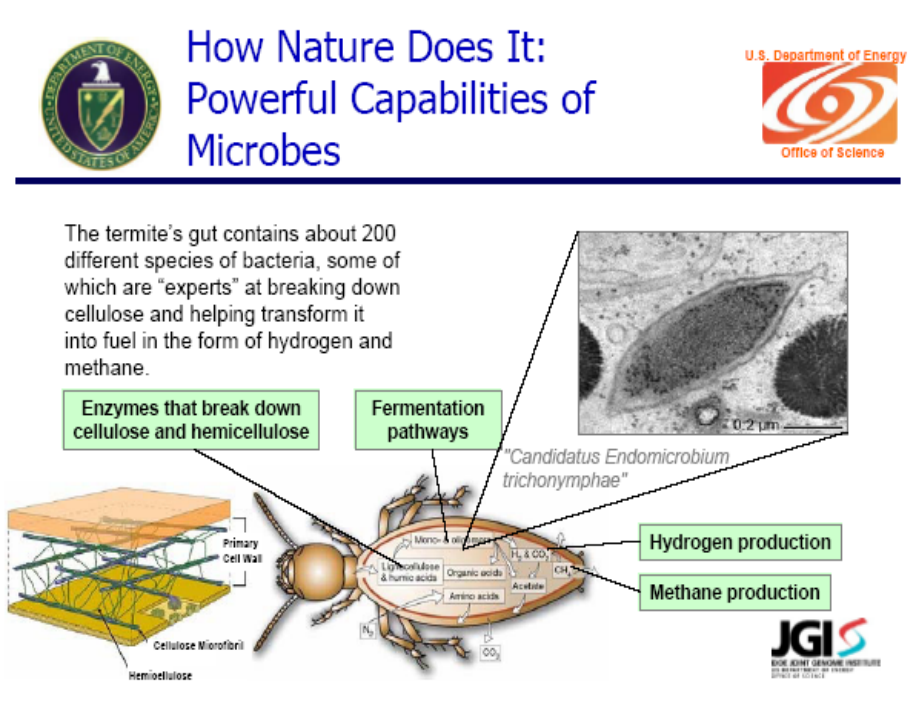
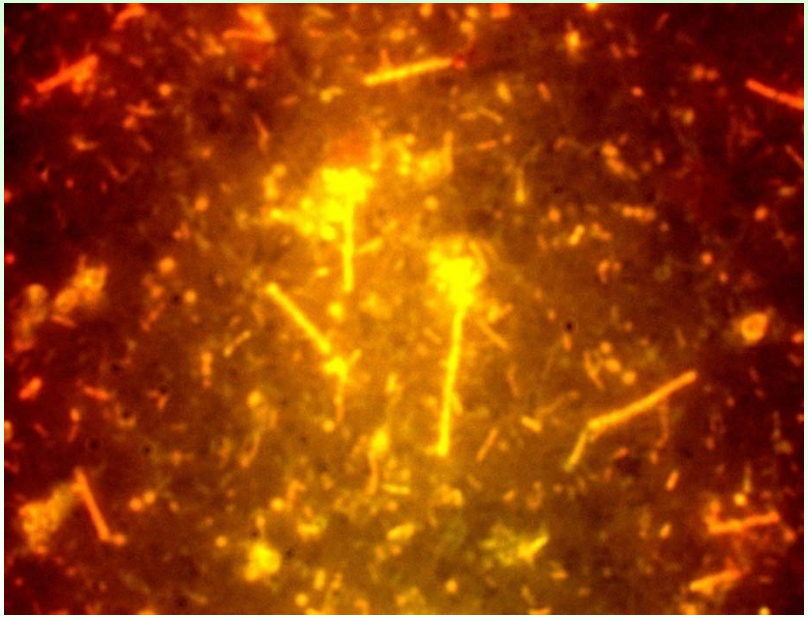
MicGAS™ Coal Biotechnology Among U.S. Department of Energy 14 Transformation Technologies



US Department of Energy *2007*



Mic1 Biotechnology Microbes from Termite Guts

Dr. Steven Chu sees an America free from foreign oil, powered by home-grown genetically engineered and eco-friendly fuel. The Nobel laureate gets his inspiration from the guts of termites. The processes that allow insects to turn the hard fabric of plant material - cellulose - into an ethanol-like fuel is the key to cheap, clean-burning and virtually limitless fuel.

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Why Biotechnology?

- **Biotechnology is use of living matter to achieve useful processes and products economically and environmentally safe manner**

- **For centuries humans have been using biotechnology for making wines and alcohols from grapes and grains using yeast microbes**

- **Today Biotechnology is Used by Many Industries**

  - **PHARMACEUTICAL : Majority of medicines made today with biotechnology**
  - **AGRICULTURE: Enhanced crops and foods**
  - **ENERGY: Crops to Ethanol, anaerobic digesters. landfill gas and coal bed methane**
  - **MINING: Recovery of valuable metals from low grade ores –**
  - **ENVIRONMENT: Treatment of sewage water and industrial wastes**

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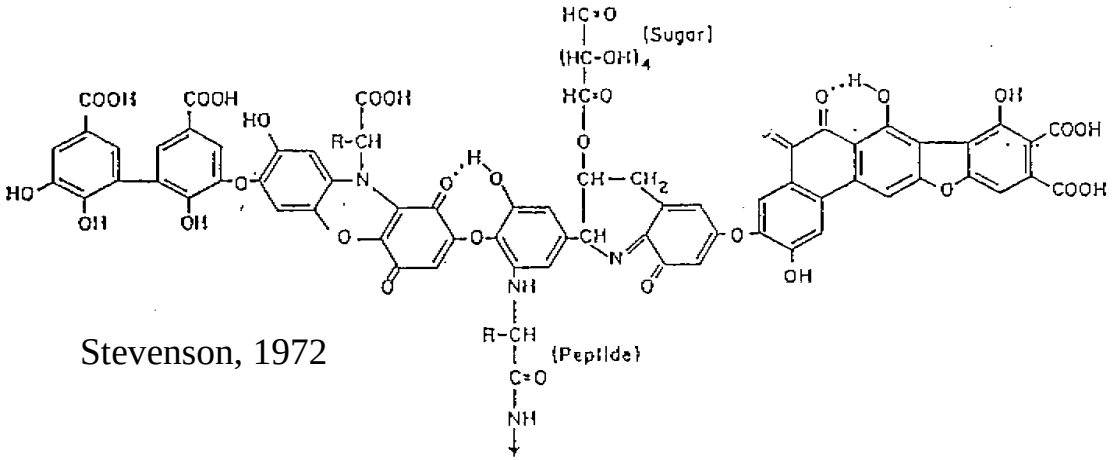
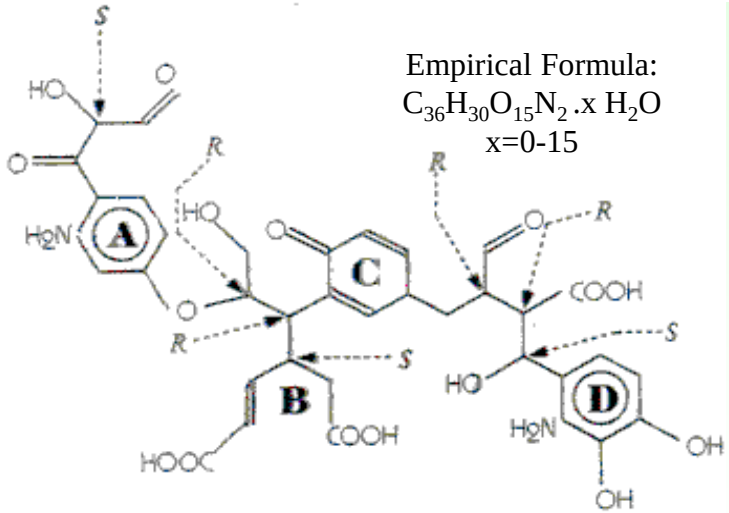
Coal and Humic Substance Similarities



