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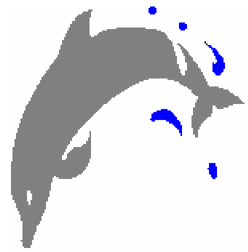
Marketing



BioWastEnergy

A Division of WaterSmart Environmental, Inc.

www.biowastenergy.com

Converting BioWastes Into Green Energy Through Anaerobic Digestion

Prepared for: Website Visitor

About the Company

BioWastEnergy is able to convert municipal solid wastes and animal manure biowastes into energy through anaerobic digestion technology. Anaerobic digestion generates methane gas which is a near equivalent to natural gas. Methane gas can be used as a primary fuel for heating and cooling. This gas can also be used to power a generator to produce **green power** electricity. Other co-products simultaneously produced consist of carbon dioxide gas, organic fertilizer, liquid fertilizer concentrate, and reverse osmosis permeate water, all of which are valuable commodities in the marketplace. The technology can make a farmer or municipality energy and water independent while completely eliminating both lagoons and landfills. All nutrients are always captured thereby preventing their uncontrolled harmful release to the environment. This fantastic technology is being marketed on a build-own-operate basis which eliminates capital costs to the waste generator.

Mission Statement

Our steadfast passion is to eliminate biowastes while generating renewable and sustainable **green energy** and other valuable co-products thus eliminating the potential for air, water, and solids pollution. We are dedicated to the management of biowastes as a valuable resource rather than a monumental and growing burden on society.

Converting Wastes-To-Energy

Is not new! There exist over 50 energy plants in North America that incinerate municipal solid wastes (MSW) in order to produce steam. The steam in turn is beneficially used to drive a turbine to generate electricity. The ever present moisture content in the MSW significantly reduces the efficiency of incineration technology by artificially lowering its Btu content. The incineration method in achieving wastes-to-energy is known as a *dry technology*. Because of the high moisture content of MSW this technology is but barely profitable to its owners.

Landfill gas-to-energy is not new as over 100 sanitary landfills in North America are now using landfill gas (similar to digester biogas) to generate electricity. Landfills produce gas in a manner similar to digesters. Landfills are well known to be highly inefficient generators of biogas.

Municipal digester gas-to-energy is not new as there are over 100 existing municipal treatment plants in North America that are now using digester biogas to generate electricity. Digester gas is capable of providing between 1/3 to 1/2 the treatment plant's electricity requirements.

The OAT™ process of anaerobic digestion is new. The **O**ptimized **A**naerobic **T**reatment process is capable of producing significant excess energy because it is a *wet process* which produces valuable co-products from each and every feedstock.

Did you know that bacteria can change the vast majority of both liquid and solid wastes into methane gas? Methane gas is currently being used worldwide as a fuel for heating homes and industrial boilers as well as running transportation equipment. It can also be converted into electricity. In reality, human, animal, and agricultural wastes represent *renewable and sustainable energy sources*. **The production of useful energy from these wastes represents a preferred environmental solution and an intelligent use of modern technology.**

The specialized bacteria that convert wastes into energy are always used in the OAT™ process of Anaerobic Treatment. Generating fuels and energy is responsible management of wastes. It is also extremely beneficial as ***upwards of 15% of the energy usage of a community can be generated from its own wastes.*** Industrial wastes can easily increase the energy potential to 100%.

In addition to the above economic benefits, the associated *environmental impact* is extremely beneficial because:

- Waste volumes are reduced,
- Waste disposal creates usable energy,
- Waste disposal actually pays for itself with a positive return on investment,
- This type of waste disposal helps preserve the environment for our children, and
- Wastes represent a renewable energy source because they are a natural byproduct of human and animal life.

The OAT™ Process In General

The following brief introduction to the OAT™ process of anaerobic treatment will enable engineers and consultants to learn more about this very special waste-to-energy technology.

The OAT™ process is cutting edge technology. **U.S. Patent No. 5,630,942** was recently awarded to the process. It is now being introduced to several countries.

Liquid wastes that can be treated include both municipal wastewater and industrial wastewaters such as chemical production, distilleries, fish & food processing plants, landfill leachates, paper & pulp mills, and pharmaceutical wastes. Solid wastes can be mixed into the liquid wastes and also treated. These wastes can include cardboard, sawdust, ocean kelp & seaweed, animal manure, and agricultural wastes such as rice hulls, grain stalks/stems/husks, and silage.

New OAT™ process plants can be built for the above applications. It may also be possible to **upgrade** existing anaerobic treatment plants to the OAT™ process. If so, the digester upgrade could easily exhibit a *tenfold increase* in biowaste loading.

The opportunity to convert wastes into energy is quite real. This splendid environmental solution to the effective management of both liquid and solid wastes deserves serious consideration in your waste management planning.

