

A Balanced Sustainable Climate Change Solution

With MicGAS™ COAL BIOTECHNOLOGY



October 2021
Updated

Must Have:

Cleaner Air, Water, Food, Energy, Shelter

Desire:

Health, Environment

Wants:

Comfort, Entertainment, Communication,
Information, Transportation

Must Maintain:

Productive Soils, Cleaner Water & Air

Desire :

Sustainability

Wants:

Sustain Other Inhabitants

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“Offering Balanced Sustainable Solutions”

A Balanced Sustainable Climate Change Solution With MicGAS™ CLEAN COAL BIOTECHNOLOGY

In 1995 Vice President Al Gore wrote a book entitled “Earth in the Balance”, highlighting the adverse global changes which have occurred since the industrial revolution and their escalations will result on our very ways of existence. He pointed out consequences of the emissions of greenhouse gases, the increasing loss of topsoil, and the pollution of our environment. He stressed an urgent need for austerity to our human needs and balance with our planet’s ecology. Today, public and worldwide leaders are recognizing a need for global solutions. But many experts are concerned with high costs to the worldwide economies, while meeting critical needs of rapidly increasing populations and the burgeoning economic crisis.

The MicGAS™ biotechnology offers an economic and practical approach of utilizing our vast resources of coals to reverse the adverse global impacts, while meeting “Must Have” needs of humans, planet and ecological balance for its inhabitants: A Balanced Sustainable Solution. Coals, to date primarily are used as fuel or carbon. Huge resources of coals are available to all on the continents, so it is inclusive. It is also the cheapest carbon available to us. Oil and gas are divisive as some have it some do not. Nuclear is threatening as it has shown its horror and adverse environmental impacts, coal products proving out to tame it, renewables are parochial as applicable to certain local conditions; we need to harness.

The MicGAS™ biotechnology converts coals into clean fuels and organic humic products. The primary strategy of the technology is to capitalize on the plant originated coal components to produce highly useful carbon-rich humic products, while bio-converting coals into methane gas for production of affordable, clean energy. The humic matter derived from coals is same as the natural humic component of soil organic matter and is useful for replenishing soils for increased food production, recycling wastes, and cost effectively cleaning our contaminated waters, soils and air. The DOE leadership highlighted this biotechnology approach among the 14 transformational technologies. The Director of Air Pollution Control at EPA has stated that **“this approach lowers the environmental foot-print from coal use and a creative value generation approach for mitigation of carbon emissions”**.

The industrial revolution, which started in mid 1800’s, has been fueled with ever increasing use of fossil fuels, most notably coals. This has resulted into unprecedented economic growth worldwide and has changed forever our relationship with our planet earth. One of the major impacts now recognized is resulting global warming

from build up of greenhouse gases, especially CO₂. The greenhouse effect, by which a small amount of solar heat is retained near the surface of our planet, is critical to maintain the fragile life and ecology. However, unacceptable levels of its accumulation above 400 ppm from avg.250 ppm preindustrial are now causing gradual heating of the planet. This is now resulting in drastic adverse ecological imbalances for inhabitants throughout the world. In 2015, in Paris, for the first time in human history all the Nations entered into an UN global treaty, with a goal to lower global temp. by 1.5 degrees C by 2050 to preindustrial time by reducing emissions of greenhouse gases to net zero. The experts agree with the overall reduction levels but are concerned that this requirement will drive up the cost of electricity and fuels. The climate experts assert that significant rapid reductions are critical to reverse the ecological impacts. Many are still questioning global warming. In spite of the prevailing economic challenges, it has become urgent to address this planetary need now, to avert the adverse impacts already underway in many regions.