Stevenson, 1972



Empirical Formula:
$C_{36}H_{30}O_{15}N_2 .x\ H_2O$
x=0-15

TNB, 1998 (Temple, Northeastern and Birmingham)

Element	Humic Acid %	Coal
Carbon	53.8-58.7	60–75
Hydrogen	3.2-6.2	6.0–5.8
Oxygen	32.8	34
Nitrogen	0.8-4.3	1.5
Sulfur	0.1-1.5	0.2-10

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Methane Gas Flame From MicGAS™ Clean Coal Bioreactor

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MicGAS™ Coal Biotechnology Demo Unit In Turkey

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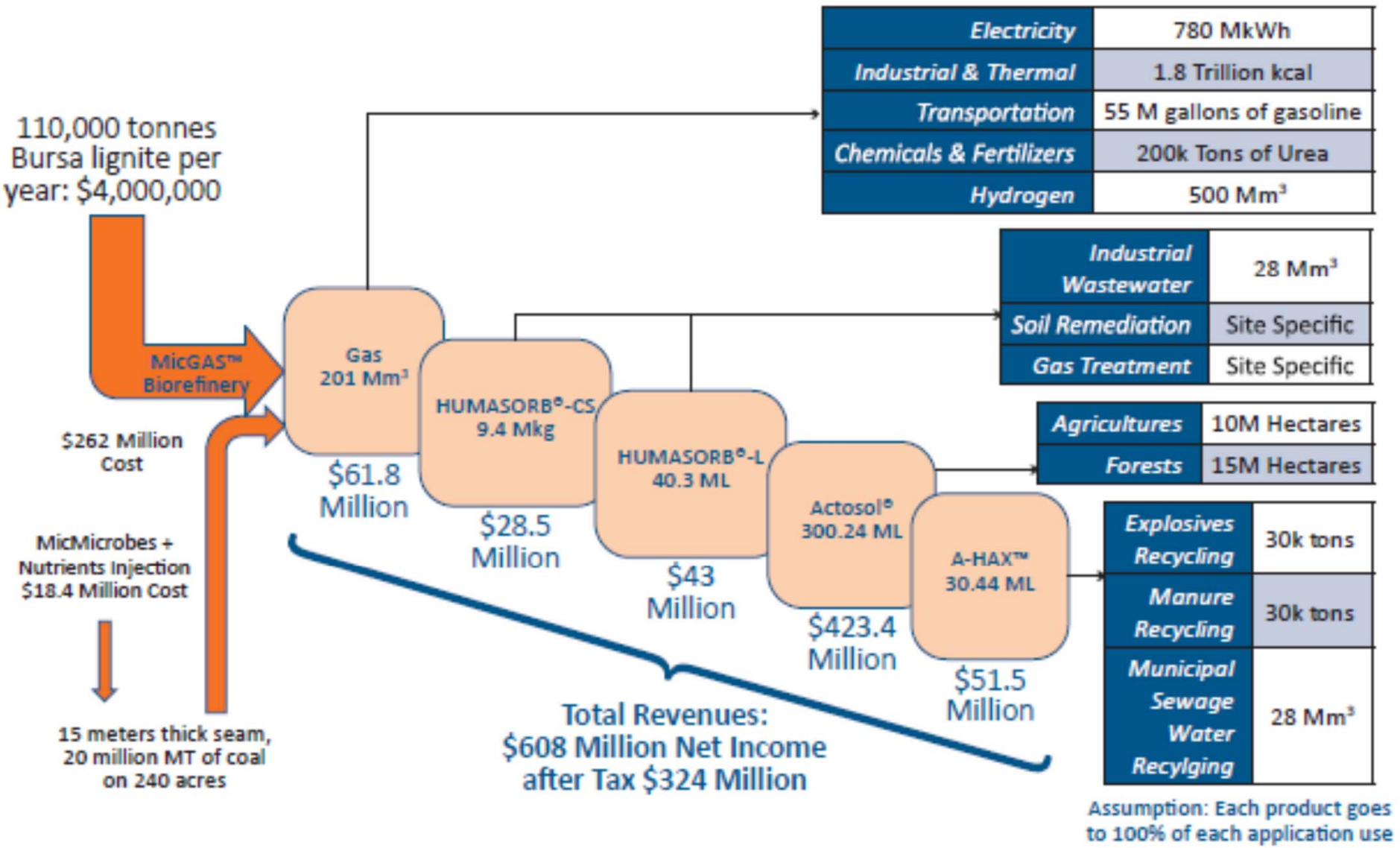
Total value chain of HUMAXX MicGAS™ coal biorefinery for Turkish lignite



Notes: 1 m^3 of gas = 4.44 kWh (www.eia.gov), 1 m^3 gas = 0.28 gal gasoline (www.nist.gov), 1000 m^3 gas = 1.1 ton urea (wiki.answers.com), 1 m^3 gas = 1.5 m^3 H_2 (www.nrel.gov), Wastewater: 1.67 m^3/kg HUMASORB®-CS, 0.2 m^3/L HUMASORB®-L, Agriculture: 30 L actosol®/hectacre, Forests: 20 L actosol®/hectacre, Wastes: 1000 L a-HAX™/1.1 ton wastes