Technical Aspects of the OAT™ Process

The OAT™ Process is the one and only anaerobic treatment process that utilizes:

- Thermophilic Bacteria
- Attached Growth Bacteria
- Two-Phase Digestion
- Staged Treatment
- Flow recirculation
- Nutrient Feed
- Computerized Process Controls

Thermophilic Bacteria

Bacteria occur in three main species, spherical (cocci), rod-shaped (bacilli), and spiral (spirilla). Their actual shapes are frequently referred to as spherical, cylindrical, and helical. They vary widely in size from 0.5 to 15 microns.

There are three temperature groups of bacteria in nature, namely cold, medium, and hot. The cold temperature (about 15°C) group is named *Cryophilic* or *Psychrophilic* bacteria. This group has but little significance in wastewater treatment, as their metabolic rates are very slow. The medium temperature (about 38°C) group is named *Mesophilic* bacteria. Mesophilic bacteria are used in perhaps 95% of all digesters in current use worldwide with the remainder using lower and less efficient temperatures. ***Thermophilic*** bacteria (about 60°C) are just recently being considered, as their metabolic rates are extremely attractive. The metabolic rates of reaction of all microorganisms directly increase with increasing temperature, approximately doubling with each 10°C rise in temperature. ***Thermophilic bacteria therefore exhibit over four (4) times the reaction rates of Mesophilic bacteria.***

Attached Growth Bacteria

Bacteria can accomplish beneficial wastewater treatment in either of two ways. If they are randomly suspended in a liquid they are referred to as *suspended growth bacteria*. If they are attached to a fixed surface such as filter media, plastic media, or fiberglass plates they are referred to as fixed or *attached growth bacteria*.

The bacterial population density of attached growth anaerobic treatment systems is always many times greater than suspended growth anaerobic treatment systems due to the inherent preference of virtually all bacteria to live in an attached growth mode. ***As a result of this cell immobilization, attached or fixed growth anaerobic treatment systems are always significantly smaller and far more resistant to process upsets than suspended growth systems. In addition, initial plant start-up is accomplished much faster due to the quicker colonization of acclimated bacteria.***

Attached growth systems are also known to exhibit much higher organic loading capabilities due to the existence of many more bacterial colonies than suspended growth digesters. More bacteria per unit volume translate into a much greater capability to successfully treat more organic wastes per unit volume.

Understanding Two-Phase Treatment

The aerobic biological treatment process that oxidizes ammonia nitrogen to nitrates is called *nitrification*. Nitrification proceeds in two distinct phases. In the first phase, Nitrosomonas bacteria oxidize ammonia nitrogen to nitrites. In the second phase, Nitrobacter bacteria oxidize nitrites to nitrates. Both phases are carried out in a single compartment or vessel. The optimum microbiological environment as defined by pH, ORP or oxidation/reduction potential, alkalinity, temperature, chemical oxygen demand, biochemical oxygen demand, etc.) at which maximum phase performance occurs **is identical** for both such bacteria species.

In anaerobic treatment there also exists two distinct phases. In the first phase, called **acidogenesis,** facultative acid-forming organisms reduce complex organic matter to organic acids. The anaerobic mechanisms consist of:

Anaerobic Respiration consisting of sulfate reduction and denitrification:

- Sulfates are reduced to sulfides while nitrates are simultaneously reduced to nitrogen gas
- Substrate is converted to minerals
- Cytochromes and enzymes are oxidized
- Electron transport produces energy for metabolism

Fermentation (electron donors and electron acceptors are organics)

- Substrate is transformed to organic intermediates
- Carbohydrates are oxidized
- Acetogens produce organic acids
- Yeasts produce alcohols and CO_2

In the second anaerobic treatment phase, referred to as **methanogenesis**, methane-forming bacteria convert the organic acids to methane gas and carbon dioxide (called biogas). Some of the carbon dioxide produced is also converted to methane gas through biological **methanation**. The larger the average acid molecule the greater the conversion to methane gas and vice versa.

Unlike aerobic nitrification, however, each above referenced anaerobic bacteria species exhibits an optimum microbiological environment that differs, and differs substantially, from the other. Consequently, *optimum anaerobic performance cannot possibly be achieved in a single-phase anaerobic digester or reactor.* Using both species of bacteria in the same reactor vessel automatically retards the efficiency of the other! This reality has been mostly ignored or misunderstood by anaerobic treatment researchers and anaerobic treatment system manufacturers. As a result, ***almost all of the world's existing anaerobic digesters are designed as highly inefficient single-phase reactors.***

Staged Treatment

The OAT™ process also uses two stages of treatment in both anaerobic phases thus greatly increasing overall system performance. Since both aerobic and anaerobic treatment processes closely follow first order reaction kinetics, the more the stages the greater the process efficiency.