With Executive Orders, Obama mandated the EPA Clean Power Plan for rapid reduction of especially CO₂ from coal power plants. But States and Industry objected to high-cost carbon capture technology solution. Trump withdrew from the Paris Agreement, though recognizing need for CO₂ reduction agreed to support planting of 1.2 Trillion Trees to increase CO₂ capture. President Biden recognizing that Climate Crisis is worldwide and a priority national security concern of USA, has rejoined the Paris Agreement. He seeks to eliminate the use of fossil fuels, especially coals, the highest CO₂ producer. These drastic actions will adversely impact USA economic competitiveness, while further loss of jobs. A need for solution for coal continues to be at front and center of the worldwide controversy. Several strategies for CO₂ reduction being considered include improved fuel and energy efficiency, capture CO₂ for reuse and disposal in land and ocean reservoirs and switching to less CO₂ producing fuels. Already a significant progress is being made in improving energy efficiency, but most experts believe that even though it is beneficial, it is not enough to address the problem. The MicGAS™ biotechnology approach sequesters carbon as useful products and facilitate cost effectively and sustainable afforestation, and reforestation of lands to increase CO₂ adsorption resulting in zero to negative carbon footprint and 20-40 X economic value than current approach of coal use.



USGS States USA Coal Fields Contain 250 Billion Tons of Mineable Coals and 9.5 Trillion Tons of Unmineable Coals Sufficient for Several More Centuries.

Coal, being the least efficient fuel in terms of Btu to electric energy, and highest CO₂ producing fuel compared to natural gas and petroleum fuels, faces a serious challenge and increasingly becoming obsolete. Coals are still the most abundant and cost-effective biomass (albeit buried biomass) available today on almost all the continents. Cheap electricity produced with it continues to be critical to alleviate poverty and improve the health of many poor. Sustainability of abundant coal resources in USA as a viable is not only needed to produce low-cost energy, but also to sustain the enormous economic infrastructure which millions of Americans depend upon for employment.

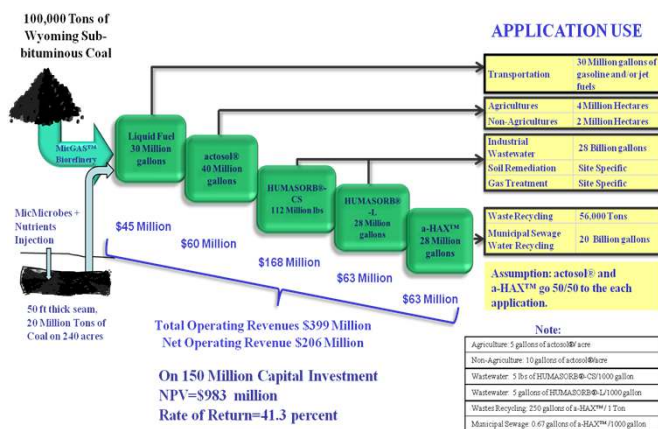
The power industry depended upon coal for its one third fuel and largest market for coal. Today it is rapidly shifting to lower cost and environmentally safer gas and renewables. The conventional method of generating electricity with coal involves spraying finely pulverized coal, along with hot air, into a furnace chamber lined with water-filled coils. Coal burning inside the chamber converts the water in the tubes to steam, which is then used to rotate a turbine-power generator. This process, devised more than a century ago, is termed the “Rankine Cycle”. Use of emissions controls has been mandated to prevent pollutants such as sulfur dioxide and fly ash from being discharged into the atmosphere. However, stringent pollution control mandates by many States, even stop use of coal-based electricity, its use almost decreased 24% in 2020 per DOE-EIA. Projected to further decline as renewables are now competing with coal as well as being mandated by many States. With increasing dependence on vulnerable supply sources of oil, USA attempted in 1970-80’s to convert coals to synthetic fuels utilizing the WWII thermal technologies. But failed because could not compete with falling oil prices. Though these are in use in South Africa for many years due to oil embargo during apartheid to meet domestic fuel needs without regard for economics. Recently, China adopted these, but pollution concerns and economic viability continues to be elusive due to fluctuating oil prices. Expert state need at \$80+/bbl long term to remain viable. Since oil production costs are low but OPEC set production quotas to fluctuate prices. Excessive production and large reserves remain. So long term stable acceptable prices are unlikely. An integration of MicGAS™ with proven methane reforming results in producing liquid fuels at prices, which will compete with made from \$3-15/bbl oil, the real production costs of almost 70% of the world oil.

