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Press Release

Contact: C. G. Steiner
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For Immediate Release
Date: December 25, 2007

Subject: Phil Lusk Completes Feasibility Study of biowastes-to-renewable energy, organic foods, biofuels, and water independence technology for the United Kingdom.

WaterSmart Environmental, Inc. announces the completion of the feasibility study of its **wastes-to-renewable energy, organic foods, biofuels, and water independence technologies** for the United Kingdom

WaterSmart Environmental is marketing its Kyoto Protocol compliant wastes-to-energy technology on an economic development platform to concentrated animal feeding operators and to municipalities. Animal farmers benefit by purchasing biodiesel, electricity, and natural gas (methane) at a 20% discount from retail. Municipalities also benefit by making biodiesel, electricity, natural gas, and potable water available to its citizens and businesses at a 20% discount from existing prices. The technology is marketed on a build-own-operate basis thereby eliminating the necessity for local sales and property tax increases since project financing is entirely secured from the financial marketplace. Municipalities that embrace the waste-to-energy technology automatically become zero waste-to-landfill communities.

The waste-to-renewable energy technology has been slowly developed over the last 10 years. It is just now being introduced to the international marketplace. The technology has the clear potential for making every single city throughout the world energy and fuels independent while reducing oil and natural gas imports. The technology will also permit every single city throughout the world to improve water and wastewater treatment infrastructure while creating jobs and investment opportunities. The waste-to-energy technology can also be applied to Sugar Cane Mills as well as Pulp & Paper Mills with equal success. Both types of mills become energy, food, fuels, and water independent while significantly increasing profits from routine operations. In the case of Sugar Cane Mills temporary and seasonal jobs turn into full time better paying jobs. **Widespread use of the technology carries with it the potential for contributing substantially to the reversing of global warming.**

WaterSmart Environmental, Inc. is a provider of waste-to-energy, food independence, water independence, and energy independence technologies and a manufacturer of highly engineered water purification components and systems. The company designs and builds a wide variety of water treatment equipment including packaged water and wastewater treatment plants, UltraPaq™ aerobic package plants, OAT™ Process anaerobic digesters with associated energy production, aerators, filters, PuriSep™ and SmartWater™ oil/water and solids/liquids separators, RainDrain™ perimeter trench sand filters for stormwater runoff, dissolved air flotation separators, air strippers, complete skid assembled aqueous waste treatment plants, FilterFresh™ skid mounted potable water production plants, skid mounted wastewater treatment systems for laundromats, commercial laundries, and car/truck wash facilities with water reclamation and reuse, softeners, demineralizers, activated carbon treatment equipment, and water purifiers for domestic and international markets.

PROPRIETARY AND CONFIDENTIAL

FEASIBILTY STUDY

United Kingdom of Great Britain and Northern Ireland

BioWastes-To-Renewable Energy, Food, Biofuels, and Water Independence

WaterSmart Environmental, Inc.

www.watersmart.com

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Promoting World Peace Through Economic Prosperity

December 25, 2007

Dear Investor:

The UK, a leading trading power and financial center, is one of the quintet of trillion dollar economies of Western Europe. Over the past two decades, the government has greatly reduced public ownership and contained the growth of social welfare programs. Agriculture is intensive, highly mechanized, and efficient by European standards, producing about 60% of food needs with less than 2% of the labor force. The UK has large coal, natural gas, and oil reserves; primary energy production accounts for 10% of GDP, one of the highest shares of any industrial nation. Services, particularly banking, insurance, and business services, account by far for the largest proportion of GDP while industry continues to decline in importance.

GDP growth slipped in 2001-03 as the global downturn, the high value of the pound, and the bursting of the "new economy" bubble hurt manufacturing and exports. Output recovered in 2004, to 3.2% growth, then slowed to 1.7% in 2005 and 2.7% in 2006. The economy is one of the strongest in Europe; inflation, interest rates, and unemployment remain low. The relatively good economic performance has complicated the BLAIR government's efforts to make a case for Britain to join the European Economic and Monetary Union (EMU). Critics point out that the economy is doing well outside of EMU, and public opinion polls show a majority of Britons are opposed to the euro. Meantime, the government has been speeding up the improvement of education, transport, and health services, at a cost in higher taxes and a widening public deficit.

The **BioWastes-To-Renewable Energy, Organic Foods, Biofuels, and Water Independence Technology** consists of the construction of 1,220 project buildings measuring 1 km x 1 km x 3 stories plus 3 additional larger project building measuring 2 km x 2 km x 200 m high. The smaller buildings will engage in agricultural production and processing activities to produce food products for the export markets to create visible cash flow that will repay debt financing requirements.

Each of the 1,220 project buildings will employ 1,500 workers (1,830,000 total employees). The project buildings always include a hospital and educational facilities per the attached engineering drawing. In addition to the normal agricultural activities the larger buildings will engage in the construction of tidal generators, self fueling concrete ships, and self fueling locomotives.

The steel requirements of these activities will be satisfied by the associated shipbreaking activities. The larger sized project buildings will employ 2,500 each (2,500 x 3 = 7,500) for a total of 1,830,000 + 7,500 = 1,837,500. This many new jobs will totally eliminate all unemployment throughout the United Kingdom. With Warm Regards I am

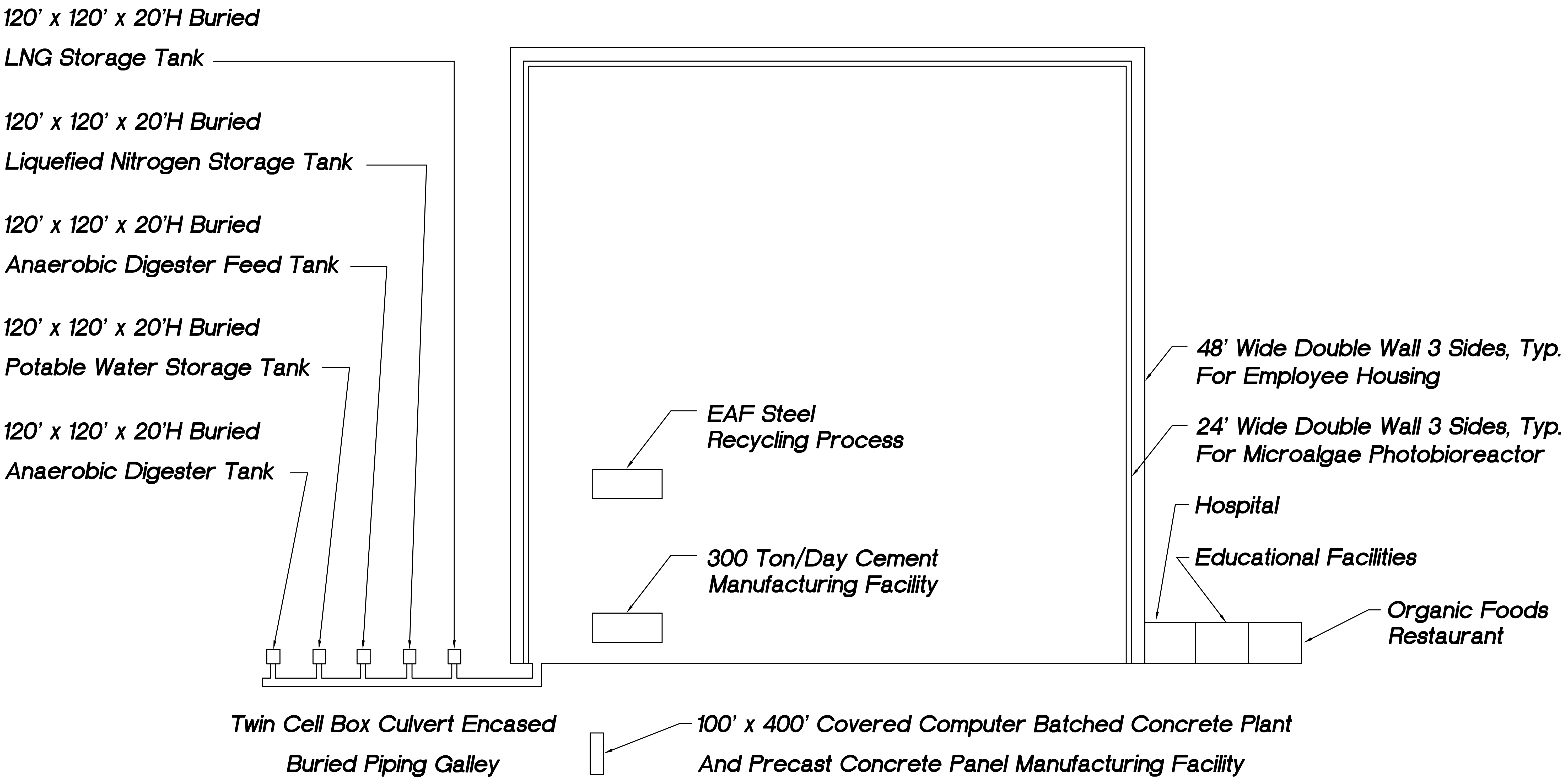
Very truly yours,

WaterSmart Environmental, Inc.