Nutrient Feed

Inadequate nutrients promote the growth of Methanothrix bacteria that exhibit a low specific activity. Adequate nutrients promote the growth of Methanosarcina bacteria that have a specific activity *five times greater*. Since the methane gas phase is rate limiting, any process improvement translates into a significant positive enhancement of the total process. Since nutrient addition also supports better acidogenesis, nutrients are added to both first and second phases.

Stage Flow Recirculation and System Process Controls

Generous flow recirculation within each stage of treatment further increases process performance, as attached growth systems must await the arrival of food at their fixed locations before they are able to feed. Flow recirculation accomplishes that delivery requirement. Lastly, precise process controls keep the microbiological environmental conditions at their respective optimums thus achieving maximum and consistent process treatment.

OAT™ Process System Start-Up

1. Fill the several reactors from any water source.
2. Start all recirculation pumps.
3. Heat all reactors to approximately 38°C.
4. Initiate chemical feed pumps to adjust the pH in each stage of treatment.
5. Seed the first phase reactors with mesophilic sludge from another digester.
6. Add a blend of selectively adapted bacterial cultures (provided by the OAT™ Process vendor) developed to degrade a wide variety of industrial wastewaters.
7. Fill the first phase digesters only with the feedstock to be treated.
8. Slowly (2-3 days) raise system temperature to 60°C.
9. Every two days thereafter add sufficient feedstock to again fill the first phase digesters.
10. In approximately 10 days gas production will begin in the first phase and in 15 days the second phase as well.
11. After gas production has started in both phases, wait five (5) days. Feedstock addition to the OAT™ process may then be increased to 25% for 3 days, 50% for the next 3 days, and then 3 days later to 100% capacity thereafter.

Within 3 weeks the plant should exhibit 100% treatment efficiency as determined by BOD/COD and Volatile Solids reductions coupled with biogas generation.

Miscellaneous Matters

The amount of sludge generated from the OAT™ process is approximately 0.01 kg/kg of COD removed. Aerobic treatment processes, by comparison, generate about 0.40 kg/kg of COD removed or 40 times as much.

The quality of sludge generated from the OAT™ process is excellent in that the fecal coliform count is less than 150 MPN/g. This easily qualifies the sludge as a Class A biosolids and a soil conditioner/amendment or a potting soil.

In single-phase digesters (this type of digester represents 99% of all active digesters in current use worldwide) all gasses generated are automatically commingled. Methane gas usually averages 65-70%. By comparison, the first phase OAT™ digesters generates mostly CO_2 with a minor amount of nitrogen gas whereas the second phase digesters generate mostly CH_4 along with very little CO_2. Since the first phase gasses are automatically segregated from the second phase, the resulting methane purity will be 85-95% depending on the type of wastewater feedstock being treated.

The beneficial use of the methane gas generated is strongly recommended as it represents a positive return on investment. In fact, owners of OAT™ process plants are encouraged to maximize treatment capacity thereby enhancing the production of methane gas and the significant commercial value it represents.

Using Energy From Wastes

Several types of ordinary renewable wastes may be biologically converted into methane gas. The gas can be used as a primary fuel to power boilers, furnaces, mechanical equipment, or to heat domestic homes and businesses. Additionally, it may also be used to power an electric generator to generate electricity. The wastes that qualify for conversion into methane gas include municipal solid wastes (MSW), human and animal wastes, food wastes, green wastes, high strength industrial liquid wastes, and all other biowastes. The process that makes this possible is highly specialized anaerobic treatment that generates much more gas than ordinary conventional high rate digestion. This specialized anaerobic treatment process also produces Class A biosolids that easily qualify as an organic fertilizer for land application as a soil conditioner or soil amendment or as a potting soil.

The energy produced is far greater than that required to operate the plant making ***energy from waste*** a profitable ongoing activity. Rather than a burden on society, many typical wastes may now be considered an **asset**—an incredible reversal of common perception.

Solid waste landfills have been generating methane gas, also called landfill gas or biogas, for many years. It is no secret that landfills are filling up faster than new ones can be built. They invariably pollute groundwater aquifers thus preventing their continuing use as a source for drinking water. In an effort to eliminate the impact on groundwater pollution, it is now increasingly standard practice worldwide to collect and treat the landfill leachate prior to discharge.

And to prevent the continuing discharge of methane gas into the atmosphere, landfills now convert the biogas into carbon dioxide and water vapor by thermal combustion, a practice called waste flaring.

Several companies saw the production of landfill gas as a waste-to-energy business opportunity and entered into DBOO (design, build, own, and operate) contracts to generate electricity for profit. Unfortunately, the biogas invariably disappears in 5-10 years thus making the DBOO effort unprofitable.

Other companies have seen municipal solid wastes (MSW) as yet another waste-to-energy business by incinerating the waste (after waste sorting, called classification) and using the waste heat to run steam turbines in the production of electricity. This business has proved to be mediocre at best as the classified waste, although renewable, has a low Btu content. Only a few companies engage in this worthwhile activity. All report disappointing returns on their investment due to the highly inefficient technology used in converting solid wastes into energy.