In one innovative stroke, this technology would mitigate 25% of CO₂ emissions for energy production but also set a path for mitigation of 75% from other industrial and agriculture sources, enabling net zero.

It would:

- **Eliminate further buildup** of CO₂ by capturing it , the use of lower CO₂ producing fuel gas and hydrogen, and indirectly as carbon sink through the pre-combustion sequestration of useful humic acid in soil for enhanced vegetation and algae biomass;
- **Enhance economic growth** though lower cost electricity and fuels, increased food production, and environmental cleanup;
- **Revitalize the coal industry** and enhance national security by maintaining low-cost energy supply from vast domestic coal resources; and
- **Constitutes a “no regrets” strategy for CO₂ control.** If it is determined CO₂ was not the cause, carbon unique to our planet would have been retained for useful purposes while creating economic value.

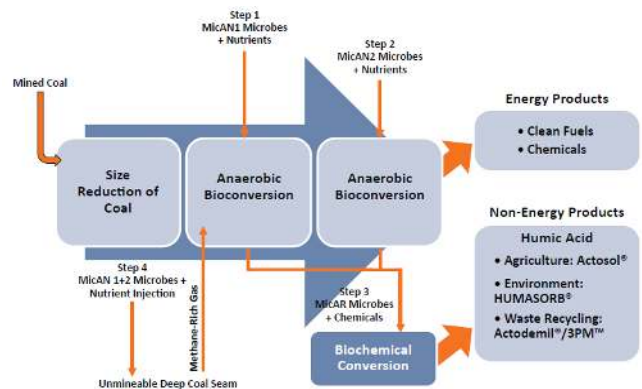
Total Value Chain of MicGAS™ Coal Biorefinery Plant



The innovative MicGAS™ technology is based upon applying natural microorganisms adapted to convert coal into clean fuels under anaerobic conditions. Unlike the conventional coal gasifier, the solid residue from the MicGAS™ anaerobic treatment is not a waste but is rich in organic humic matter. The residual coal from this treatment is further subjected to biochemical process for extraction of humic acid. This valuable byproduct has applications as a fertilizer material and also for environmental remediation. Thus, it results in utilizing total value chain of coals. Applicability proven for coals from USA, China, India, Germany, Australia, Brazil, Turkey, Hungary, Poland, Indonesia and Pakistan.

ARCTECH has developed this technology by adapting wood termites to eat coals and then the microbes isolated from their guts to digest coals in presence of appropriate nutrient components. The process conditions have been optimized, so that the technology can be applied in lower cost sewer treatment plants. The technology has also been adapted for conversion of unmineable coal, shale, residual oil in reservoirs into clean methane gas. Per DOE-EIA, unmineable deep coals globally account for 90.7 % of all the fossil fuels, coal, oil and gas. Thermal UCG tested for harnessing these deep coals have both proven uneconomical as well as field test sites been left polluted with toxins. Still, no viable approach to monetize these largest fossil fuel resources. However, in many coal fields, CBM gas made by natural microbes over geological times had become almost 20%+ supply source of gas in U.S. in 2005. Though now depleting due to lack of optimum natural microbes and nutrients and being abandoned. MicGAS™ Insitu offers to rejuvenate these as well bioconvert non CBM containing deep coal seams. Also eliminates producer water discharge required for CBM production to release gas formed long time ago and trapped in coal seam. With MicGAS™, new gas formed is recovered by pumping water out, releasing the gas and reinjecting the water in coal seam, along with microbes and nutrients in it. Average production is 350 SCF/ Ton/year and can last 30-50 years. Production achieved from mined coals is average 2-10,000 SCF/Ton. Cannot predict only by testing.