C. G. (Chuck) Steiner
President and CEO

enclosures

CGS/mns



Wastes-To-Renewable Energy Project Building Site Plan

1 km x 1 km x 3 Stories High

Construction Manager:
BioWastePower Constructors
A Division of WaterSmart Environmental, Inc.

WaterSmart Environmental, Inc.
Post Office Box 26346
Shawnee Mission, Kansas 66225-6346

TITLE	Site Plan Project Building			
JOB	United Kingdom			
SCALE	NONE	DRAWN	B.E.H.	DWG. NO. S-9900-4.1
DATE	11/14/07	CHECKED	C.G.S.	

REV.	DATE	DESCRIPTION	BY	CHK

DO NOT SCALE DRAWING. USE DIMENSIONS ONLY.

Plot Date 12-25-07/1500 Plot Scale 1=24 Produced On AutoCAD Release 2000i

Nonrecourse Project Capital Cost Structure

United Kingdom

BioWastes-To-Renewable Energy, Food, BioFuels, and Water Independence Plant

The total estimated capital and development costs of the design-build-own-operate wastes-to-renewable energy project total $501,226,585 (plus funding broker commissions) utilizing both new and remanufactured process equipment. The major components of capital and other costs are as follows:

Item Description	**Cost in US$**
Anaerobic Digester Feed Tank Constructed Cost[1]	2,000,000
Biodiesel Manufacturing Equipment Constructed Cost[2]	15,000,000
Building Size 1 km x 1 km x 2 stories high Constructed Cost[3]	75,000,000
Cement Kiln Constructed Cost[4]	12,000,000
Concrete Ready Mix Batch Plant Constructed Cost[5]	3,000,000
EAF Steel Recycling Process Equipment Constructed Cost	3,000,000
Fish Processing Equipment Constructed Cost[6]	500,000
LED Lighting Purchase Cost[8]	10,000,000
Liquefied Nitrogen Air Separation Equipment Procurement Capital Cost	15,000,000
Liquefied Nitrogen Delivery Equipment Procurement Capital Cost	500,000
Liquefied Nitrogen Storage Tank Constructed Cost	2,000,000
LNG (Liquefied Natural Gas) Storage Tank Constructed Cost	2,500,000
Methane Gas Compression Equipment Installed Capital Cost	10,000,000
Potable Water Storage Tank Constructed Cost	2,000,000
Photobioreactor Capital Equipment Constructed Cost[7]	100,000,000
Power Generation Equipment Procurement Cost[9]	56,650,000
Reverse Osmosis Equipment Procurement Cost	2,000,000
Sow procurement Costs	5,000,000
Two-Phase Anaerobic Digester Constructed Cost[1]	74,780,080
Subtotal Project Costs	**390,930,000**
Add 15% Contingencies	58,639,500
Total Capital Costs	**449,569,500**
Finance Charges	8,000,000
Interest During Construction	20,000,000
Administration/Legal	150,000
Permitting	20,000
Technology & Development Cost	284,559,700
Project Development Fee @ 3% of US$449,569,500	13,487,085
Working Capital	10,000,000
Total All Costs	**785,786,285**

Nonrecourse Project Financing Will Be Structured As Follows:

Developer Equity as Technology, 70%[10]	284,559,700
Investor Equity as Cash, 30%	94,712,728

Finance	406,513,857
Loan Term, Years	10
Interest Rate	10%
Developer will contribute 70% equity in the project as the value of the technology.[10]	
Investor will contribute US$94,712,728 cash and the balance will be financed.	

With Following Notes:

1. **The anaerobic digester and its associated feed tank will be constructed of precast concrete panels. The panels will be manufactured by Wieser Concrete Products, Inc. and barge shipped to destination project site. The Wisconsin based precast concrete manufacturer POC is Phil Miller @ phone 800.325.8456 (see http://www.wieserconcrete.com/about.html).**

2. **The biodiesel production equipment will be designed and manufactured by California based R. C. Costello & Associates, Inc. The POC is Rocky Costello, P.E. @ phone 310.792.5870 (see http://www.rccostello.com/).**

3. **The low cost of the project building is made possible by the 100% internal recycling of inorganic wastes that are produced from the anaerobic digestion process. These inorganic wastes are combined with cement and water in the production of precast concrete panels. The special purpose project company will produce its own cement to further minimize construction costs. See attached WSE Engineering Drawing No. S-6099-1 for additional details. The POC at WaterSmart Environmental is Chuck Steiner @ 913.897.2727 (see http://www.watersmart.com/).**

4. **The cement kiln will be sourced through Canada based Cement Process Consulting, Ltd. The POC is Ken Postle @ phone 403.472.4519 (see http://www.cement-process.com/index.htm).**

5. **The concrete ready mix plant will be sourced through Canada based Cement Process Consulting, Ltd. The POC is Ken Postle @ phone 403.472.4519 (see http://www.cement-process.com/index.htm).**

6. **The fish production and processing equipment will be sourced through Colorado based Fisheries Technology Associates, Inc. The POC is Bill Manci @ phone 970.225.0150 (see http://www.ftai.com/).**

7. The enclosed photobioreactor consists of 2 miles long 12"Ø clear PVC pipe. A possible supplier is Harvel Plastics, Inc. but other sources will be considered prior to procurement (see http://www.harvel.com/).

8. The artificial lighting for the photobioreactor consists of 5 miles of high efficiency long lasting (10 years or more) light emitting diode (LED) lighting that will be wrapped barber pole fashion around the clear PVC pipe. A possible supplier is Light Waves Concept, Inc. but other sources will be considered prior to procurement (see http://www.lightwavesconcept.com/).

9. The power generation equipment will be sourced through UK based Combustion, Energy & Steam Specialists, Ltd. The POC is Mike Craigie @ phone +44 (0) 1856 851177 (see http://www.cess.co.uk/).

10. The seemingly high percentage of developer equity as technology is justified on the basis that it is the only economic development technology that simultaneously achieves:

- **100% compliance with Kyoto Protocol thus helping to reverse global warming,**
- **Distributed Biofuels (biodiesel and compressed natural gas or CNG) independence,**
- **Distributed Food independence,**
- **Distributed Renewable energy independence,**
- **Distributed Water independence, and**
- **Complete internal recycling of all byproducts and waste streams thereby producing a useful product—namely precast concrete products that will be used for constructing the project building itself as well as infrastructure roads, light rail transit surface transportation system, precast concrete potable water distribution system, precast concrete wastewater collection system, and precast concrete encased renewable energy power distribution system. In doing so the community initiative project will become the very first zero carbon and zero waste community in the world.**

Climate Change has now become the most serious worldwide concern as the sustainability of our planet appears to be at rapidly increasing risk. Renewable Energy Technologies that address climate change are therefore in great demand. Technologies that address both climate change and substantial economic development are in even greater demand. The proposed waste-to-energy technology has required over 30,000 hours of research over a 10 year period to develop thus fully justifying the seemingly high percentage of developer equity as technology. It is the very first and only worldwide technology that is technically capable of simultaneous distributed energy independence, distributed food independence, distributed fuels independence, and distributed water independence with all in full compliance with Kyoto Protocol.