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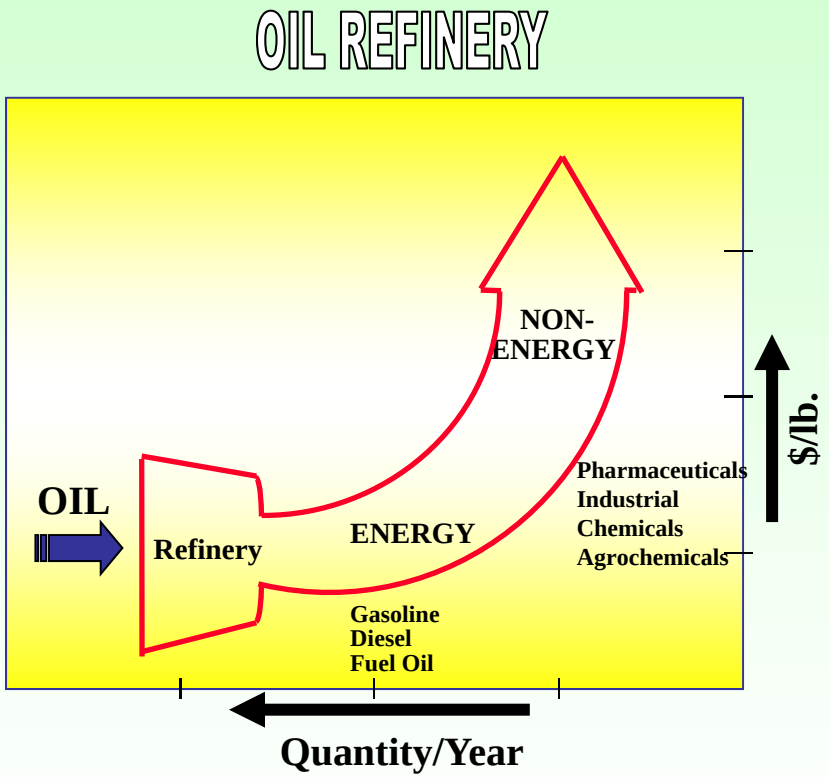
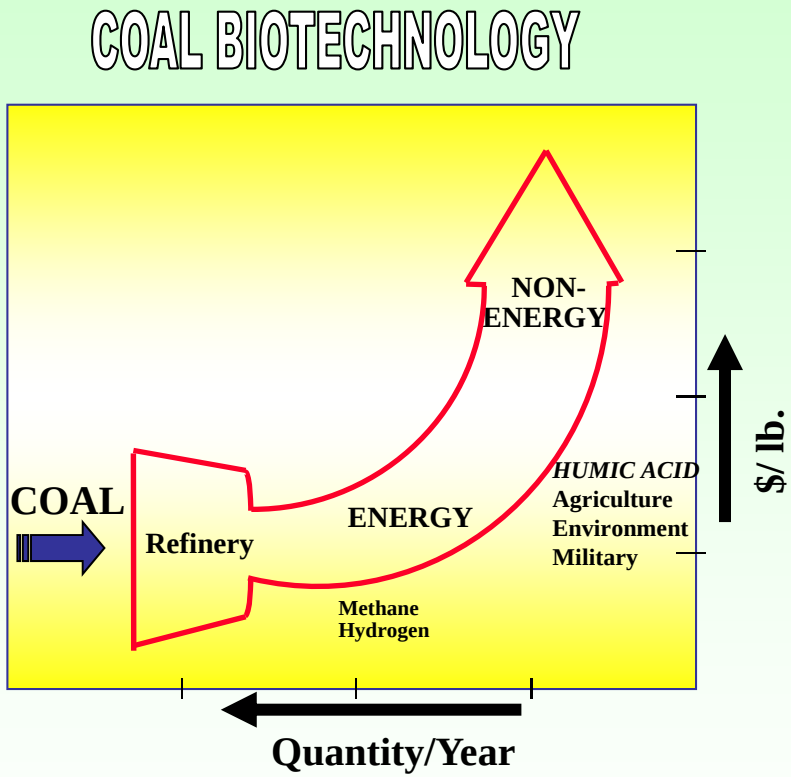
Coal Biotechnology Follows Rockefeller Oil Refinery Strategy of Producing Low Cost Energy Fuels By Creating High Value Non-Energy Co-Products





Humic Acids Co-Products are unique to coal because of its plant origin ---- can not be made from oil.

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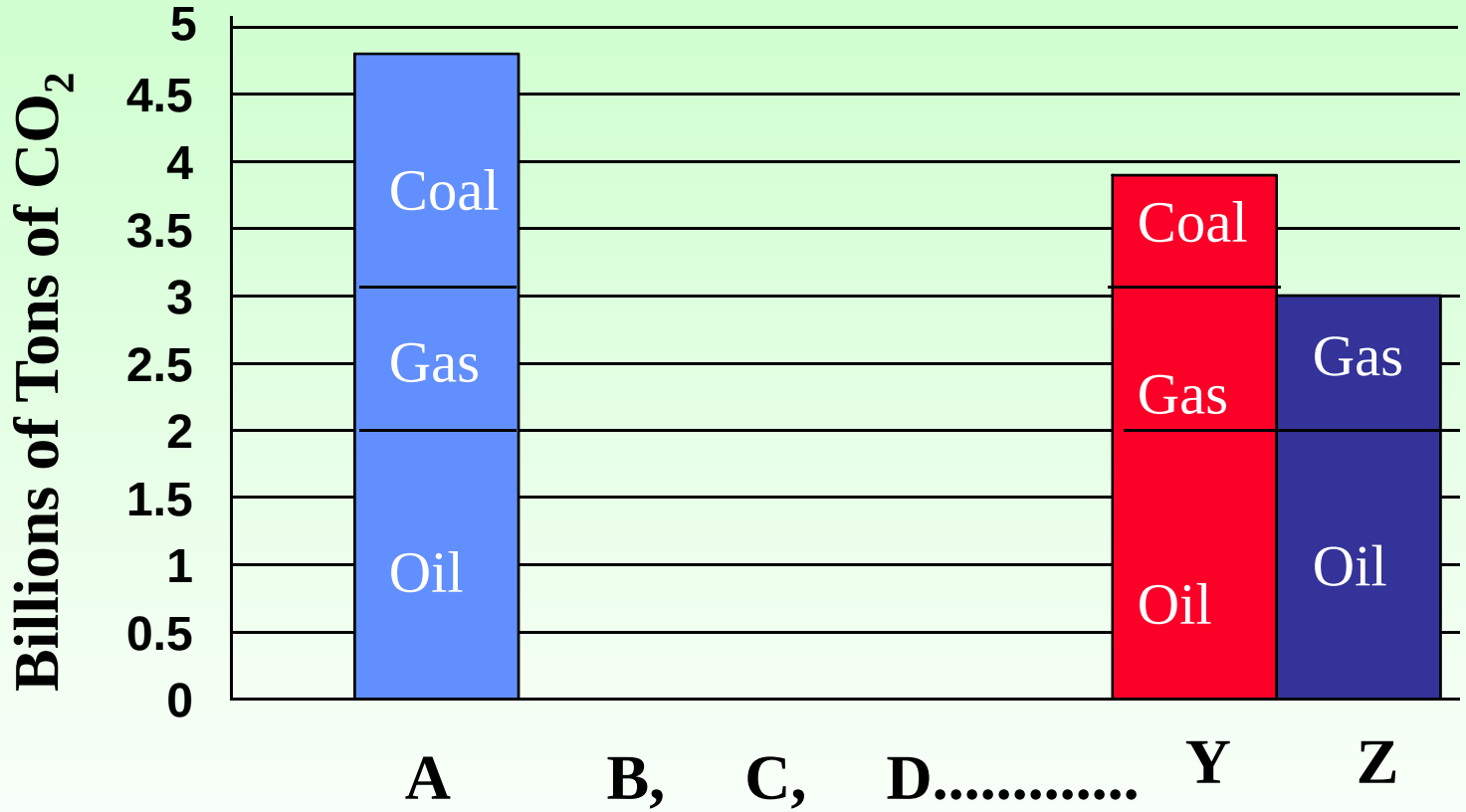
Significant Potential Exists For Mitigating Green House CO_2 With The MicGAS™ Coal Technology