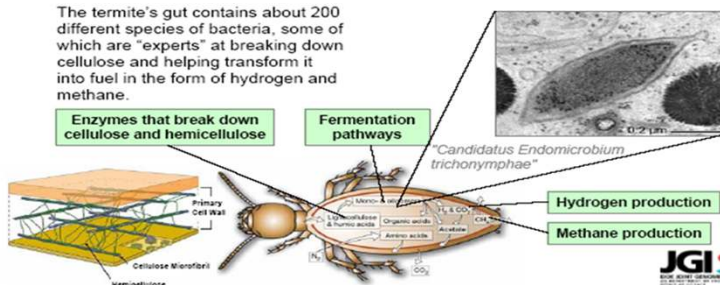
MicGAS™ Bioconversion is accomplished in four major steps. In the first step, the hydrolytic and fermentation process, microbes convert the coal into volatile organic liquids (primarily acetate). In the second step, the liquid from the first step, along with the gases produced, are contacted with methanogenic (“methane producing”) microbes which hydrogenate the acetate and CO₂ to methane. The methane produced is separated and the unconverted residual coal then, in the third step, undergoes a biochemical conversion. In this step, the coal residue is converted into humic acid for formulating into agriculture and environmental products. Fourth step, entails injection of microbes and nutrients into deep unmineable coal seams for production of gas. Depending upon site specific factors, it can be applied only for mined coals or for deep unmineable coals or integrated for both. Though, integrated approach offers highest monetization, as well as competitively priced gas because of higher value realization from humic products. The State of Wyoming in 2011 has passed Biogenic Gas Law for well and reservoir injections to restore or enhance the microbial conversion of hydrocarbon substrates (coal and oil) to methane gas. US EPA allows use of microbes in soils and groundwater for remediation. DOI BLM has established royalty fees for gas produced from unmineable coals.



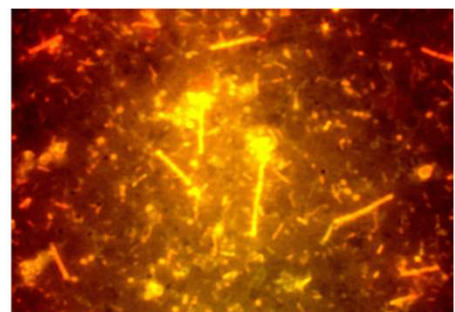
How Nature Does It: Powerful Capabilities of Microbes



The termite's gut contains about 200 different species of bacteria, some of which are "experts" at breaking down cellulose and helping transform it into fuel in the form of hydrogen and methane.



Termite Derived Microbes Bio-converting Coal



In its simpler version, the MicGAS™ converts carbon in coal into two primary components. One is hydrogen rich gas and the second is carbon rich humic acid products. The use of gas in higher efficiency advance power generation systems such as gas turbines and fuel cells, will keep the costs of electricity production low, while reducing the 50% of CO₂ emissions for every unit of power production than today's approach. It also offers path to economical hydrogen with use of the low-cost gas. The use of humic acid for enhanced vegetation, trees etc. will further remove CO₂ from the atmosphere through natural processes. This coal utilization concept is like oil refineries. A barrel of crude oil as a result of cracking and refining provides a multitude of byproducts that are valued several times higher than the price of crude itself. The higher value obtained from the sale of these byproducts (petrochemicals) enables the oil industry to competitively price fuels even if needed below price of crude oil. This business model fostered by Rockefeller with his first refineries producing cost competitive kerosene, even sold below cost to gain large market share, while compensating with profits from high value asphalt. Oil Companies follow his model and making oil must use resource and highly profitable industry. Though the strategy of MicGAS™ follows the today's oil refineries multiple product scenarios, it centers around products based on humic acid products unique to coal. These products will serve large agricultural and environmental market sectors, and thus will not displace the traditional petrochemical products. Also, these can not be made from oil, shale, gas and even biomass, but unique to coals which resulted from humification of biomass over geological times.