Bacteria play a vital role in converting waste to energy. The same bacteria that produce methane at the landfill are used in the anaerobic treatment process to treat wastewater. But sadly, only a few thrifty municipal treatment plants are converting their digester gas (biogas containing 65-70% methane) into energy rather than flare wasting this valuable fuel. Those that do are typically reducing their total wastewater treatment plant energy costs by one third to one half. As attractive as this is it represents but the tip of the iceberg.

Traditional anaerobic treatment processes, frequently referred to as conventional high rate (CHR) treatment, **are extremely inefficient at producing methane gas.**

Conventional anaerobic treatment consists of a single vessel suspended growth digester at about 35º C (95º F). It is well known that the routine operation of anaerobic digesters requires very close attention as the continuing adjustment of pH and alkalinity is process demanding.

The most significant underlying reason is that two independent biological steps, or phases, are occurring simultaneously within a single fermentation or digestion vessel. In the first phase *hydrolytic* and *acidogenic* bacteria convert dispersed and dissolved organics into aldehydes, alcohols, acids, and carbon dioxide (called acetogenesis). In the second phase, methanogenic bacteria convert the 1st phase intermediates into mostly methane gas (called methanogenesis).

The first phase digestion is optimized at a pH between 3.8 and 4.5 at an ORP (oxidation/reduction potential) between +200 to +300mV whereas the second phase is optimized at a pH between 7.2 and 8.2 at an ORP range between -400 to -450mV. When both such steps occur in a single vessel at a single pH and a common ORP an anaerobic digestion reactor always operates at a **highly depressed level** of process efficiency. By isolating these independent biological phases, one significantly optimizes the process efficiency of each thus greatly enhancing overall system performance while greatly reducing the total size of the anaerobic digestion equipment.

Other significant improvements available to CHR anaerobic treatment technology consist of:

- Utilizing attached growth rather than suspended growth bacteria. This modification greatly decreases the total reactor size because of the inherent ability to accommodate up to a five-fold increase in active bacteria population when compared with traditional suspended growth anaerobic digesters,
- Employing thermophilic bacteria at 59°C (138.2°F) that are capable of metabolizing organics at four times the rate of mesophilic bacteria. This higher temperature permits a further reduction in the size of the digestion equipment as well as the associated HRT (hydraulic residence time).
- Staged treatment which increases process efficiency,
- Flow recirculation to further increase process efficiency by reducing the size of the required reactor vessel,
- Process controls and instrumentation to achieve environmental conditions that permit the several biological reactions to be optimized rather than obstructed, and
- The continuous addition of essential micronutrients to enable anaerobic biology to reach its ultimate and remarkable effectiveness.

Anaerobic treatment digesters which take advantage of the several process improvements available are fully capable of treating **ten** times as much waste (on an organic loading basis) as an equivalent sized CHR digester vessel.

Conventional anaerobic treatment has been commercially practiced for the last sixty years. Process improvements have been slow to develop and unimpressive. Researchers and anaerobic treatment equipment manufacturers worldwide have been consistently troubled by the complexity of the biology as several biochemical reactions are always occurring simultaneously.

Research reports frequently cite plant start-up problems associated with the lowering of the pH so as to diminish methane production. The remedy was always to raise the pH to favor the methanogenic or methane producing biology. In so doing, the higher pH also suppressed the performance of the several acidogenic reactions. Both such reactions work entirely without artificial restraint when they are separated from each other and permitted to function at their individually preferred pH and ORP. This method is referred to as **two-phase treatment** and looks to rapidly become the dominant process of anaerobic treatment.

This single anaerobic treatment process refinement is far from the penultimate however as the several additional improvements of flow recirculation, fixed growth bacteria, staged treatment, and nutrient addition described above also play an invaluable role in achieving levels of treatment efficiency thought unattainable until now. Fortunately most existing CHR plants can be upgraded to take advantage of the several process improvements available.

Energy from waste can indeed be achieved using conventional CHR technology. Any such program would likely be as unsuccessful as the landfill methane gas-to-energy or MSW-to-energy incineration efforts previously discussed. Elevating waste-to-energy technology to a successful commercial operation with a positive ROI (return on investment) is, however, now possible. This environmentally attractive business concept also requires energy awareness on the part of governments and civic leaders that most renewable wastes may be biologically processed to produce fuel. India, for example, has created an alternative energy initiative that promotes the production of energy from sources such as waste and waste products. In a country where low energy using fax machines are frequently turned off at night to conserve electricity, this speaks volumes. In China, electricity shortage is retarding industrial growth. Since all countries produce renewable wastes, all can significantly benefit from the conversion of wastes into energy. By adopting such a program a society's wastes become a valuable asset rather than a further burden on the world's already polluted rivers, lakes, streams, and aquifers.