A: Current yearly rate of emissions of CO_2

Y: Reduction with maximum potential of MicGAS™

Z: Reduction with additional biomass sink (assuming 30% increase in biomass with actosol® humic acid)

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MicGAS™ Coal Biotechnology - Commercial Activities

Energy:	
Canada - Alberta CCEMC Global Challenge Project	Recycling CO2 into water filter
Australia - Mitchelle/Verso Energy	MicGAS™ in-situ
Turkey - Turkish Coal Enterprise	MicGAS™ Biorefinery
India – Reliance India Limited	MicGAS™ in-situ
Non-Energy:	
U.S.A , Egypt, China	actosol® commercial applications
U.S.A	HUMASORB® commercial applications
U.S.A	ActoCLENSE commercial application for poultry industries

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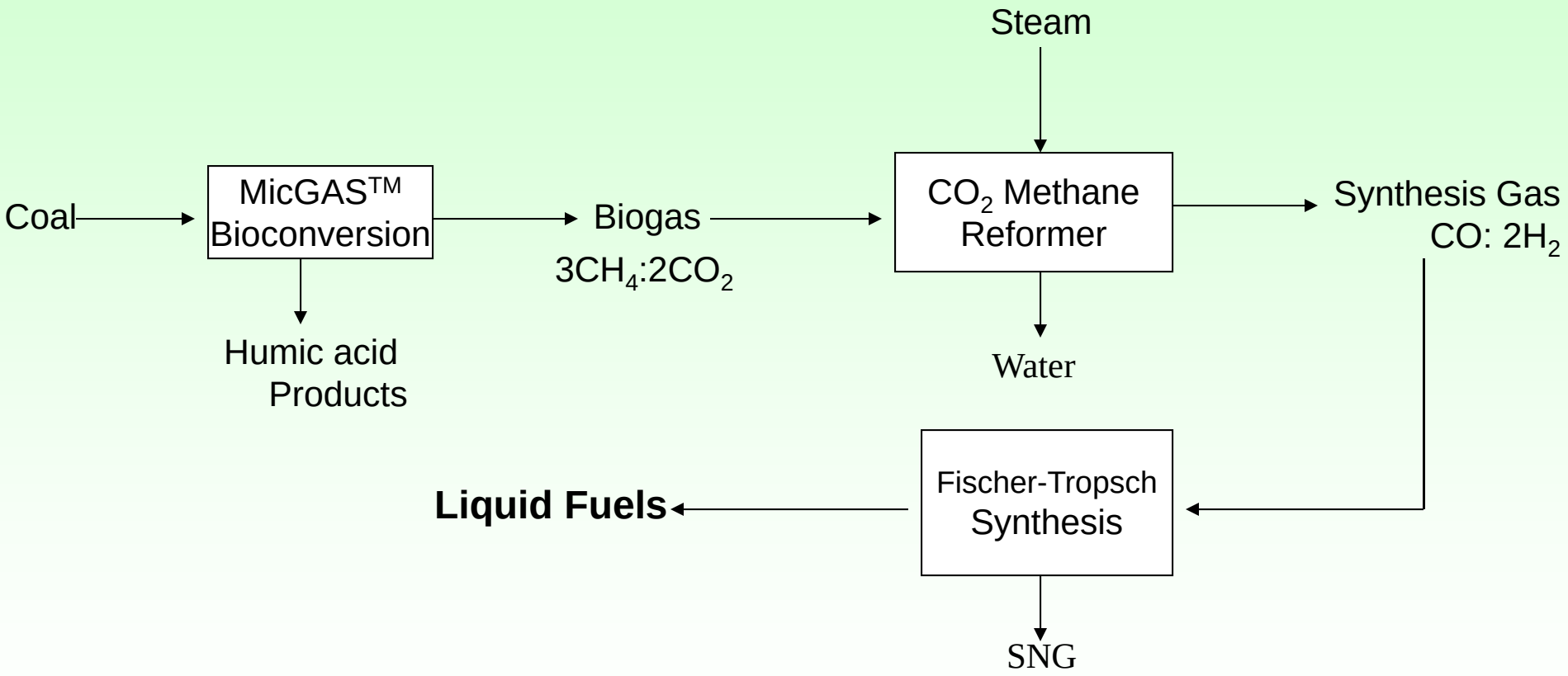
Integrated Flow Scheme of MicGAS™ Coal Biotechnology With Fischer-Tropsch Liquids Production