MicGAS Coal Biotechnology offers to mitigate emissions of most prevalent greenhouse CO₂ gas both directly and indirectly from both coal use and from other sources as follows:

Directly by capturing CO₂ and other pollutants with use of coal derived humic reagent. The spent humic reagent with bound CO₂ and pollutants is recycled in a water filter product. Thus, enabling permanent sequestration of carbon while deriving economic value by controlling toxic leachates from coal wastes and ash ponds.

Indirectly, the use of coal derived humic acid in soils for improving their fertility for increasing crop yields as well as planting trees even in impaired lands while capturing 3-9 Tons of CO₂ and releasing 4 Tons of oxygen. Note: www.ihccs.org For production of liquid fuels, it offers potential of negative carbon footprint 2-8 tons of CO₂ per barrel. Even at low level, it will result in carbon intensity of sustainable aviation fuel net -200 gm of CO₂e/MJ compared to almost 90 made today from petroleum.

A widespread application of humic acid products is therefore needed to mitigate CO₂ emissions and at the same time create higher value from the vast resources of coals. Thus, ARCTECH has developed several innovative applications of humic acid and proving out for meeting real world needs of both agriculture and environmental markets.

Humic acid is a black to brown, highly functionalized, carbon rich macro-molecule. The structural makeup and properties of this chemical have been the subject of extensive research studies at various universities and research institutions throughout the world. Pre-eminent researchers at three universities (Temple and Northeastern in the U.S. and Birmingham in the U.K.) have offered a breakthrough understanding of the humic acid molecule. They have evaluated humic acid samples from a wide variety of sources and locations in both North America and Europe and have found these materials to be remarkable in not only uniform chemical composition but also similar attributes in terms of ability to capture metal ions. These researchers have put forward a new model structure (TNB Model) of this uniform polymer consisting of repeated units called building blocks. These building blocks are joined together through a peptide-like linkage. Joining four building blocks results into a helical structure. This helix has a central cavity for water, metal and solute binding. The water filled helical model is consistent with properties of different humic acids extracted from many different places.

As a water retainer, metal binder, and absorbent, humic acid is essential to maintenance of fertile soils. Soils are the fourth largest storehouse of carbon as humic substances in our planet after sedimentary rocks, fossil fuels and oceans. Fifth is atmosphere. Not only increasing CO₂ in atmosphere but also stripping topsoils. UN FAO reports worldwide 25 Billion Tons of topsoils eroded every year, 6 Billion Tons in USA. Further state by 2050, soils will no longer remain fertile due to topsoils loss to feed the increasing world population projected to be 9 Billion. Humic acid in soil organic matter is the most stable form of carbon. The versatile characteristic properties of humic acid include: a high cation exchange capacity, the ability to chelate metals, the ability to adsorb organics, a high-water holding capacity, drought and salinity tolerance, and uniquely precipitates at low pH and water soluble at high pH.

Today depleting organic humic carbon in Soils is equally at peril as increasing carbon in our atmosphere.

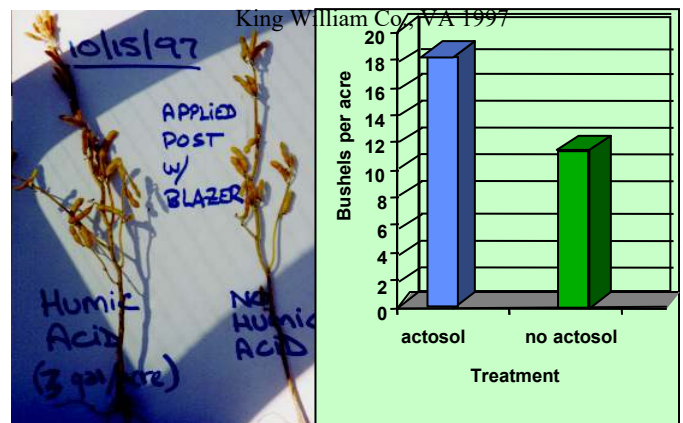
The diverse properties of humic acid make it extremely useful material for increasing yields and nutrition of our food, while enabling organic farming. The environmental applications include cost effective removal of both metal and organic toxins from contaminated waters, CO₂ and pollutants from gases, recycling of industrial wastes, and even the safe disposition of the most dangerous chemical agents and explosive chemicals devised for the military warfare.