Developing countries are always far more concerned about potable water for its populations than the management of its wastes. When the impact of ignoring waste treatment results in polluted rivers, lakes, and aquifers, one's attention then becomes focused on treating society's wastes. These wastes are invariably in large supply whereas energy is frequently in short supply. Converting these surpluses of waste into energy makes good environmental sense. The generated energy creates significant economic development.

Recognizing the true potential of converting wastes into energy is long overdue. It can and perhaps should be accomplished during the next 25 years for our children's benefit as well as the earth's extremely stressed and fragile environment.

Marketplace Applications

1. **Biowaste Energy Regional Industrial Parks**

WaterSmart Environmental, Inc. announces a breakthrough in the technology of managing municipal solid waste (MSW). Rather than sending MSW to distant landfills, municipalities may now utilize a local or regional industrial park which immediately processes the wastes on arrival. Other than maintaining a "digester ready pile" to satisfy continuous feedstock addition, no wastes will be stored. Ferrous and non-ferrous metals are removed and the remaining constituents are anaerobically digested producing the several co-products of methane gas, carbon dioxide gas, organic fertilizer, liquid fertilizer concentrate, and reverse osmosis permeate water. The methane gas may be sold to the industrial park businesses and/or converted into electricity. The carbon dioxide can be purified, liquefied, and sold to local distributors. The organic fertilizer may be sold as a soil amendment or soil conditioner. The liquid fertilizer concentrate may be sold to fertilizer dealers. The reverse osmosis water may be used by the park businesses as boiler water make-up, for fresh fish farming, or for aquifer or reservoir recharge where drought conditions impact on local water resources. The removed metals are also sold. 100% of the MSW is beneficially recycled and none is sent to any landfill. Expensive source waste separation may be continued but is not required. The recycling of glass and plastics has become an expense rather than a profit due to the increased sorting, handling, storage, and transportation costs along with the continuing decline in their market value. Cities that embrace this technology can claim a zero-waste-to-landfill community. They can also actively attract new industrial development.

The parks will be developed and the wastes will be managed by **Biowaste Energy**. Since the business model is satisfied by the profits made on the co-products produced, very attractive tipping fees may be offered to attract MSW and other area wastes. Other eligible biowastes include municipal sludge, green wastes, food wastes, animal wastes, industrial wastes, liquid organics, and solid organics.

2. **Bicycle™ Process for Drought Control and Nutrient Capture**

The southern half of Florida is now experiencing severe saltwater intrusion due to over pumping of its massive aquifer system. Within the next 10 years extensive use of expensive seawater desalination will have to be implemented in order to produce potable water. The Upper Floridian aquifer isn't far behind. Seawater intrusion is also occurring extensively in California and other coastal cities.

The bicycle process™ can permanently eliminate both seawater intrusion and landfills at the same time. Because there is so much value in wastes, the technology can be provided on a *no-capital cost basis* to the impacted communities. After implementation each community become a *zero-waste-to-landfill* society.

The State of Pennsylvania has over 100 municipalities which discharge excess nutrients into the environmentally stressed Chesapeake Bay. The bicycle™ process captures and manages nutrients. Pennsylvania has over $280 million available through the Pennsylvania Infrastructure Investment Authority (PENNVEST) for loans and grants to fund water, sewer, and stormwater infrastructure upgrades.

Drought control can also be achieved by utilizing the bicycle™ process in the same manner that seawater intrusion and aquifer recharge are implemented. The extended drought of 1998-2002 has exposed serious weakness in the nation's water resources. Extensive studies are now underway to mollify future droughts.

3. **Concentrated Animal Feeding Operations**

Corporate production of beef, swine, and poultry have generated problematic wastes resulting in significant environmental damage. The same can be said about larger dairies, especially in California. Liquid manure spreading on cropland is widespread resulting in extensive nitrate pollution of groundwater and excessive TMDL discharges. High nitrates have an adverse impact on animal reproduction.

The cutting edge Optimized Anaerobic Treatment (OAT™) Process not only provides highly efficient and cost-effective treatment of animal wastes, it goes a step further and converts one co-product of that treatment, biogas, into a usable, and sustainable fuel source. With the OAT™ Process the burden of waste treatment is turned into an asset.

Additional treatment equipment is supplied to capture ammonia-nitrogen, ortho-phosphates, and potassium nutrients as liquid fertilizer. The fully treated effluent is recycled as potable livestock drinking water. The residual sludge qualifies as Class A biosolids thus enabling its beneficial use as a soil conditioner or an organic fertilizer.