The proposed wastes-to-renewable energy technology consists of a suite of individual component technologies. The individual component technologies are:

- **Biodiesel Production With Associated Waste Processing. The National Renewable Energy Laboratory (NREL) pioneered the very first production of biodiesel from microalgae. The research and development was carried out under the "Aquatic Species Program" (ASP) that consisted of the first production of a biofuel called "algal biodiesel" (see http://www1.eere.energy.gov/biomass/pdfs/biodiesel_from_algae.pdf). Under the referenced program Algal Biodiesel was produced through the growing of microalgae for their lipid content. The lipid content was then converted into biodiesel through chemical transesterification in the same manner that soybeans and other vegetable oils are now being converted into biodiesel. The ASP funding totaled $25.05 million over a 20 year period that began in 1978. Continuation funding was ultimately terminated when it was officially determined that algal biodiesel could not be produced economically. The ASP obtained its research data from growing microalgae in warm open ponds (Salton Sea in Southern California) at a pH of 8.2 using atmospheric carbon dioxide. The Salton Sea is the recipient of agricultural runoff nutrients as well as additional nutrients contained in municipal sewage treatment plants discharges. The Middle Cordoba Province Project will produce microalgae within an enclosed photobioreactor that will operate at the optimum growing temperature of 35ºC (95ºF) and at the optimum growing pH of 9.4. Photosynthesis will occur 24/7 rather than just during daylight hours by using long lasting light emitting diode (LED) lighting. The photobioreactor will receive the total carbon dioxide output from both the anaerobic digester as well as the power generation equipment thus substantially increasing production over that obtainable from using carbon dioxide from the atmosphere. Microalgae production will be further increased by adding the micronutrients contained in the reverse osmosis concentrate stream thus substantially improving microalgae production. The total increase of these process modifications over that obtained by the National Renewable Energy Laboratory's ASP is estimated at a factor of at least 1000 to 1. By producing the microalgae within an enclosed photobioreactor the technology becomes totally compliant with Kyoto Protocol since all discharges of greenhouse gases to the environment are eliminated.**

- **Cement manufacturing as a technology has been practiced for many hundreds of years throughout the entire civilized world.**

- **Fish farming was first practiced by the Chinese over 100 years ago. Due to the over fishing of the oceans fish farming is now widespread throughout the entire civilized world.**

- **Precast concrete panels and piping have been manufactured for the last 50 years. The use of precast concrete panels has become quite popular in the building industry during the last 10 years.**

- **Liquefied Nitrogen and Liquefied Oxygen have been produced in the marketplace for the last 50 years. Names of today's largest industrial suppliers consist of Air Liquide, Air Products & Chemicals, Inc., Cryogenic Industries, Inc., Gas Systems Corporation, and Praxair, Inc.**

- **Methane gas-to-methanol alcohol through synthesis gas (syngas) technology represents the standard method of producing methanol throughout the civilized world.**

- **Microalgae production through the use of a photobioreactor (use of artificial light rather than sunlight) is now being done at several research institutions. The technology has yet to be put into full scale commercial operation.**

- **The anaerobic digestion of municipal solid wastes (MSW) was first accomplished by two-phase anaerobic digestion in 1996 (see http://lib.kier.re.kr/caddet/retb/no66.pdf). More recently the management of municipal solids wastes is being accomplished using conventional anaerobic digestion by Waste Management, Inc., a waste management company (see http://www.wm.com/WM/environmental/Bioreactor/technologies.asp).**

- **Pig farming and processing has been practiced around the world for the last 100 years.**

- **Precast concrete panels and precast concrete pipes have been manufactured for the last 50 years throughout the world.**

- **Renewable energy power generation has been practiced for at least 30 years in the EU and 20 years in the United States.**

- **Reverse osmosis treatment has been around on a commercial basis for over 30 years. During the last 5 years its marketplace costs have been halved and it is now considered very good and very affordable technology.**

United Kingdom Prefeasibility Study, December 25, 2007	Totals
Location: United kingdom	
Technology Provider: WaterSmart Environmental, Inc.	
Project Developer: POC: Phil Lusk Phone: 605.224.4334 email: plusk@pipeline.com	
Project Type: Economic Development through Design-Build-Own-Operate BioWastes-To-Renewable Energy, BioFuels, Organic Foods, and Potable Water Independence	
Project Dollar Size: US$500 million for each 1 km x 1 km x 3 story high project building	
Number of project buildings required: 1,220	
Project Activities: Extensive Agricultural Production and Processing that additionally includes renewable energy, biofuels, and water production along with 100% recycling of all byproducts into precast concrete panels and piping for infrastructure development	
Jobs Creations Potential for each 1 km x 1 km x 3 story high project building: 1,500	
BioWastes Treated: Municipal Solid Wastes (MSW), Medical Wastes, Construction & Demolition Wastes, Foods Production & Processing Wastes, and Biodiesel Processing Wastes	
Local Population Served for each 1 km x 1 km x 3 story high project building: 50,000	
Residual Wastes to Landfill: Zero	
Greenhouse Gaseous Emissions to the Environment: Zero	
Climate Change Carbon Footprint: Zero	
Investor Internal Rate of Return: Optimal	

Detailed Project Description

Extensive Agricultural Production in each project building will consist of a 10,000 sow farrow-to-finish operation that is sized to produce excess local marketplace demand for finished pork and a 50 hectare tilapia fish farming operation that is also sized to produce excess local marketplace demand for tilapia fish. On a total processed weight basis the amount of excess processed fish produced will be about 4 times that of processed pork. Processed Tilapia fish are worth about 1.5 times as much as processed pork and therefore more profitable. The excess processed pork and processed fish will be exported to distant markets to provide visible cash flow to the project. The worldwide demand for pork on a weight basis is about 4 times that of the worldwide demand for fish. With a world population approaching 7 billion the pork and fish output of a single project building calculates out to approximately 0.075% of worldwide demand of processed pork and tilapia fish. A total of 1 ÷ 0.00075 = 1,333 project buildings would therefore be required to satisfy worldwide demand for both pork and fish. Worldwide consumption of pork and fish data is attached. The marketing idea is to produce 100% of the local demand for pork and fish with the entire excess of each sold to export markets for visible sales revenue.

In addition to agricultural production, each project building will produce Portland cement for the purpose of manufacturing precast concrete panels and piping for direct infrastructure development.

1. In the production of cement considerable carbon dioxide gas is produced.
2. When processing biowastes using anaerobic digestion both methane gas and carbon dioxide gas are produced.
3. When generating renewable energy both water vapor and carbon dioxide gas are produced.

100% of the carbon dioxide gas produced during the production of cement, the processing of biowastes, and the generation of electricity will be routed to an enclosed photobioreactor for the purpose of producing Spirulina microalgae. 75% of the Spirulina microalgae will be used as animal feed in the production of tilapia fish and pork. The remainder 25% will be converted into biodiesel biofuel (B100) and sold locally to produce visible sales revenue.

Spirulina microalgae contain about 6% lipids (fats). The production of biodiesel produces about 6% lipid (fat) conversion into biodiesel biofuel from Spirulina microalgae. The 94% remaining biowastes are returned to the anaerobic digester to produce additional methane gas and carbon dioxide gas. The resulting methane gas produced can be used for power generation or sold as a biofuel. The resulting carbon dioxide gas produced from electricity generation will be automatically routed to the enclosed photobioreactor to enable production of additional Spirulina microalgae.

The economic development objective is to produce 100% of the local demand for electricity, 100% of the local demand for biodiesel biofuel, 100% of the local demand for natural gas (methane gas is a near equivalent to natural gas) biofuel, and 100% of the local demand for compressed natural gas (CNG) automotive biofuel. Biodiesel (B100) can be used as a direct replacement for petroleum diesel without equipment modification. CNG biofuel must be used in vehicles equipped for this fuel. Each project building will engage in the modification of gasoline automotive equipment to enable the use of CNG biofuel. Automobiles that operate on CNG biofuel enjoy extended useful life of the engine by a factor of 4 or more. Trucks that operate on biodiesel biofuel enjoy extended useful life of the engine by a factor of 2 or more. Each economic development project includes the infrastructure for local distribution of renewable natural gas. To the extent that methane gas is used for electricity generation, the production of biodiesel biofuel, and the production of CNG biofuel, each qualifies for renewable energy credits since all such uses are carbon neutral.