It lowers environmental footprint of coal mining; With coal derived products to treat, reclaim wastes and wastewaters including acid mine waters. Enable lower carbon footprint with use of coal derived fuels. Capture and convert coal seam methane to liquid fuels and even monetize coals with MicGAS insitu with microbes.

The MicGAS™ technology provides an approach of pre-combustion sequestration of coal carbon as useful humic acid products for meeting our critical human needs of safe food and clean environmental.

Recognizing the potential for MicGAS™ technology, ARCTECH has built a prototype-production facility to produce humic acid from inherently-humic rich lignite. At this facility in South Boston, Virginia, ARCTECH produces humic acid and formulates it into commercial products. ARCTECH has also conducting several developmental projects focusing on environmental cleanup of the U.S. DOE Weapons Complex, and the safe disposal of DOD munitions.

actosol® fertilizer products are being successfully marketed worldwide. In the U.S. *actosol* is widely used for golf course maintenance, landscaping, erosion control, and for agricultural crops such as corn, wheat, and soybean. *actosol* is also being successfully marketed in the Middle East to enhance growth of alfalfa, palm trees, and other crops grown both in field and greenhouses in the harsh desert climate. In China, South Korea and India, *actosol* has been proving out to increase soil fertility and crop yields and quality in agriculture, horticulture, greenhouse and even in landscaping applications.



Increase In Soybean Yield Using *actosol*®



Without *actosol*®

With *actosol*®

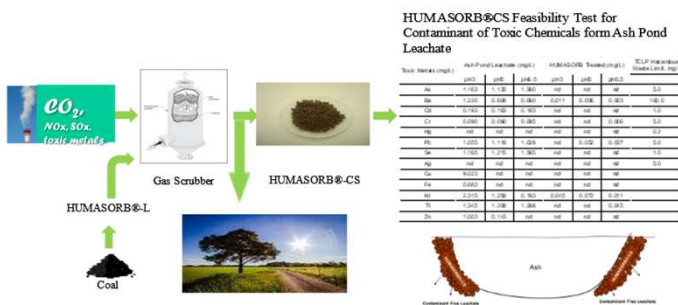
Humic Acid Fertilizer Enables Growth of Vegetation, Even In Beach Sand (Ocean City, Maryland).

Applications of actosol are increasing yields of crops 10-40%.resulting in net value gain of about 2 to 5 times of costs to a farmer. USDA, approves the use of humic acid for organic food production. USEPA FIFRA laws allows use of actosol® humic acid with pesticides as adjuvant and accepts actosol® safe for food production. **actosol®** is also on approval list of OMRI as organic fertilizer. Crop Science Forum&Awards 2021 selected for award improving efficiency of fertilizers and pollutions concerns. ,

Several projects are underway at ARCTECH to implement applications of humic acid products also to meet our challenging environmental needs. A successful development of a novel adsorbent termed HUMASORB®-CS (a water insoluble polymer). This novel adsorbent has been shown to remove both inorganic and organic contaminants in a single step from water at a cost savings of as much as 50% than conventional approaches. HUMASORB®-CS is being emplaced as a subsurface barrier at large groundwater contaminated sites, thus presenting a permanent low-cost solution. Two patents on this highly versatile adsorbent were awarded by the USPTO (#5,906,960 and #6,143,692). USPTO awarded a groundbreaking patent # 901177 for this unique and novel uses of including CO₂ and pollutants capture and recycling into a water filter. Several worldwide patents also been awarded.