4. **Sustainable and Renewable National Energy Independence**

Only a few very well known countries currently enjoy energy independence**.** Every single country throughout the world, however, has the inherent ability to achieve complete and lasting energy independence on a renewable and therefore sustainable basis. This may be accomplished by adopting the simple agricultural approach of growing vegetable oil crops for the purpose of refining biodiesel fuels. The climate, size, and geographic location of a country are nonfactors if vegetable oil farming occurs within multistory greenhouses that utilize artificial lighting. Biodiesel fuels may be refined to produce heating oil, jet fuel, and vehicle transportation fuels as well as lubricating oils and greases.[1] Traditional fossil fuels may well become obsolete when greenhouse farming coupled with biodiesel refining produce biofuels at a lesser marketplace price than petroleum distillates.

Vegetable oil was used as a diesel fuel as early as 1900 when Rudolf Diesel (1858-1913) demonstrated that a diesel engine could run on peanut oil. The name "biodiesel" was introduced in the United States in 1992 by the National SoyDiesel Development Board (Now the National Biodiesel Board) which has pioneered the commercialization of biodiesel in the U.S. To his significant credit, Diesel invented the first biodiesel fuel as well as the first *compression ignition* type engine which now bears his name. Diesel engines are far more efficient than gasoline engines in that for every 100 gasoline miles a diesel engine delivers 170 miles with the same payload.

Biodiesel is a completely natural and renewable fuel which may be substituted wherever and whenever petroleum diesel is used. Even though diesel is part of its name, there are no petroleum or other fossil fuels in biodiesel. Biodiesel is 100% vegetable oil based and may be made from animal fats, recycled cooking oil, and all virgin vegetable oils. During the past decade this renewable biofuel has been rapidly gaining worldwide popularity as an alternative energy source because of its many performance and environmental benefits. It is formed by removing the triglyceride molecule from vegetable oil in the form of glycerin. Biodiesel biofuel consists of very simple long-chain hydrocarbons which contain no sulfur, ring molecules, or aromatics associated with fossil fuels. Biodiesel is made up of almost 10% oxygen making it a naturally "oxygenated" fuel. At this time the marketplace price of biodiesel is about twice that of petroleum diesel. Its use is therefore limited to the blend market which consists of a 2-20% blend of biodiesel with petrodiesel to improve the environmental performance of the combined fuels. In order for biodiesel to compete head-on with petroleum diesel its marketplace price must be reduced below that of petroleum diesel.

The efficiencies of vegetable oil farming and biodiesel refining are eligible for enormous improvements by adopting a comprehensive holistic material processing approach to both. It is the combination of these improvements which can lead to an approximate fivefold decrease in the production cost of biodiesel. Here's how.

Vegetable oil farming can be significantly improved by utilizing multistory greenhouses and artificial lighting. The greenhouse environment enables complete control of soil matrix, humidity, lighting, temperature, ventilation, nutrient control, soil moisture, pests, and weeds. The result is four or more crops/year in the case of soybeans with virtually no vegetable oil loss due to growing conditions. Pesticide use can be totally eliminated as a practical matter. By utilizing economical multistory concrete construction, the volume of vegetable oil may be increased as desired by adding more floors. After each soybean harvest, significant quantities of agricultural debris remain as solid wastes. The agricultural debris is managed as an energy crop. If the soy oil is extracted utilizing steam, highly efficient vegetable oil extraction is achieved. Steam extraction produces a high organic strength liquid waste stream. A 100 acre 12-story greenhouse would support the production of about 225,000 GPY of biodiesel and the generation of about 36,000 kWh/day of excess electricity to place the technology into economic perspective. Larger greenhouses would tend to be more productive and efficient because of the economies of scale.

Biodiesel refining can be immediately started with the already hot vegetable oil thus eliminating a heating step. After refining, the 20% remaining glycerin represents a waste stream as there is already a growing worldwide glut of this byproduct. The Btu content of the finished hot biodiesel can be captured for greenhouse heating purposes.

The Institute of Gas Technology[2] (now known as the Gas Technology Institute) is the organization that first developed two-phase anaerobic digestion technology. Two-phase anaerobic digestion produces the three co-products of methane gas, carbon dioxide gas, and organic fertilizer. WaterSmart Environmental[3] further improved two-phase anaerobic digestion by adding the two co-products of liquid fertilizer concentrate and reverse osmosis permeate water.

Making electricity, steam, methane gas, organic fertilizer, and water is achieved by the two-phase anaerobic digestion of:

- The agricultural debris and already hot high organic strength liquid waste stream from vegetable oil farming and
- The already hot glycerin from biodiesel refining

