## A Balanced Sustainable Climate Change Solution For Fast Track To Net Zero Carbon & Enable Must Haves With MicGAS<sup>™</sup> COAL BIOTECHNOLOGY



Must Have: Cleaner Air, Water, Food, Energy, Shelter Desire: Health, Environment Wants: Comfort, Entertainment, Communication, Information, Transportation

Must Have: Productive Soils, Cleaner Water & Air Desire : Sustainability Wants: Sustain Other Inhabitants

November 2023 Updated ARCTECH, Inc. Centreville, Virginia USA 571 338 5005 www.arctech.com



## A Balanced Sustainable Climate Change Solution With MicGAS <sup>TM</sup> CLEAN COAL BIOTECHNOLOGY

In 1995 Vice President Al Gore wrote a book entitled "Earth in the Balance", highlighting the adverse global changes that have occurred since the Industrial Revolution and their escalations will result on our very ways of existence. He pointed out the 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. However, many experts are concerned with high costs to the worldwide economies while meeting critical must-have needs of rapidly increasing populations and the burgeoning economic crisis.

The MicGAS<sup>TM</sup> biotechnology offers a practical approach to repurposing our vast resources of coals to reverse the adverse global impacts, boost economy while meeting the "Must Have" needs of humans, the 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, and renewables are parochial as applicable to certain local conditions; we need to harness.

The MicGAS<sup>TM</sup> biotechnology converts coals into clean fuels and organic humic products. The primary strategy of the repurposing 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 the production of affordable, clean energy. The humic matter derived from coals is the 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 footprint from coal use and a creative value generation approach for mitigation of carbon emissions".

The Industrial Revolution, which started in mid-1800's, was fueled by the ever-increasing use of fossil fuels, most notably coal. This has resulted in 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.

The greenhouse effect, by which a small amount of solar heat is retained near the surface of our planet, is critical to maintaining 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. The World Meteorological Society reports from 1970-2019 more than 11 000 reported disasters attributed to weather hazards globally, with just over 2 million deaths and US\$ 3.64 trillion in losses. In 2015, in Paris, for the first time in human history, all the Nations entered into a UN global treaty, with the goal of lowering 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.

.-President Xi states "Low-carbon ambitions must not interfere with 'normal life'. He seeks to modernize all countries" and work to build a "shared future for mankind." Mitigating carbon and pollution is at the front and center of the strategy. -Poland reports growing "demand for coal even before the outbreak of war" in Ukraine. As a result planning to increase production wherever possible.

-Germany in the wake of the cutback in the supply of energy by Russia is restarting coal plants and reopening c]coal mines. -PM Modi is financing to increase the use of 100 million tons of coal per year in India to meet the increasing needs of the growing population.

-USA Senator John Kerry asked at the recent Davos Economic Forum how to convince people of urgency to move forward to save our planet!

A need for a solution for coal continues to be at the front and center of the worldwide controversy. Several strategies for  $CO_2$  reduction being considered include improved fuel and energy efficiency, capturing  $CO_2$  for reuse and disposal in land and ocean reservoirs, and switching to renewables. Already 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<sup>TM</sup> biotechnology approach sequesters carbon as useful products and facilitates cost-effective and sustainable afforestation, and reforestation of lands to increase  $CO_2$  adsorption resulting in zero to negative carbon footprint and 20-40 X economic value than the 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. Similar hige resources of coal are available in worldwide coal fiels. Coal, being the least efficient fuel in terms of Btu to electric energy, and highest  $CO_2$  producing fuel compared to natural gas and petroleum fuels, faces a serious challenge and increasingly becoming obsolete. Coals are still the most abundant and costeffective 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<sup>TM</sup> 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, it offers inclusive solutions to conflicting priorities and a path to net zero by 2050.

**Eliminate further buildup** of  $CO_2$  with the use of lower CO2-producing fuels from coals.

**Increase capture** of  $CO_2$  by accelerating photosynthesis resulting from increased roots and plant growth with the use of coal-derived humic acid organic fertilizer on farms and forests on managed lands.

**Farming carbon** to feed the world and reach net zero, while rebalancing by taking the excessive carbon from the air and storing in soils

**Enhance economic growth** with lower-cost electricity and fuels, increased food production, and pollution cleanup of air, water and soils.

• **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  $CO_2$  control. If it is determined  $CO_2$  was not the cause, carbon unique to our planet would have been retained for useful purposes while creating economic value.