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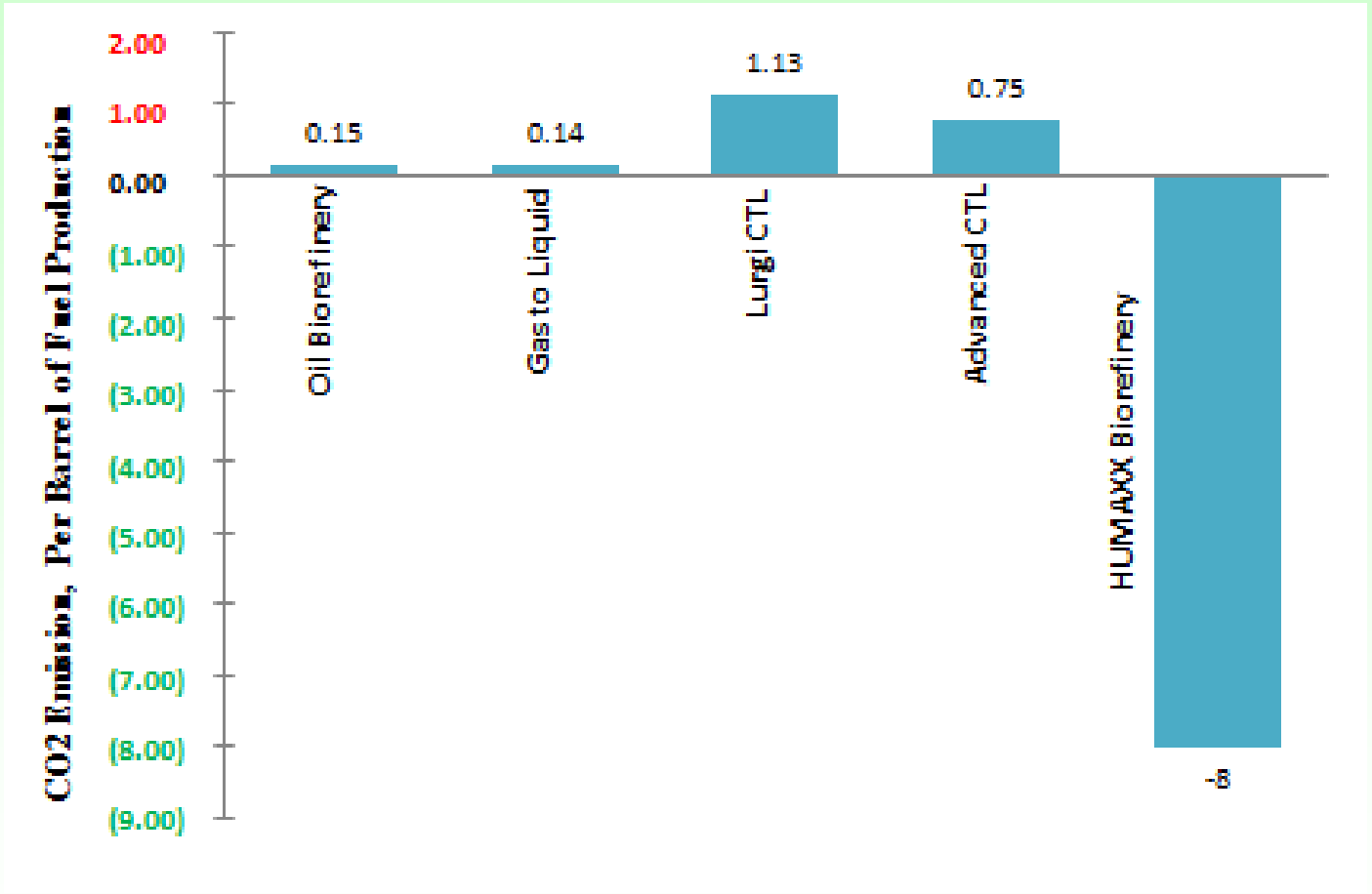
MicGAS™-FTL Eliminates Carbon Foot Print for Coal to Liquids Productions



US Government mandate to purchase aviation fuel from alternate sources with equal or lower GHG emissions by petroleum sources (EISA 2007 §526).

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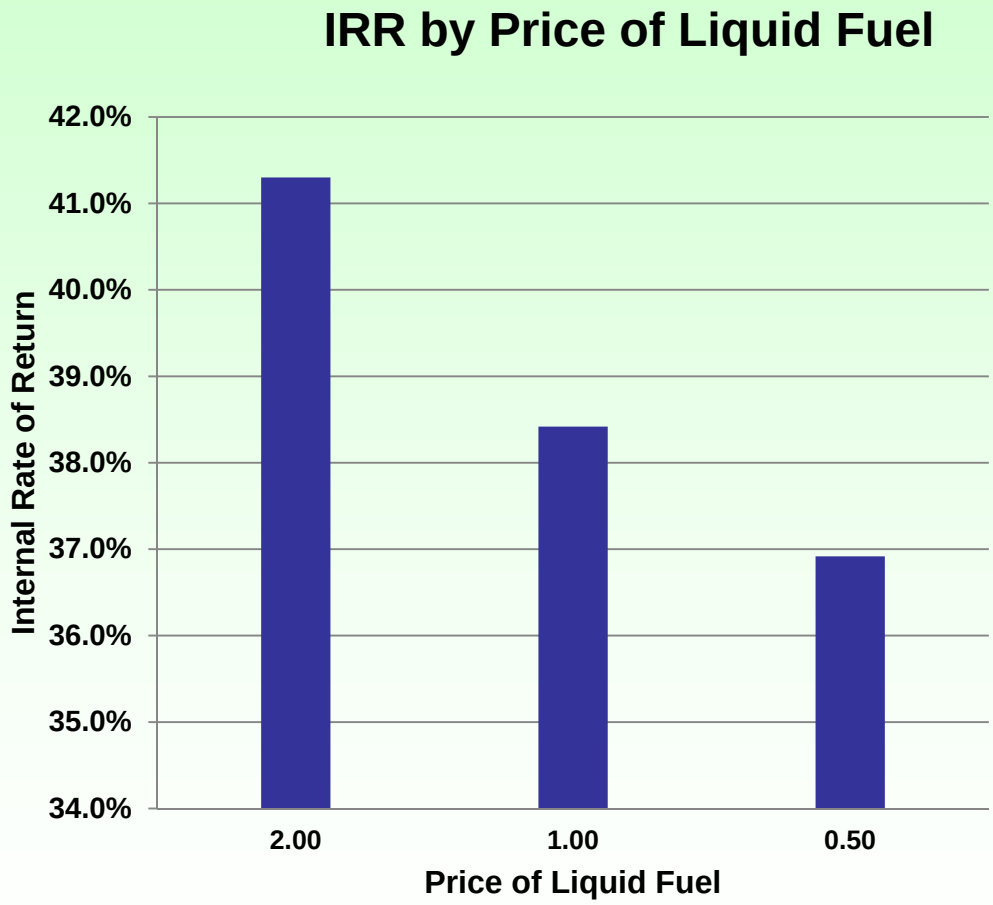
HUMAXX MicGAS™ Coal Biorefinery Produced Aviation Fuel Prices Even at $0.50/gallon Will Produce 37% IRR – Remains Competitive During Falling Oil and Gas Prices



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ORGANIC HUMIC PRODUCTS PRODUCTION PLANT
South Boston, Virginia

PRODUCTS

HUMASORB® ; Multipurpose Pollution Filter

actosol® ; Organic Humic Bio-stimulant/Fertilizer

Actodemil®; a-HAX™ for Safe Destruction and Recycling of Explosive s and Wastes

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Soils are Fourth Largest Storehouse for Carbon

Table 1. Estimated Size of Major Pools of Carbon in the World Carbon Budget

	Trillion kilograms of carbon
Atmosphere (as CO_2)	700
Land	
Biomass	480
Humic substances (expressed as 50% of soil organic matter)	1500-2500
Waters	
Freshwater	250
Marine dissolved and suspended	4150
Sediments	2,000,000
Fossil fuels	10,000

Sources: B. Bolin Science, **196**, 613 (1977); B. Bolin and R. B. Cook, Eds. *The Major Biogeochemical Cycles and Their Interactions*, Wiley, New York, 1983.

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Land Degradation and Water Shortages Threaten Global Food Production – UN FAO, November 28, 2011

- **Global food production is being undermined by land degradation and shortages of farmland and water resources, making feeding the world's rising population – projected to reach nine billion by 2050 – a daunting challenge.**

- **A quarter of the land is highly degraded, while another eight per cent has moderate degradation, 36 per cent is classed as stable or slightly degraded and 10 per cent ranked as "improving."**

United Nations has declared 2015 International Year of Soil.