The methane is used to generate electricity and to fuel the steam boiler. The waste heat from the electricity generator is beneficially utilized to make additional steam. Before using the steam for oil extraction it is routed through a steam turbine generator to make additional electricity thus accomplishing highly efficient combined cycle electricity generation. The liquid fertilizer concentrate is beneficially utilized by recycling it back to the vegetable oil farm. If soybeans are grown as the vegetable oil crop the ammonia-nitrogen is stripped out and sold since soybeans fix their own nitrogen requirements. The pathogen free organic fertilizer is recycled as soil matrix. The hot exhaust gas from the methane gas generator is routed though catalytic converters to oxidize the carbon monoxide to carbon dioxide. The hot CO_2 and NOx gasses are beneficially used for greenhouse heating and to enhance plant growth. While generating electricity, carbon dioxide and water are always combustion products in the ratio of 1 mole of methane (or its chemical equivalent) to 2 moles of water. This is the equivalent of 1 gram of methane to 2.25 grams of water. The capture of water through dehumidification equipment makes each biodiesel production facility water independent on a sustainable basis. Each one megawatt of electricity generation (24 MWh/day) permits the capture of about 3,200 gallons/day of combustion produced water vapor. Some of the carbon dioxide gas can be used as a refrigerant for cooling purposes. Each co-product from two-phase anaerobic digestion and electricity generation is beneficially used. None is discharged to the environment or wasted. As an approximation, the energy attributable to electricity generation is about three times that represented by the finished biodiesel. Each biodiesel refining facility therefore becomes a significant generator of electricity on a distributed basis.

The same greenhouse complex may be expanded to grow a variety of vegetables and flowers; for fresh water fish farming; and for pigs, dairy cows, beef cattle, and poultry production. Required odor control is achieved by utilizing the odor laden air as combustion gas intake air thus accomplishing thermal destruction of all odors. Reverse osmosis permeate water is recycled as excellent livestock drinking water. Biodiesel refining site animal food processing may also be accomplished since 100% of the associated waste products may be added to the anaerobic digestion process. Lastly, portions of the same greenhouse may be dedicated for employee housing since all utilities are readily available from the biodiesel refining process to achieve total climate control. Sufficiently expanded into produce, fish, and animal production, distributed biodiesel refining facilities may be viewed as providing food independence as well as energy and water independence.

Prime real estate is never ever required as the biodiesel refining facilities may be located on the high plateaus of Tibet, within the jungles of Bangladesh, and at landfills in Europe, the United States, and elsewhere. The geographic considerations include:

- Installation of power transmission lines to utility grid
- Installation of water pipe lines to use locations
- Installation of roads for transport of liquefied carbon dioxide, biodiesel, and food

Once the electricity, biodiesel, and food satisfy market demands within the country of use, excess electricity, excess biodiesel, excess water, and excess food may each be managed as quite profitable export products.

Anaerobic digestion is old technology having been around for several centuries, especially in China. The cited improvements in this article coupled with the beneficial, comprehensive, and holistic management of waste products are cumulatively responsible for achieving energy independence on a sustainable basis. All of the supporting science already exists. The proposed energy independence, in turn, can wholly support the future massive industrial growth that is now but gradually occurring throughout Asia. Compliance with the Kyoto protocols occurs automatically as the biodiesel refining and electricity generation technologies are both environmentally benign. Many permanent jobs are created as are export opportunities. Governmental subsidies are not required as the technology manifests a quite positive return on investment. There are no political, environmental, or economic downsides that have yet been identified.

Marketplace success is intimately tied to:

1. The use of highly efficient anaerobic digestion of all liquid and solid waste streams,
2. The use of steam for highly efficient vegetable oil extraction,
3. The use of highly efficient combined cycle electricity generation,
4. The use of inexpensive land for distributed greenhouse siting,
5. The use of cost-effective greenhouse construction materials and labor,
6. The beneficial recycling of plant nutrients,
7. The beneficial recycling of carbon dioxide to enhance plant growth,
8. The beneficial recycling of organic fertilizer to replace soil matrix lost during harvesting,
9. A comprehensive use of air and liquid heat exchangers to minimize operational heat loss, and
10. An unequivocal commitment to launch the technology without looking back.

The beneficial recycling of plant nutrients, carbon dioxide, and organic fertilizer translates into sustainability. No outside resources are required after each greenhouse becomes fully operational. If the greenhouses are built large enough, economical pipeline transportation of finished biodiesel, water, and liquefied carbon dioxide may be evaluated. Each greenhouse may be considered for additional fruit and vegetable production, concentrated animal feeding/processing, and fresh fish farming/processing as all such activities require the same recycling of plant nutrients, organic fertilizer, carbon dioxide, and water for routine operations. All such additional activities generate liquid and solid wastes which can be anaerobically digested to generate more energy than that required for product production. It’s all about highly efficient waste-to-energy coupled with comprehensive holistic material processing.

Energy independence on a sustainable basis represents a massive economic impact on each country that utilizes the technology. Economic development can proceed without energy limitations. The energy is clean and environmentally benign while entirely satisfying ground, air, and ocean transportation fuels and lubricants demand as well as a country’s electricity requirements. After full development fossil based fuels will no longer be necessary.