As background information, the production of ethanol from corn and biodiesel from beans has precipitated a massive food or fuel issue throughout the world causing the marketplace price of both corn and soybeans to increase dramatically. These increases have, in turn, caused the marketplace price of ethanol and biodiesel to increase as well the marketplace price of corn and soybean based food products. It is these increases in marketplace prices that have caused the food or fuel issue. With our business model, the production of biodiesel from Spirulina microalgae stays completely clear of the food or fuel issue as does the production of CNG biofuel from biowastes. To achieve total sales of the biofuels production outputs they will be sold at a 20% discount from existing retail. At this attractive pricing 100% of routine production will easily sell in the marketplace.

No Charge For Potable Water

No Charge For Wastewater Treatment

Because nutrients will be 100% recycled internally, each project building will produce substantial liquid fertilizer concentrate that will be distributed to area farmers in need on a no-charge basis. Excess liquid fertilizer, if any, would be eligible to sell to distant markets or possibly converted into value added products. To the extent that the local market does not make use of the liquid fertilizer concentrate the fertilizer product will be sold to international markets to increase additional visible cash flow to the project.

No Charge for Stormwater Treatment

Because 100% of the water is recycled internally, potable water of the quality of bottled water will be distributed locally on a no-charge basis. Because water is required to process municipal solid wastes each project building will accept both sanitary wastewater and storm water for that purpose on a no-charge basis. Over time, additional stories will be added to each project building to enable additional agricultural activities that could include bananas, beets, black bass, beef cattle, beans, cassava, coffee, corn, cotton, dairies, lobster, onions, poultry, prawns, rice, shrimp, sugar cane, sweet potatoes, trout, and many other crops.

Throughout the prefeasibility study extensive efforts are made to provide balanced chemical equations and mathematical calculations, where appropriate, to permit extensive due diligence evaluations of the proposed sciences to be used.

Marketplace BioWastes-To-Energy Feedstocks

A determination of the amount of volatile solids (VS) is necessary in order to calculate the amount of methane gas that can be produced from the anaerobic digestion of biowastes. Eligible feedstocks consist of municipal solid wastes (MSW), medical wastes, and construction & demolition wastes. For the purpose of arriving at conservative waste figure availability, a total of 2 lbs/person/day will be used for the purpose of calculating total feedstock biowaste amounts for developing countries and a total of 5 lbs/person/day will be used for the purpose of calculating total feedstock biowaste amounts for developed countries. For an area population of 50,000 for each project building the available biowastes calculate out to 50,000 x 2 lbs/person/Day = 100,000 lbs/day, or when divided by 2,000 lbs/Ton = 50 Tons/Day for developing countries and 50,000 x 5 lbs/person/day = 250,000 lbs/Day, or when divided by 2,000 lbs/Ton = 125 Tons/Day for developed countries.

For undeveloped countries, the calculation for municipal solid wastes is as follows:

> **Assuming 25% moisture content 50 Tons/Day x 75% = 37.5 Dry Tons/Day**
> **Assuming 80% organic content 37.5 Dry Tons/Day x 80% = 30 Organic Tons/Day**
> **Assuming 80% volatile solids content 30 Organic Tons/Day x 80% = 24 Tons Volatile Solids/Day or x 2,000 lbs/Ton = 48,000 lbs/Day. This amount of waste translates into 48,000 lbs Volatile Solids/Day x 12 cubic feet of methane/lb Volatile Solids = 576,000 CFD of CH_4. At 24 cubic feet/lb, the methane production translates into 576,000 CFD CH_4/24 = 24,000 lbs/2,000 = 12.0 Tons CH_4/Day for undeveloped countries.**

For developed countries, the calculation for municipal solid wastes is as follows:

> **Assuming 25% moisture content 125 Tons/Day x 75% = 93.75 Dry Tons/Day**
> **Assuming 80% organic content 93.75 Dry Tons/Day x 80% = 75 Organic Tons/Day**
> **Assuming 80% volatile solids content 75 Organic Tons/Day x 80% = 60 Tons Volatile Solids/Day or x 2,000 lbs/Ton = 120,000 lbs/Day. This amount of waste translates into 120,000 lbs Volatile Solids/Day x 12 cubic feet of methane/lb Volatile Solids = 1,440,000 CFD of CH_4. At 24 cubic feet/lb, the methane production translates into 1,440,000 CFD CH_4/24 = 60,000 lbs/2,000 = 30.0 Tons CH_4/Day for developed countries.**

In addition to fresh municipal solid wastes, the project will directly collect an additional 10 lbs/person/Day from existing landfills, rubbish piles, and dumps for the twofold purpose of producing additional methane gas and reclaiming additional ferrous and nonferrous metals while getting rid of existing dump/landfill sites. This activity will increase the methane gas and carbon dioxide gas production from two-phase anaerobic digestion by a factor of 5/2 or 2.5 thus increasing the volatile solids from undeveloped countries from 24 Tons/Day to 60 Tons/Day and from developed countries from 60 Tons to 150 Tons/Day. The associated methane gas is increased from 12 Tons CH_4/Day to 30 Tons CH_4/Day for undeveloped countries and from 30 Tons CH_4/Day to 75 Tons CH_4/Day from developed countries.

The 60 Tons Volatile Solids/Day from undeveloped countries can be converted into CO_2 production by multiplying the Volatile Solids by 12 to determine cu. ft. of methane gas produced. Cu. ft. of methane gas produced ÷ 24 cu. ft./lb = lbs methane gas. Lbs. methane gas multiplied by 1.375 = lbs CO_2 produced or 60 Tons VS/Day x 2,000 lbs/Ton x 12 = 1,440,000 cu. ft. CH_4/Day. 1,440,000 cu. ft. ÷ 24 cu. ft./lb = 60,000 lbs CH_4/Day. 60,000 lbs CH_4/Day x 1.375 = 82,500 lbs CO_2/Day. 82,500 lbs CO_2/Day ÷ 2,000 lbs/Ton = 41.3 Tons CO_2/Day.

The 150 Tons Volatile Solids/Day from undeveloped countries can be converted into CO_2 production by multiplying the Volatile Solids by 12 to determine cu. ft. of methane gas produced. Cu. ft. of methane gas produced ÷ 24 cu. ft./lb = lbs methane gas. Lbs.

60 Tons VS/Day From MSW Undeveloped Countries

30 Tons CH_4/Day From MSW Undeveloped Countries

150 Tons VS/Day From MSW in Developed Countries

75 Tons CH_4/Day From MSW in Developed Countries

No charge for MSW disposal

US$0.00/Day From MSW

methane gas multiplied by 1.375 = lbs CO_2 produced or 150 Tons VS/Day x 2,000 lbs/Ton x 12 = 3,600,000 cu. ft. CH_4/Day. 3,600,000 cu. ft. ÷ 24 cu. ft./lb = 150,000 lbs CH_4/Day. 150,000 lbs CH_4/Day x 1.375 = 206,250 lbs CO_2/Day. 206,250 lbs CO_2/Day ÷ 2,000 lbs/Ton = 103 Tons CO_2/Day.

Revenue collected for management of landfill wastes, municipal solid wastes, medical wastes, and construction & demolition wastes: US$0/Day/Ton. Never a charge, ever. This service always provided as a public service activity only.

Agricultural Food Production and Processing

A 10,000 Sow Farrow-To-Finish farming operation will be provided for each project building that will produce about 22 pigs/sow/year. There is a potential to increase the number of pigs since the Dutch are now reporting upwards of 30 pigs/sow/year. The 10,000 sows therefore translate into 22 x 10,000 = 220,000 pigs/year with possible future expansion possible. At a midterm weight of 100 lbs, each hog will generate wastes sufficient to produce 3.02891 cubic feet of methane gas per day (archived data from Premium Standard Farms, Kansas City) through anaerobic digestion for a total daily production of 3.02891 x 220,000 or 666,360 cubic feet. At 24 cubic foot/lb, the methane production translates into 666,360/24 = 27,765 lbs/2,000 = 13.9 Tons CH_4/Day.