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Approval of actosol® Humic Acid

A. **USDA National Organic Food Production Program**
October 21, 2002
Allows use of Humic Acid for Growing Organic Foods
Additional Info : www.ams.usda.gov/nop

B. **US Environmental Protection Agency**
June 13, 2003
Approves Humic Acid as Environmentally Safe and Exempts from Tolerance Requirement when Used as an Ingredient (adjuvant, UV protectant) in Pesticide Formulations
Additional Info : www.epa.gov/fedregstr

C. **OMRI Listed (Organic Materials Review Institute)**
February 18, 2005
Additional Info : www.omri.org

D. **South Carolina, DOT**
March, 2012
Approves as Biological Stimulant

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Magic of actosol®

Turf

actosol® creates vegetation in sand dunes

Ocean City, MD

hydroseed mix

hydroseed mix plus actosol®

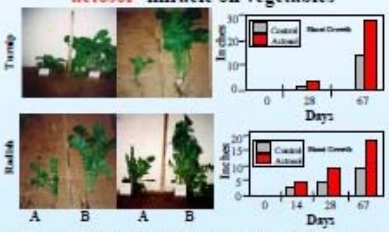
6 weeks growth, Virginia Tech., testing

Floriculture

actosol® brightens flowers

Horticulture

actosol® miracle on vegetables



A - Standard Garden (20-20-20) B - Garden actosol® (10-10-10)

Agriculture

60% increase in soybean yield using actosol®

effect of actosol® on corn plants

actosol® Commercial Products

Bio-activated Base actosol®	-	Humate
Calcium actosol®	-	plus Ca (2%)
Horticulture actosol®	-	plus K(10%)
Potash actosol®	-	plus K (6%)
Garden actosol ®	-	plus NPK (10%-10%-10%)
Turf Booster actosol®	-	plus NPK (20%-5%-5%)
Micronutrient actosol®	-	plus Fe, Mn, Zn, Cu, (total 2%)

Worldwide actosol® Applications

UNITED STATES
- Landscaping
- Erosion Control
- Landfill Closure
- Golf Courses
- Sod Farms
- Nurseries-Tomatoes
- Sand Dunes
- Floriculture
- Agriculture
- Horticulture

GULF COUNTRIES
- Rhodes Grass
- Water Melons
- Cucumbers
- Alfalfa
- Orange Groves
- Grapes
- Onions
- Date Trees

MAURITIUS
- Sugar Cane
- Horticulture

S. KOREA
- Golf Courses
- Greenhouses

For additional information:
visit our web site at www.arctech.com
or contact

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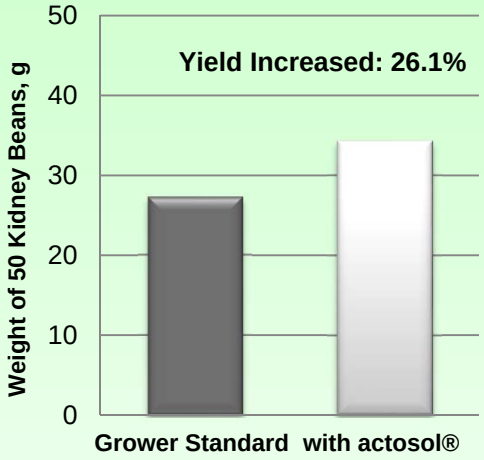
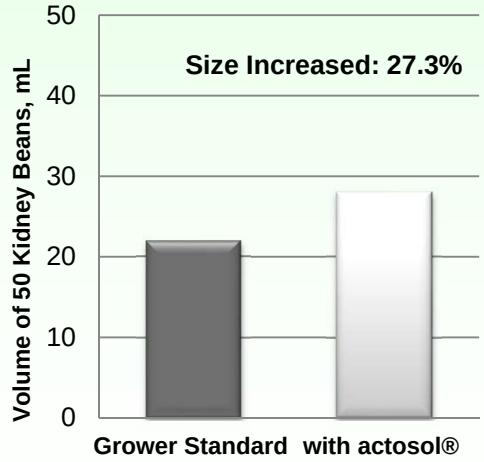
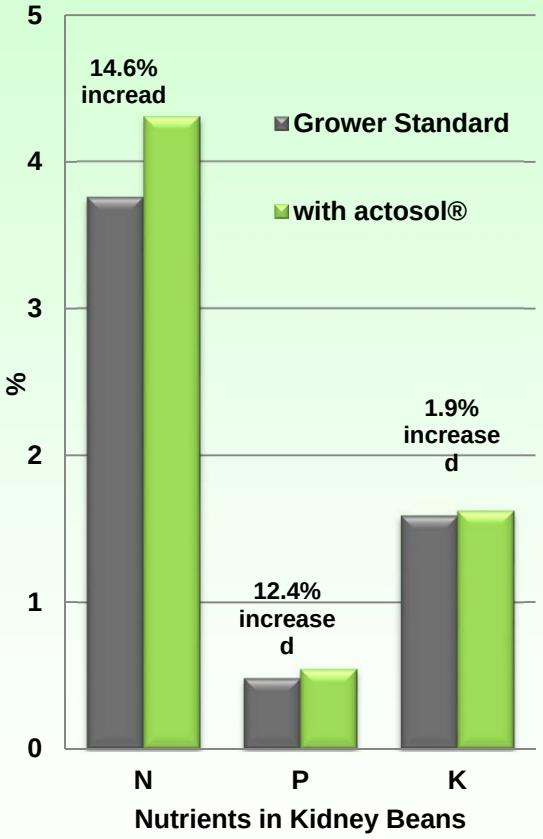
Did use our fertilizer
actosol

Kidney Beans Grown with actosol® by Carlson Farm, MN Showed Increased Yield and Size