Likely future development of this technology will likely consist of constructing a 100 acre two-story demonstration greenhouse to establish the validity of all pertinent features, i.e., four crops/year, recycling of nutrients, carbon dioxide, NOx, and irrigation water. Electricity generation and biodiesel yield/acre will also be established along with construction costs and facility operational expenses. This size facility will also establish the feasibility of adding additional future floors to increase production. Ten to fifty story greenhouses of 1.5 km x 1.5 km in area are viewed as a minimum size because of the economies of scale. After the demonstration facility establishes technology viability, additional development will likely be pursued rapidly by many countries.

The proposed energy independence technology is being marketed by WaterSmart Environmental on dbo and dboo bases depending on the country of use.

[1] www.biodiesel.org
[2] www.gri.org
[3] www.watersmart.com

Acronyms:

Btu: British thermal unit
dbo: design-build-operate
dboo: design-build-own-operate
GPY: gallons per year
kWh: kilowatt-hour
MWh: megawatt-hour
NOX: oxides of nitrogen

Project Development Steps

1. Provide waste characteristics and volumes to enable BioWaste Energy to calculate approximate energy and other co-products that can be produced.
2. Authorize feasibility study to determine project costs, benefits, and estimated timetable to complete biowastes-to-energy installation.

Converting biowastes into green energy through super-efficient anaerobic digestion is a fantastic win-win technology for all humans and our environment. How soon may we begin?

Request Additional Information

Thank you for your interest in our treatment technologies. To request additional literature simply photocopy this page, mark desired WSE Publication selections, and then mail or fax to WSE with your return address. You may also contact us by phone or email with your request, or visit our webpage. We look forward to helping you find cost-effective and practical answers to your water and wastewater treatment requirements.

No.	Title
❑ 191	Standard Conditions of Sale
❑ 194	Equipment Maintenance Wastewater Treatment: Commercial Yards, Garages, and Repair Facilities
❑ 195	AquaRound IV™ Car/Truck Wastewater Treatment and Water Reuse System
❑ 196	ContamAway II Plus™ Mini Series
❑ 198	Capabilities Bulletin
❑ 291	Rental and Lease Agreement
❑ 294	Stormwater Runoff and Washdown Treatment: Automotive Dealership/Service Stations
❑ 295	Airport Deicing Fluid Treatment and Recovery System
❑ 296	SkimAway™ Floating Oil Skimmer
❑ 298	RainDrain *Plus*™ Perimeter Trench Dual Media Filtration System + Phosphorus Removal
❑ 380	Silica Contamination Removal from Spent Fuel Pools and Refueling Water Storage Tanks at Nuclear PWR Power Generation Plants
❑ 394	A Historical Review of Oil/ Water Separator Designs
❑ 395	PuriSep™ Differential Gravity Separators
❑ 494	Stormwater Runoff and Washdown Treatment: Automotive Wrecking/Salvage

No.	Title
❑ 498	RipTide™ Pulse Blender/Static Mixer
❑ 593	The Removal of PCBs From Aqueous Waste Streams
❑ 594	Ansorb™ Adsorbent for Arsenic, Hexavalent Chromium, and Selenium Removal
❑ 595	Take a New Look at the RBS Process
❑ 598	PuriQuad™ Physical/Chemical Treatment Plant
❑ 693	Advanced Aqueous Waste Treatment Concepts
❑ 694	OrganoSorb ™
❑ 695	The Biological Approach To The Rotating Disc Process
❑ 791	Quality Assurance Program Plan
❑ 794	DeOiler™ Coalescing Filter Cartridge
❑ 796	Design Manual and Tutorial
❑ 894	ContamAway II Plus™ Aqueous Waste Treatment and Water Recycling System
❑ 895	Plate Separation - Budding Conventional Technology?
❑ 898	Fundamentals of Water and Wastewater Treatment
❑ 993	ContamAway I™ High Performance Aqueous Waste Treatment System
❑ 994	ContamAway II™ High Performance Aqueous Waste Treatment System

No.	Title
❑ 995	OPCT™ - Optimized Physical/Chemical Treatment
❑ 996	Schedule of Typical Performance Results: Challenge Oil/Water Separation Testing
❑ 998	ABT™ - Aerobic Biological Treatment Process
❑ 1094	Mob-to-Demob™ High Performance Aqueous Waste Treatment System
❑ 1194	AquaRound II™ Laundromat Wastewater Treatment and Water Recycling System
❑ 1195	FilterFresh™ Potable Water Production Plant
❑ 1196	ContamAway II Plus™ Mini Series with Spot Free Rinse
❑ 1294	AquaRound III™ Laundry Wastewater Treatment and Water Recycling System
❑ 1495	EXPRESS™ Simultaneous Ground and Groundwater Remediation
❑ 1595	Cost-Effective Energy Savings
❑ 1695	UltraPaq™ Packaged Waste-water Treatment Plants
❑ 1795	Selecting an Energy Management System and Contractor
❑ 1895	OAT™ - Optimized Anaerobic Treatment Process
❑ 2195	RainDrain™ Perimeter Trench Dual Media Filtration System

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