27.0 Tons VS/Day From Pig Farming

13.9 Tons CH_4/Day From Pig Farming

Pigs usually reach market weight between 5 and 6 months of age at approximately 260 to 280 pounds. During this time, the pigs are often fed several corn-soybean meal based diets that change in nutrient composition to meet their needs. Pigs weigh about 3 pounds at birth and stay with the sow until 21 days of age. At this time, they are placed on a grain diet. Pigs have unlimited access to feed and water at all times. Pigs will eat about 1 pound of feed per day at weaning and as much as 8 pounds of feed per day by market weight. Water intake is about 1 gallon per day up to 5 or 6 gallons per day by market weight. Just weaned pigs (21 days of age) need to be kept at about 80 to 85 degrees Fahrenheit and by market weight 65º F. Therefore, heating and cooling systems need to be in place throughout. A total of 2 MW of electricity will be required for the pig farming operations.

2 MW Electricity Required

For market hogs the pigs will consume about 3 to 4 percent of their body weight. A 200-pound hog will consume about 6 to 6.5 pounds each day.

- Nursery pigs weighing about 10 pounds consume around 0.5 pounds
- Feeder pigs weighing about 50 pounds consume around 1 to 2 pounds
- Grower pigs (now referred to as hogs) weighing about 100 pounds consume around 3 to 4 pounds
- Finisher hogs weighing about 150 pounds consume around 4 to 5 pounds
- Hogs more than 200 pounds consume around 6 to 7 pounds

United States retail pork prices are currently around US$2.87/lb. The wholesale producer receives about 43% of this price or US$1.46/lb. The above prices represent the average for the last 3 years. As a commodity there is no guarantee they will drift up or down but will likely continue to fluctuate as they have been for the last 50 years. Current marketplace dressed pork yields are over 2,750 lbs/year/sow. A 10,000 sow farrow-to-finish operation is estimated to produce 27,500,000 lbs of dressed pork/year or an average of 75,342 lbs/Day. At US$1.46/lb the daily revenue is estimated at US$110,000.00. Associated electricity requirements for temperature and humidity control are estimated at 2 MW. The exported pork product will be the first Organic Pork produced worldwide since all the principles for its production will be followed. Organic food is produced according to a set of principles and standards concerning such issues as pesticides, additives, animal welfare (medications) and sustainability. Organic pork will carry a higher marketplace value than non-organically produced pork similar to all organically produced

US$110,000/Day From Pork

food products. In terms of investor risk assessment, the existence of the very large pork commodity market is regarded as ample proof of probable visible cash flow from this specific food product. At a finished market weight of 250 lbs 220,000 pigs translate into 220,000 x 250 lbs = 55,000,000 lbs/year. 55,000,000 lbs/year ÷ 2,000 lbs/Ton = 27,500 Tons/year. 27,500 Tons/year ÷ 365 days/year = 75.34 Tons/Day. The processing of pork yields about 30% biowastes. The total processing wastes calculate out at 75.34 Tons/Day x 30% = 22.60 Tons/Day. When multiplied by 2,000 lbs/Ton, the amount of volatile solids = 45,200 lbs/Day. This amount of biowastes translate into 45,200 lbs Volatile Solids/Day x 12 cubic feet of methane gas/lb Volatile Solids = 542,400 cubic feet/Day (CFD) of methane gas (CH_4). At 24 cubic feet/lb, the methane production translates into 542,400 CFD CH_4/24 = 22,600 lbs/2,000 = 11.3 Tons CH_4/Day.	**22.6 Tons VS/Day From Pork Processing** **11.30 Tons CH_4/Day From Pork Processing**
Additional Agricultural Food Production and Processing Will consist of a 50 hectare Tilapia fish farm at each project building for producing and thereafter processing organically grown Tilapia filets, mostly for the export fish market. Electricity requirements are estimated at 0.5 MW. The estimated raw fish produced per day is 670,000 lbs. At a filet yield of 42% a total of 281,000 lbs (140.5 Tons of Tilapia filets) will be produced/Day along with 389,000 lbs or when divided by 2,000 lbs/Ton = 194.5 Tons of biowastes/Day. At a commodity sell price of US$2.18/lb, the daily revenue is estimated at 140.5 Tons/Day x 2,000 lbs/Ton x US$2.18/lb = US$612,580/Day It is virtually impossible to obtain a buyer commitment on a current basis in the form of a purchase agreement for a product that is 36 months away from coming into existence. In terms of investor risk assessment, the existence of the very large fish commodity market itself is regarded as ample proof of probable visible cash flow from this specific food product. The 194.5 Tons/Day of biowastes x 2,000 lbs/Ton = 389,000 lbs of Volatile Solids/Day. This amount of waste translates into 389,000 lbs Volatile Solids/Day x 12 cubic feet of methane/lb Volatile Solids = 4,668,000 cubic feet/Day (CFD) of CH_4. At 24 cubic foot/lb, the methane production translates into 4,668,000 CFD CH_4/24 = 194,500 lbs/2,000 = 97.3 Tons CH_4/Day.	**0.5 MW Electricity Required For Tilapia Fish Farming** **US$612,580/Day From Tilapia Fish** **194.5 Tons VS/Day From Fish Processing** **97.3 Tons CH_4/Day From Fish Processing**
Subtotal Carbon Dioxide Gas Produced From Municipal Solid Wastes Processing:	**41.3 Tons CO_2/Day**
The 60 Tons Volatile Solids/Day from Municipal Solid Wastes can be converted into CO_2 production by multiplying the Volatile Solids by 12 to determine cu. ft. of methane gas produced. Cu. ft. of methane gas produced ÷ 24 cu. ft./lb = lbs methane gas. Lbs. methane gas multiplied by 1.375 = lbs CO_2 produced or 60 Tons VS/Day x 2,000 lbs/Ton x 12 = 1,440,000 cu. ft. CH_4/Day. 1,440,000 cu. ft. ÷ 24 cu. ft./lb = 60,000 lbs CH_4/Day. 60,000 lbs CH_4/Day x 1.375 = 82,500 lbs CO_2/Day. 82,500 lbs CO_2/Day ÷ 2,000 lbs/Ton = 41.3 Tons CO_2/Day.	
Subtotal Feedstocks Volatile Solids From Pig Farming Wastes:	**27.0 Tons VS/Day**
The 27 Tons Volatile Solids/Day from Pig Farming Wastes can be converted into CO_2 production by multiplying the Volatile Solids by 12 to determine cu. ft. of methane gas produced. Cu. ft. of methane gas produced ÷ 24 cu. ft./lb = lbs methane gas. Lbs. methane gas multiplied by 1.375 = lbs CO_2 produced or 27 Tons VS/Day x 2,000 lbs/Ton x 12 = 648,000 cu. ft. CH_4/Day. 648,000 cu. ft. ÷ 24 cu. ft./lb = 27,000 lbs CH_4/Day. 27,000 lbs CH_4/Day x 1.375 = 37,125 lbs CO_2/Day. 37,125 lbs CO_2/Day ÷ 2,000 lbs/Ton = 18.6 Tons CO_2/Day.	**18.6 Tons CO_2/Day From Pig Farming Wastes**
Subtotal Feedstocks Volatile Solids From Pork Processing Wastes:	**22.6 Tons/Day**