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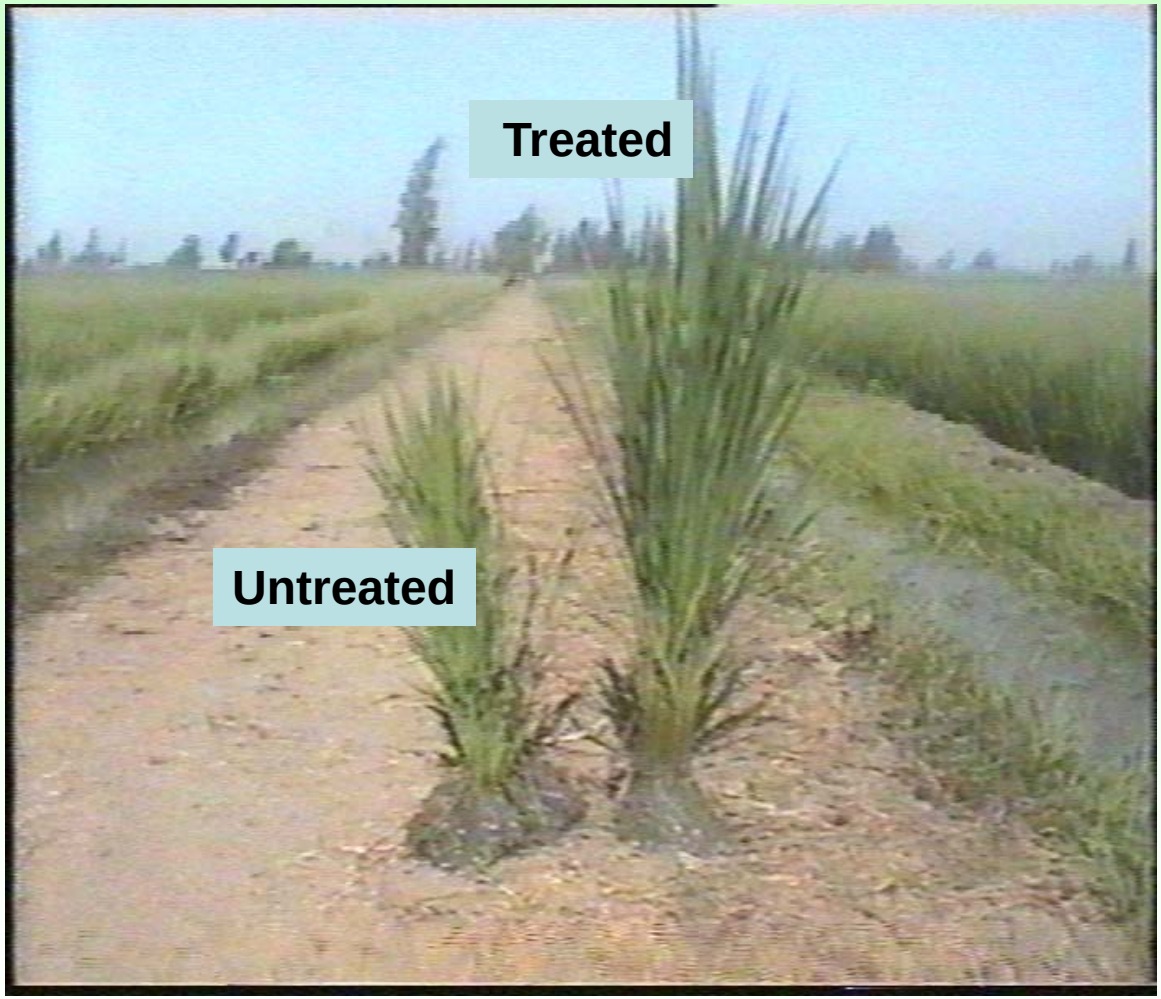
Rice



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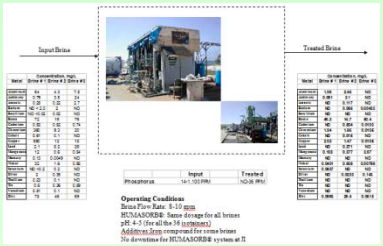
HUMASORB® Product and Technology Applications Proven in Multiple Markets

Military Wastes Applications

HUMASORB®TREATED AND DISPOSED SPENT DECONTAMINATION SOLUTION FROM US ARMY CHEMICAL WEAPONS DEMIL FACILITY AT JOHNSTON ATOLL

US ARMY



- Successfully completed treatment of approximately 24,000 gallons of Spent Decontamination Solution (SDS) that contained RCRA hazardous levels of arsenic, lead and mercury.

DESTRUCTION OF LEWISITE IN TON CONTAINER SLUDGE AND ONSITE SECONDARY WASTE MANAGEMENT AT PINE BLUFF ARSENAL WITH HUMASORB® TECHNOLOGY

US Army Chemical Material Agency and EAI Corporation

- Pine Bluff Arsenal (PBA) has approximately 4,400-Ton Containers (TCs) requiring final disposal. The ton containers were originally used to store variety of chemical agents since almost World War I.
- The micro-scale destruction experiments were conducted by EAI Corporation in 15-mL glass vials with TFE/silicone lined phenolic caps. A total of 24 decontamination reagents were evaluated by EAI, including five (5) HUMASORB decontamination reagents. Only HUMASORB reagents included hydrolysis, oxidation and adsorption mechanisms.
- HUMASORB decontamination reagents were effective even at 100°F compared to other reagents, which required higher temperatures (150 or 180°F).
- The results from the secondary waste minimization tests show that after the HUMASORB® treatment, arsenic levels are reduced to non-detect levels (Detection Limit: 0.6 ppm). The Resource Conservation and Recovery Act (RCRA) limit for arsenic is 5 ppm.

HUMASORB® and Advanced Actodemil® Neutralization Technology for Safe Destruction of Picric Acid and Arsenic

KOBE STEEL, LTD

Table 1. Results of Analyses for Contaminants in the Treated Sample

Compound	Concentration	Regulatory Limit
Arsenic	ND	5.0 mg/L TCLP
Barium	1.3 mg/L TCLP	100 mg/L TCLP
Cadmium	ND	1.0 mg/L TCLP
Chromium	1.3 mg/L TCLP	5.0 mg/L TCLP
Lead	ND	5.0 mg/L TCLP
Mercury	ND	0.2 mg/L TCLP
Selenium	ND	1.0 mg/L TCLP
Silver	ND	5.0 mg/L TCLP
Semivolatile Organic Compounds – None Detected		
Volatile Organic Compounds – None Detected		

- Using the Actodemil® technology for destruction of the explosive material picric acid from aqueous solution and the HUMASORB® technology for the removal of As (V) from an aqueous solution.
- initial concentration of picric acid of 6,600 mg/L. However, picric acid was not detected after treatment with the a-HAX reactant. A summary of the results from the TCLP analyses are presented in Table 1. No organic compounds were detected.

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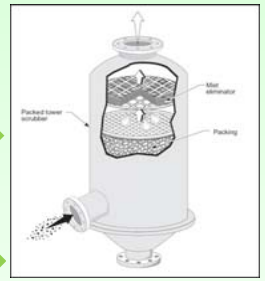
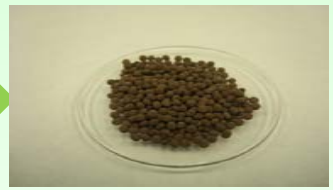
Carbon Dioxide Along with Other Contaminants are Recycled into HUMASORB® Water Filter

CO_2, NOx, SOx, and toxic metals from combustion gases



Gas Scrubber

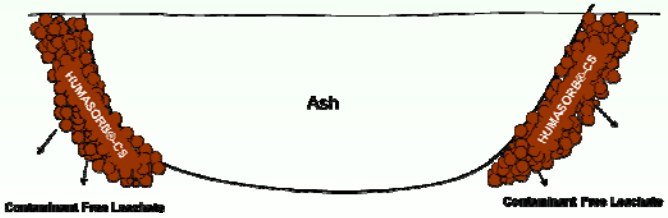
Coal



HUMASORB®-CS

HUMASORB®-CS Feasibility Test for Contaminant of Toxic Chemicals form Ash Pond Leachate