HUMASORB-L Capture CO₂ Along with Other Contaminants are Recycled into HUMASORB®-CS Water Filter and Soil Fertility



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

Total Metals (mg/L)	HMF (HUMASORB®) (mg/L)			HUMASORB®CS (mg/L)			ECP (Maximum Concentration) (mg/L)
	As	Cr	Pb	As	Cr	Pb	
As	1.162	1.128	1.391	1.162	1.128	1.391	0.5
Cr	0.222	0.188	0.392	0.222	0.188	0.392	0.5
Pb	0.162	0.162	0.162	0.162	0.162	0.162	0.5
Fe	1.022	1.116	1.024	1.022	1.022	1.022	0.5
Mn	1.122	1.122	1.391	1.122	1.122	1.391	0.5
Ni	0.162	0.162	0.162	0.162	0.162	0.162	0.5
Cu	0.222	0.162	0.162	0.222	0.162	0.162	0.5
Zn	0.222	0.162	0.392	0.222	0.162	0.392	0.5
Co	1.162	1.162	1.391	1.162	1.162	1.391	0.5

Grand Challenge Awarded by Canada, 2014



ARCTECH is also successfully demonstrating applications of its humic acid-based ACTODEMIL® technology for recycling of nitrogen-containing energetics from conventional munitions into usable fertilizers. Now ActoCLENSE is proving out for ammonia and pathogens control in poultry houses.



Actodemil® Unit for Safe Destruction and Recycling of Explosives into Fertilizer

This fertilizer product has met all regulatory requirements and is approved recycling approach per the USEPA Munitions Rule.

The USPTO awarded a patent to ARCTECH # 5,538,530, entitled, **“Method for Safely Disposing of Propellant and Explosive Materials and for Preparing Fertilizer Compositions”**. The U.S. Army selected ARCTECH’s Actodemil® technology for further evaluation for the safe disposal of chemical munitions, which contain both energetics and chemical agents. These applications truly incorporate the philosophy of “swords to plow shares”.

ARCTECH has utilized the Iroquois Indians 7th Generation impacts analysis to ascertain if any future collateral damages and concluded none expected. Rather this approach of coal use would give our future generations a legacy of facing challenges with creative value generating solutions. Widespread deployment of this multi solutions technology requires another “Moon Shot” and by harnessing the strengths of institutions of government, industry and academia to address this common global goal , which otherwise are stove piped.

A fully integrated approach of using coal to produce cost effective energy, enhance agriculture and protect the environment shall mitigate greenhouse effects, win the battle for equity of resources by providing at lower costs the “musts” for us humans, our planet and its other inhabitants. It offers an approach for rejuvenating the Coal fields, establish 3 million jobs and propel the second industrial revolution ...just as steam production from coal combustion helped propel the first industrial revolution in mid 1800’s.

ARCTECH, Inc. is a diversified company that provides technologies, services and products to meet growing needs of clean energy and for preserving the environment. Formed as a spin-off company from the Environmental Science and Technology division of the Atlantic Research Corporation, the ARCTECH group through 30+ years of experience in energy, energetics, environment and agriculture, has created outside the box solutions in these interrelated market sectors. The entrepreneurial scientists and engineers at ARCTECH have pioneered the use of vast resources of coal and coal-derived humic acid products such as actosol® fertilizer; HUMASORB®, a multipurpose contaminant adsorber; ACTODEMIL®, for cost-effective disposal of munitions; ActoCLENSE™, a general-purpose industrial cleaner, and an overall encompassing MicGAS™ technology described herein for production of clean energy while eliminating the build up of greenhouse CO₂ emissions. For additional information about our products and applications, please visit our web site: www.arctech.com

**For more information on the remarkable
MicGAS™ technology and the status of our
projects, please contact:**

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