The 22.6 Tons Volatile Solids/Day from Pork Processing Wastes can be converted into CO_2 production by multiplying the Volatile Solids by 12 to determine cu. ft. of methane gas produced. Cu. ft. of methane gas produced ÷ 24 cu. ft./lb = lbs methane gas. Lbs. methane gas multiplied by 1.375 = lbs CO_2 produced or 22.6 Tons VS/Day x 2,000 lbs/Ton x 12 = 542,400 cu. ft. CH_4/Day. 542,400 cu. ft. ÷ 24 cu. ft./lb = 22,600 lbs CH_4/Day. 22,600 lbs CH_4/Day x 1.375 = 31,075 lbs CO_2/Day. 31,075 lbs CO_2/Day ÷ 2,000 lbs/Ton = 15.5 Tons CO_2/Day.	15.5 Tons CO_2/Day From Pork Processing Wastes
Subtotal Feedstocks Volatile Solids From Tilapia Fish Farming Wastes:	1.4 Tons/Day
The 1.4 Tons Volatile Solids/Day from Tilapia Fish Farming Wastes can be converted into CO_2 production by multiplying the Volatile Solids by 12 to determine cu. ft. of methane gas produced. Cu. ft. of methane gas produced ÷ 24 cu. ft./lb = lbs methane gas. Lbs. methane gas multiplied by 1.375 = lbs CO_2 produced or 1.4 Tons VS/Day x 2,000 lbs/Ton x 12 = 33,600 cu. ft. CH_4/Day. 33,600 cu. ft. ÷ 24 cu. ft./lb = 1,400 lbs CH_4/Day. 1,400 lbs CH_4/Day x 1.375 = 1,925 lbs CO_2/Day. 1,925 lbs CO_2/Day ÷ 2,000 lbs/Ton = 0.96 Tons CO_2/Day.	0.96 Tons CO_2/Day From Tilapia Fish Farming Wastes
Subtotal Feedstocks Volatile Solids From Tilapia Fish Processing Wastes:	194.5 Tons/Day
The 194.5 Tons Volatile Solids/Day from Tilapia Fish Processing Wastes can be converted into CO_2 production by multiplying the Volatile Solids by 12 to determine cu. ft. of methane gas produced. Cu. ft. of methane gas produced ÷ 24 cu. ft./lb = lbs methane gas. Lbs. methane gas multiplied by 1.375 = lbs CO_2 produced or 194.5 Tons VS/Day x 2,000 lbs/Ton x 12 = 4,668,000 cu. ft. CH_4/Day. 4,668,000 cu. ft. ÷ 24 cu. ft./lb = 194,500 lbs CH_4/Day. 194,500 lbs CH_4/Day x 1.375 = 267,437 lbs CO_2/Day. 267,437 lbs CO_2/Day ÷ 2,000 lbs/Ton = 133.7 Tons CO_2/Day.	133.7 Tons CO_2/Day From Tilapia Fish Processing Wastes
Subtotal Carbon Dioxide Gas Produced From Pig Farming Wastes:	18.6 Tons CO_2/Day
Subtotal Carbon Dioxide Gas Produced From Pork Processing Wastes:	15.5 Tons CO_2/Day
Subtotal Carbon Dioxide Gas Produced From Tilapia Fish Farming Wastes:	0.96 Tons CO_2/Day
Subtotal Carbon Dioxide Gas Produced From Tilapia Fish Processing Wastes:	133.7 Tons CO_2/Day
Subtotal Carbon Dioxide Gas Produced From Electricity Generation:	247.0 Tons CO_2/Day
Subtotal Carbon Dioxide Gas Produced From Cement Manufacturing:	67.2 Tons CO_2/Day
Total Carbon Dioxide Gas Produced:	483.0 Tons CO_2/Day
Subtotal Methane Gas Produced From Municipal Solid Wastes:	30.0 Tons CH_4/Day
Subtotal Methane Gas Produced From Pig Farming Wastes:	13.5 Tons CH_4/Day
Subtotal Methane Gas Produced From Pork Processing Wastes:	11.3 Tons CH_4/Day
Subtotal Methane Gas Produced From Tilapia Fish Farming Wastes:	0.7 Tons CH_4/Day
Subtotal Methane Gas Produced From Tilapia Processing Wastes:	97.3 Tons CH_4/Day
Subtotal Methane Gas Produced From Biodiesel Processing Wastes:	97.1 Tons CH_4/Day
Total Methane Gas Produced:	249.9 Tons CH_4/Day

Two-Phase Anaerobic Digestion

All of the wastes associated with agricultural production will be managed through two-phase anaerobic digestion technology. Traditional anaerobic digestion (often referred to as conventional high rate anaerobic digestion) produces a biogas that consists of 1/3 carbon dioxide gas by volume and 2/3 methane gas by volume as a common gas mixture. Two-phase anaerobic digestion, however, produces the same gases as two distinct gases consisting individually of carbon dioxide gas and methane gas. The separation of the two gases permits each to be managed individually. In every anaerobic digester the ratio of carbon dioxide gas produced relative to methane gas is 1:2 on a volumetric basis. The molecular weight of methane gas (CH_4) is 16 (12 for Carbon + 4 for Hydrogen) whereas the molecular weight of carbon dioxide gas (CO_2) is 44 (12 for Carbon and 32 for Oxygen). 1 x 44 = 44 weight units for carbon dioxide gas and 2 x 16 = 32 weight units for methane gas. 44 divided by 32 = 1.375. Carbon dioxide produced relative to methane produced is therefore 137.5% on a mass basis. The actual weight of methane gas produced may be found by multiplying its cubic feet by the factor 0.0423 lbs/cu. ft. to arrive at its actual weight in lbs. This weight may be multiplied by the factor	Products Of Two-Phase Anaerobic Digestion Volatile Solids (VS) x 12 = cu. ft. CH_4 cu. ft. CH_4 x 0.0423 = lbs CH_4 lbs CH_4 x 1.375 = lbs CO_2

of 1.375 (137.5%) to arrive at the corresponding weight of carbon dioxide produced in lbs. The amount of methane gas generated through two-phase anaerobic digestion may be found by multiplying the volatile solids weight of the biowastes in lbs by 12 to arrive at the cubic feet of methane gas produced in lbs.

Other sometimes handy mathematical relationships are:

1 Ton VS/Day produces 24,000 CH_4/Day from two-phase anaerobic digestion
1 Ton VS/Day produces 0.508 Tons CH_4/Day from two-phase anaerobic digestion
1 Ton VS/Day produces 0.698 Tons CO_2/Day from two-phase anaerobic digestion
1 Ton CH_4/Day used for electricity generation produces 2.75 Tons CO_2/Day
83,780 CH_4/Day produces 1 MW of simple cycle electricity power generation

Enclosed Photobioreactor for Spirulina Microalgae Production

The enclosed photobioreactor consists of a 2,200,000 foot long 12"Ø clear schedule 40 PVC pipe spiral wrapped externally with ultra high efficiency long lasting (10 years +) light emitting diode lighting for continuous photosynthesis. A small portion of the Spirulina microalgae produced will be continuously recycled to the start of the photobioreactor to provide the required seed to enable continuous Spirulina microalgae production. Electricity requirements = 6.0 MW for the lighting and associated recirculation pumping equipment.

The photobioreactor will receive 100% of the carbon dioxide gas output of the two-phase anaerobic digester and 100% of the carbon dioxide gas output from electricity generation. In addition, it will receive 100% of the output of macronutrients from the reverse osmosis treatment equipment deployed downstream from the two-phase anaerobic digester. The Spirulina microalgae require both carbon dioxide and macronutrients to maximize their rate of growth. The photobioreactor will be operated at a temperature of 35ºC (95ºF) and a pH of 9.4 to further optimize Spirulina microalgae rate of growth. Please refer to attached WSE Drawing Nos. S-6099-1 and S-9900-1 for additional information.

Spirulina will be produced using photosynthesis in the same manner that has existed for billions of years in the oceans of the world. The photosynthesis reaction is:

$$6\ H_2O + 6\ CO_2 + \text{photons} \xrightarrow{\text{Chlorophyll}} C_6H_{12}O_6 + 6\ O_2$$
$$\text{water + carbon dioxide + light energy} \rightarrow \text{glucose carbohydrate + oxygen}$$

The chemical mass balance of the above equation becomes :

$$108\text{ gm } H_2O + 264\text{ gm } CO_2 \rightarrow 180\text{ gm glucose carbohydrate} + 192\text{ gm } O_2$$
$$\text{total of 372 gm reactants} \rightarrow \text{total of 372 gm products}$$

For each 264 grams of CO_2 reacted 180 grams of glucose carbohydrate and 192 grams of O_2 will be produced. For each ton of CO_2 reacted, 180/264 or 0.682 tons of glucose carbohydrates and 192/264 or 0.73 tons of O_2 will be produced. Glucose carbohydrates equate to Spirulina microalgae, a plant type material called phytoplankton.