Toxic Metals (mg/L)	Ash Pond Leachate (mg/L)			HUMASORB Treated (mg/L)			TCLP Hazardous Waste Limit, mg/L
	pH3	pH5	pH6.5	pH3	pH5	pH6.5	
As	1.163	1.135	1.580	nd	nd	nd	5.0
Ba	1.220	0.608	0.680	0.011	0.006	0.003	100.0
Cd	0.193	0.183	0.183	nd	nd	nd	1.0
Cr	0.090	0.090	0.095	nd	nd	0.006	5.0
Hg	nd	nd	nd	nd	nd	nd	0.2
Pb	1.055	1.118	1.028	nd	0.052	0.037	5.0
Se	1.165	1.215	1.585	nd	nd	nd	1.0
Ag	nd	nd	nd	nd	nd	nd	5.0
Cu	9.023	nd	nd	nd	nd	nd	
Fe	0.683	nd	nd	nd	nd	nd	
Ni	2.315	1.258	0.193	0.045	0.072	0.011	
Tl	1.345	1.208	1.288	nd	nd	0.045	
Zn	1.003	0.143	nd	nd	nd	nd	



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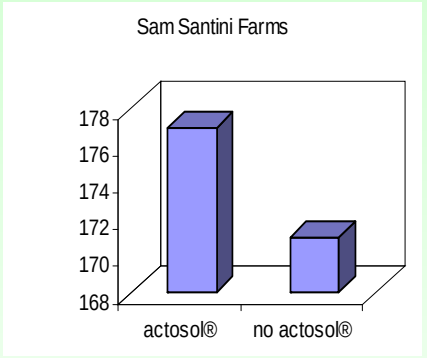
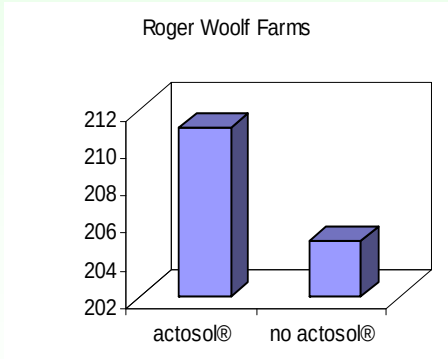
Actodemil® MOBILE TEST UNIT AT McAlester ARMY AMMO PLANT IN OKLAHOMA





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ActoCLEANSE Label

ActoCLEANSE™ is a natural, organic product to meet the demands for healthy & environmentally friendly approaches...

One Step Control of odor from ammonia, hydrogen sulfides, mercaptans, biologicals as well as safe elimination of toxic organics, energetics, & the binding of toxic metals & radionuclides.

ActoCLEANSE™

EcoFriendly General Purpose Industrial Cleaner

CAUTION:
Please apply wearing a protective rain suit, eye protection, face mask, & gloves. In case of contact, flush with plenty of water.

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P.O. Box 323
South Boston, VA 24592 USA
www.arctech.com

KEEP OUT OF REACH OF CHILDREN
NET 55 US GALLONS (213 LITERS) ~ 560 LBS

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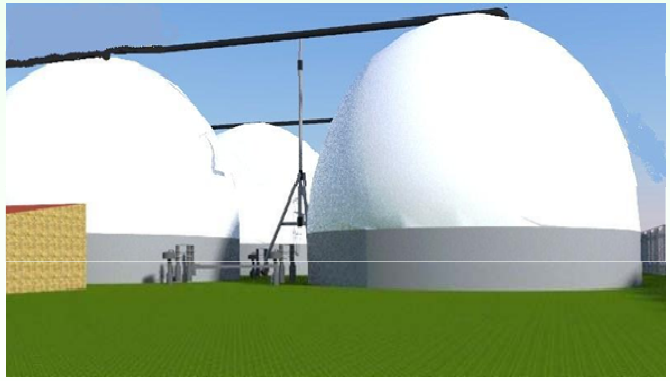
ARCTECH, Inc. USA Envisioned Commercial MicGAS™ Clean Coal Biotechnology Plant



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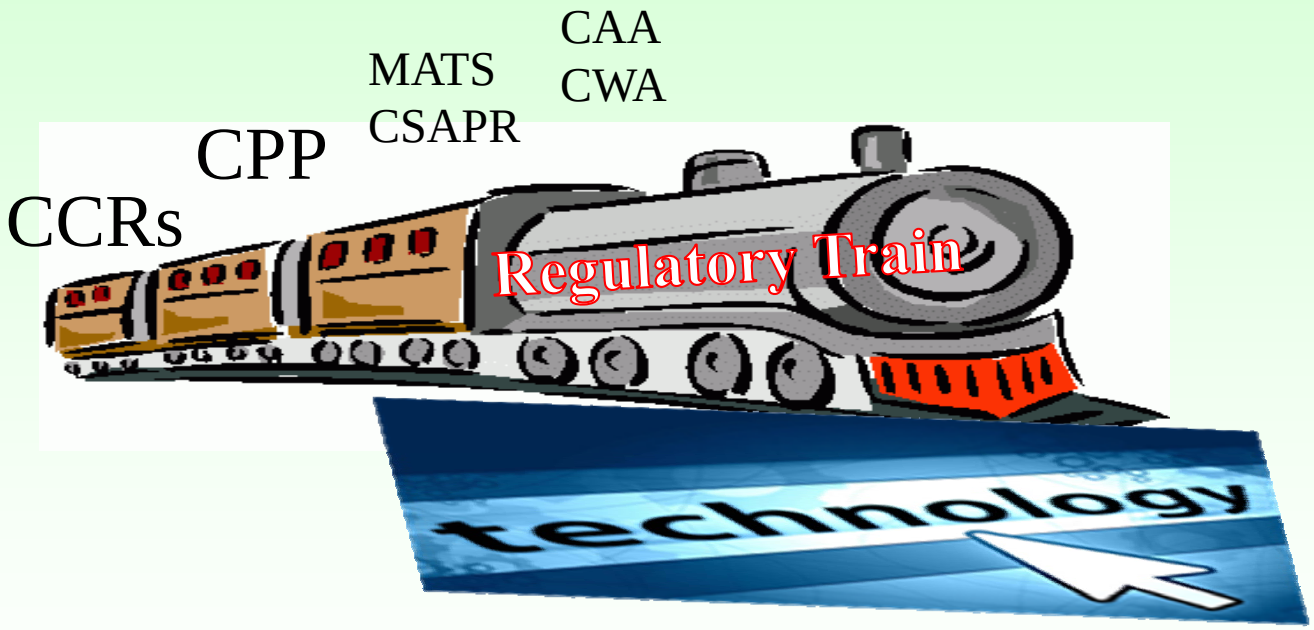
MicGAS Coal Biotechnology Offers Approaches to Catch Up Regulatory Train and Even Get Ahead of It



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