The innovative MicGAS<sup>TM</sup> technology is based upon use of natural microorganisms adapted to convert coal into clean fuels under anaerobic conditions. Unlike the conventional coal gasifier, the solid residue from the MicGAS<sup>TM</sup> anaerobic treatment is not a waste but is rich in organic humic matter. The residual coal from this treatment is further subjected to a 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 the total value chain of coals. Applicability proven for coals from USA, China, India, Germany, Australia, Brazil, Turkey, Hungry, 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 the presence of appropriate nutrient components. process The conditions have been optimized, so that the technology can be applied in lower-cost plants used for sewer treatment plants. The technology has also been adapted for the conversion of unmineable coal, shale, and residual oil in reservoirs into clean methane gas. Per DOE-EIA, unmineable deep coals globally account for 90.7 % of all fossil fuels, coal, oil, and gas. Thermal UCG tested for harnessing these deep coals have both proven uneconomical as well and field test sites have 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 the U.S. Though now depleting due to lack of optimum natural microbes and nutrients and being abandoned. MicGAS<sup>™</sup> Insitu offers to rejuvenate these as well as bioconvert non-CBM-containing deep coal seams. Also eliminates producer water discharge required for CBM production to release gas formed a long time ago and trapped in the coal seam. With MicGAS<sup>™,</sup> new gas formed is recovered by pumping water out, releasing the gas, and reinjecting the water in the 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 an average 2-10,000 SCF/Ton. Cannot predict only by testing.

MicGAS<sup>TM</sup> 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 CO<sub>2</sub> 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.



In its simpler version, the MicGAS<sup>TM</sup> 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 advanced power generation systems such as gas turbines and fuel cells, will keep the costs of electricity production low while reducing the 50% of  $CO_2$  emissions for every unit of power production than today's approach. It also offers a path to economical hydrogen with use of the low-cost gas. The use of humic acid for enhanced crops, vegetation, trees, etc. will further remove CO<sub>2</sub> 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 the price of crude oil. This business model was fostered by Rockefeller with his first refineries producing cost-competitive kerosene, even sold below cost to gain a large market share, while compensating with profits from high-value asphalt. Oil Companies follow his model and making oil must use resources and highly profitable industry. Though the strategy of MicGAS<sup>TM</sup> follows 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 are unique to coals which resulted from the humification of biomass over geological times.

MicGAS Coal Biotechnology offers to mitigate emissions of most prevalent greenhouse  $CO_2$  gas both directly and indirectly from both coal use and from other sources as follows:

Directly by capturing  $CO_2$  and other pollutants with use of coal derived humic reagent. The spent humic reagent with bound  $CO_2$  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 A widespread application of humic acid products is therefore needed to mitigate  $CO_2$  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.

How humans have damaged soil's ability to provide essential ecological services: Currently, 33% of the world's soils have lost much of their organic matter through the historical expansion of agriculture and pastoralism and subsequent land-use conversion from native ecosystems (e.g., peatlands, forests, grasslands) to arable land. This has resulted in a decline in soil structural stability, increased erosion risks, and reduced water storage and nutrient supplies.

The Green Revolution of the '50s and '60s exacerbated these losses. The massive use of chemical fertilizers and disease control chemicals being produced in WWII factories resulted in a dramatic growth in the global food supply, but the intensive farming this generated, the use of mechanized farming equipment, and runoff have also increased water pollution and soil degradation through the loss of organic matter. Crop yields have accordingly declined in proportion to inputs. Farmers are earning less and less for every unit of the costly chemicals they are applying.

Humic acid is the largest active component of humus in soils and has unique biological, chemical and physical attributes by that interacts with soil minerals, micobes and plants 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 CO<sub>2</sub> 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,  $CO_2$  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 the environmental footprint of coal mining; With coal-derived products to treat and reclaim wastes and wastewater 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<sup>TM</sup> 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 environment.

Recognizing the potential for MicGAS<sup>TM</sup> 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 been conducting several developmental projects focusing on environmental cleanup of the U.S. DOE Weapons Complex, and the safe disposal of DOD munitions. **actosol**<sup>®</sup> 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.









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%.nresulting 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<sup>®</sup>-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 lowcost 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 CO<sub>2</sub> 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



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<sup>®</sup> 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 7<sup>th</sup> Generation impacts analysis to ascertain if any future collateral damages and concluded none were expected. Rather this approach of repurposing coals would give our future generations a legacy of facing challenges with creative value-generating solutions. Widespread deployment of this multi-solution technology requires another "Moon Shot" and 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, and 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, establishing 3 million jobs, and propelling 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 the 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 The entrepreneurial scientists and engineers at ARCTECH have sectors. pioneered the use of vast resources of coal and coal-derived humic acid products such as actosol<sup>®</sup> fertilizer; NutrientENHANCER for coating granular HUMASORB<sup>®</sup>, multipurpose fertilizers. a contaminant adsorber: ACTODEMIL<sup>®</sup>, for cost-effective disposal of munitions; ActoCLENSE<sup>™</sup>, a general-purpose industrial cleaner, and an overall encompassing MicGAS<sup>TM</sup> technology described herein for production of clean energy while eliminating the build-up of greenhouse CO<sub>2</sub> emissions. For additional information about our products and applications, please visit our website: www.arctech.com

> For more information on the remarkable MicGAS<sup>™</sup> technology and the status of our projects, please contact:

> > Dr. Daman Walia President and CEO ARCTECH, Inc. Centreville, Virginia USA Phone: 571 338 5005 Email: dwalia@arctech.com