One Ton CO_2/Day Produces 0.682 Tons Of Glucose Carbohydrates/Day (Spirulina Microalgae)

Respiration occurs in the Mitochondria of cells. It is almost the exact opposite reaction to photosynthesis. These two reactions work together to maintain a biological balance on earth. The respiration reaction is:

$$C_6H_{12}O_6 + 6\ O_2 \xrightarrow{\text{Mitochondria}} 6\ H_2O + 6\ CO_2$$

It is generally believed that photosynthesis occurs only during periods of sunlight (or

artificial light) and that respiration occurs only during periods of darkness. Horticulture studies have established that several, but not all, species of plants can be grown under continuous lighting. The same studies have established that photosynthesis and respiration can and do occur simultaneously under continuous lighting conditions. Plants are multi-cell and capable of learned behavior whereas Spirulina microalgae are single cell plants and therefore totally incapable of acquiring learned behavior. Spirulina microalgae can therefore be grown under continuous lighting conditions even though they have never been exposed to continuous lighting conditions for billions of years. Continuous lighting therefore approximately doubles total Spirulina growth relative to day/night growth rates.

The glucose produced during photosynthesis contains about 6% lipids (fats). Lipids are efficiently converted into biodiesel through a transesterification process. Each ton of CO_2 will simultaneously produce 0.68 tons glucose carbohydrates x 0.06 = 0.04 tons biodiesel and 1.0 – 0.04 = 0.96 tons of byproduct biowastes. 100% of the byproduct biowastes will consist of volatile solids. One ton CO_2/Day can therefore produce 0.04 tons biodiesel/Day. At a specific gravity of 0.88 this is equivalent to 0.04 tons x 2,000 lbs/ton divided by 0.88 specific gravity = 90.91 gallons/day. The same one ton CO_2/Day will produce 0.96 tons x 2,000 lbs/ton = 1,920 lbs volatile solids/day or 21.12 lbs volatile solids/gallon of biodiesel produced/day.

One Ton CO_2/Day Produces 0.04 Tons Biodiesel/Day

One Ton CO_2/Day Produces 0.96 Tons Volatile Solids/Day

One Ton CO_2/Day Produces 90.91 Gallons Of Biodiesel/Day

Each Gallon of Biodiesel Produced Produces 21.12 lbs of Volatile Solids

Biodiesel Production

All biodiesel produced will fully comply with American Society for Testing and Materials (ASTM) Standard Specification D 6751-03. The referenced specification is attached to the prefeasibility study.

The amount of biodiesel produced is directly dependent on the amount of Spirulina microalgae produced. The amount of Spirulina microalgae produced is directly dependent on the amount of carbon dioxide gas that is added to the photobioreactor. Since carbon dioxide gas is produced by electricity generation, two-phase anaerobic digestion, and cement production, the total amount of CO_2 produced must be determined from each source.

Source No. 1: Electricity Generation:

30 MW of electricity will be produced for the community initiative. Another 21.5 MW of electricity will be used internally for the photobioreactor, air liquefaction, methane gas compression, tilapia fish lighting, pig production, and general building use. The total amount of electricity produced therefore equals 30 MW + 21.5 MW = 51.5 MW.

When generating electricity CO_2 is produced according to the following combustion equation:

$$CH_4 + 2O_2 + 7.52\ N_2 \rightarrow CO_2 + 2H_2O + 7.52\ N_2 + \text{heat}$$

methane + oxygen + nitrogen → carbon dioxide + water + nitrogen

The chemical mass balance of the above equation becomes:

$$16\text{ gm } CH_4 + 64\text{ gm } O_2 + 105\text{ gm } N_2 \rightarrow 44\text{ gm } CO_2 + 36\text{ gm } H_2O + 105\text{ gm } N_2$$

total of 80 gm reactants → total of 80 gm products

Please note that nitrogen is not a reactant as it does not participate in the reaction. For each ton of CH_4 used for electricity generation a total of 44/16 or 2.75 tons of CO_2 will be produced along with a total of 36/16 or 2.25 tons of H_2O. 2.25 tons of H_2O is, in turn, equivalent to 2.25 tons H2O x 2,000 lbs/ton = 4,500 lbs ÷ 8.34 lbs/gallon = 540 gallons of water.

1 Ton CH_4 Produces 2.75 Tons CO_2 From Electricity Generation

1 Ton CH_4 Produces 2.25 Tons H_2O From Electricity Generation

1 Ton CH_4 Produces 540 Gallons Of Water From Electricity Generation

51.5 MW Of Electricity

If 51.5 MW of electricity is produced to provide energy independence within the Community Initiative, a total of 51.5 MW x 83,780 CH_4/Day/MW = 4,314,670 cubic feet of methane gas will have to be used each day. At 24 cubic foot/lb, the methane usage translates into 4,314,670 cu. ft. CH_4/24 = 179,778 lbs/2,000 = 89.89 Tons CH_4/Day. Since each ton of CH_4 produces 2.75 Tons of CO_2 the generation of 51.5 MW of electricity produces 89.89 x 2.75 = 247.0 Tons of CO_2/Day due to the generation of electricity. Since each ton of CH_4 produces 2.25 Tons of H_2O, the generation of 51.5 MW of electricity also produces 89.89 x 2.25 = 202 Tons of H_2O/Day. Source No. 2: Two-Phase Anaerobic Digestion: To determine the amount of CO_2 produced first requires a determination of the amount of CH_4 produced as CH_4 production directly determines CO_2 production by a factor of 1.375. To determine the amount of CH_4 produced first requires the amount of volatile solids that are treated as each lb of volatile solids x 12 = cu. ft. CH_4 produced. The volatile solids available from MSW processing are 60.0 Tons/Day as listed above. The volatile solids available from pig farming are 27.0 Tons/Day as listed above. The volatile solids available from pork processing are 22.6 Tons/Day as listed above. The volatile solids available from tilapia fish farming are 1.4 Tons/Day as listed above. The volatile solids available from tilapia fish processing are 194.5 Tons/Day as listed above. The total volatile solids available as listed above = 60.0 + 27.0 + 22.6 + 1.4 + 194.5 = 305.5 Tons CH_4/Day. 305.5 Tons CH_4/Day x 1.375 = 420.1 Tons CO_2/Day. The project building will engage in the manufacturing of cement. Carbon dioxide is produced in cement making as a result of the production of a process ingredient called 'Clinker'. Clinker is made when limestone is heated to produce lime. Substantial amounts of carbon dioxide are simultaneously formed during this reaction. The final amount of carbon dioxide produced varies depending on the type of cement being made. Each project building will be manufacturing 300 Tons/Day of Portland type cement. According to the *Annual Review of Energy and the Environment,* (Vol. 26: pp 303-329, November 2001) average CO_2 emissions/Ton from cement production = 448 lbs. At a cement production rate of 300 Tons/Day the total carbon dioxide emissions = 300 Tons/Day x 448 lbs CO_2/Ton = 134,400 lbs/Day ÷ 2,000 lbs/Ton = 67.2 Tons CO_2/Day. Adding this amount of CO_2 to the above total of 420.1 Tons CO_2/Day = 487.3 Tons CO_2/Day that will be produced from electricity generation, two-phase anaerobic digestion of volatile solids feedstocks, and cement production. Since each ton of CO_2 produces 0.682 Tons of Spirulina microalgae 487.3 Tons CO_2/Day produces 487.3 x 0.682 = 332.3 Tons Spirulina microalgae/Day. 75% or 249.2 Tons Spirulina/Day will be used for feeding tilapia fish and pigs. The remaining 25% or 83.1 Tons Spirulina/Day will be used in the production of biodiesel (B100). 83.1 Tons Spirulina production is the equivalent of 25% of 487.3 Tons CO_2/Day or 121.8 Tons CO_2/Day. 249.2 Tons Spirulina production is the equivalent of 75% of 487.3 Tons CO_2/Day or 365.5 Tons CO_2/Day. Since one ton CO_2/Day produces 0.682 Tons of Spirulina microalgae, 108.3 Tons CO_2/Day produces 108.3 x 0.682 = 73.86 additional tons of Spirulina microalgae increasing its production from 295.5 Tons/Day to 369.4 Tons/Day. Since one ton CO_2/Day produces 0.04 tons biodiesel/day, 121.8 Tons CO_2/Day produces 121.8 x 0.04 tons = 4.87 tons biodiesel/Day. At a specific gravity of 0.88 this is equivalent to 4.87 tons x 2,000 lbs/ton divided by 0.88 specific gravity = 11,073 gallons/day.	Produces 247.5 Tons Of CO_2/Day 51.5 MW Of Electricity Produces 89.89 Tons Of CH_4/Day 332.3 Tons Spirulina Microalgae Produced/Day 18,381 Gallons Of Biodiesel Produced/Day 58.5 Tons CH_4/Day plus 38.6 Tons CH_4/Day = 97.1 Tons CH_4 Produced/Day From Biodiesel Production

Since each gallon of biodiesel produced generates 21.12 lbs of volatile solids, 11,073 gallons x 21.12 = 233,856 lbs. Volatile Solids/Day. 233,856 lbs Volatile Solids/Day ÷ 2,000 lbs/Ton = 116.9 Tons Volatile Solids/Day. The 116.9 Tons Volatile Solids/Day from biodiesel production can be converted into CO_2 production by multiplying the Volatile Solids by 12 to determine cu. ft. of methane gas produced. Cu. ft. of methane gas produced ÷ 24 cu. ft./lb = lbs methane gas. Lbs. methane gas multiplied by 1.375 = lbs CO_2 produced or 116.9 Tons VS/Day x 2,000 lbs/Ton x 12 = 2,806,272 cu. ft. CH_4/Day. 2,806,272 cu. ft. ÷ 24 cu. ft./lb = 116,928 lbs CH_4/Day. 116,928 lbs CH_4/Day x 1.375 = 160,776 lbs CO_2/Day. 160,776 lbs CO_2/Day ÷ 2,000 lbs/Ton = 80.4 Tons CO_2/Day.

Since one ton CO_2/Day produces 0.04 tons biodiesel/day, 80.4 Tons CO_2/Day produces 80.4 x 0.04 tons = 3.22 tons biodiesel/Day. At a specific gravity of 0.88 this is equivalent to 3.22 tons x 2,000 lbs/ton divided by 0.88 specific gravity = 7,308 gallons biodiesel/day thus increasing biodiesel production from 11,073 GPD to 18,381 GPD.

Since the basic waste-to-energy process fully satisfies electricity demand the excess methane gas will be beneficially used for:

1. The production of methanol through syngas technology that is used as a required feedstock in the production of biodiesel biofuel,
2. The production and sale of compressed natural gas (CNG) biofuel surface transportation fuel, and
3. The production and sale of renewable natural gas biofuel to the marketplace.

Pig and Tilapia Fish Feed Requirements:

The 10,000 sow operation will produce 75.34 Tons/Day of finished hogs. It takes about 1.2 lbs of feed to increase a pig's weight by 1.0 pound. The 75.34 Tons of finished hogs will require 75.34 x 1.2 or 90.41 Tons of feed per Day. The production of tilapia fish is 335 Tons/Day. It takes about 1.2 lbs of feed to increase the fish weight by 1.0 pound. The 335 Tons of finished fish will require 335 x 1.2 or 402 Tons of feed per Day. Combined feed requirements are 90.41 + 402 = 492.4 Tons feed/Day. Spirulina microalgae production at 332 Tons feed/Day will mostly satisfy pig and tilapia fish feed requirements. As the MSW volume increases the volume of Spirulina microalgae will automatically increases. It won't take much of an increase in MSW volume to fully satisfy total feed requirements.

If the percentage of Spirulina microalgae use is changed from 75%-25% to 90%-10% sufficient feed would be produced at the expense of reducing the production of biodiesel. The preferred initiative is to increase collection of MSW biowastes by excavating area landfills and dumps for the purpose of treating their contents with two-phase anaerobic digestion to increase the associated production of Spirulina microalgae. In so doing, the volume of biodiesel production could remain the same.

Subtotal Methane (CH_4) Gas Production From Municipal Solid Wastes (MSW):		
	60 Tons/Day Total Volatile Solids x 2,000 lb/Ton x 12 Cubic Feet (CF)/lb = 1,440,000 cu. ft./Day. 1,440,000 cu. ft. CH_4/Day ÷ 24 lbs/cu. ft. = 60,000 lbs. 60,000 lbs ÷ 2,000 lbs/Ton = 30 Tons CH_4/Day	1,440,000 cu. ft. CH_4/Day = 30 Tons CH_4/Day From MSW
Subtotal Methane (CH_4) Gas Production From Biodiesel Processing Wastes:		
	4,659,366 cu. ft. CH_4/Day ÷ 24 cu. ft./lb = 194,140 lbs. 194,140 lbs ÷ 2,000 lbs/Ton = 97.1 Tons CH_4/Day	97.1 Tons CH_4/Day From Biodiesel Wastes
Subtotal Methane (CH_4) Gas Production From Pig Farming Wastes:		
	27 Tons/Day Total Volatile Solids x 2,000 lb/Ton x 12 Cubic Feet (CF)/lb = 648,000 cu. ft./Day. 648,000 cu. ft. CH_4/Day ÷ 24 lbs/cu. ft. = 27,000 lbs.	648,000 cu. ft. CH_4/Day = 13.5 Tons

	27,000 lbs ÷ 2,000 lbs/Ton = 13.5 Tons CH_4/Day	CH_4/Day From Pig Farming Wastes
Subtotal Methane (CH_4) Gas Production From Pork Processing Wastes:		
	22.6 Tons/Day Total Volatile Solids x 2,000 lb/Ton x 12 Cubic Feet (CF)/lb = 542,400 cu. ft./Day. 542,400 cu. ft. CH_4/Day ÷ 24 lbs/cu. ft. = 22,600 lbs. 22,600 lbs ÷ 2,000 lbs/Ton = 11.3 Tons CH_4/Day	542,400 cu. ft. CH_4/Day = 11.3 Tons CH_4/Day From Pork Processing Wastes
Subtotal Methane (CH_4) Gas Production From Tilapia Fish Farming Wastes:		
	1.4 Tons/Day Total Volatile Solids x 2,000 lb/Ton x 12 Cubic Feet (CF)/lb = 33,600 cu. ft./Day. 33,600 cu. ft. CH_4/Day ÷ 24 lbs/cu. ft. = 1,400 lbs. 1,400 lbs ÷ 2,000 lbs/Ton = 0.7 Tons CH_4/Day	33,600 cu. ft. CH_4/Day = 0.7 Tons CH_4/Day From Tilapia Fish Farming Wastes
Subtotal Methane (CH_4) Gas Production From Tilapia Fish Processing Wastes:		
	194.5 Tons/Day Total Volatile Solids x 2,000 lb/Ton x 12 Cubic Feet (CF)/lb = 4,668,000 cu. ft./Day. 4,668,000 cu. ft. CH_4/Day ÷ 24 lbs/cu. ft. = 194,500 lbs. 194,500 lbs ÷ 2,000 lbs/Ton = 97.3 Tons CH_4/Day	4,668,000 cu. ft. CH_4/Day = 97.3 Tons CH_4/Day From Tilapia Fish Processing Wastes
Total Methane (CH_4) Gas Generation from all sources:		249.9 Tons CH_4/Day
OAT Process Power Generation Potential:		
	249.9 Tons CH_4/Day x 2,000 lbs/Ton = 499,800 lbs/Day. 499,800 lbs/Day x 24 cu. ft./lb = 11,995,200 cu. ft./Day. 11,995,200 cu. ft./Day ÷ 83,780 cu. ft./MW = 143 MW. 143 MW less 15% parasitic digester plant use = 122 MW Net	122 MW Net
	Two-Phase Anaerobic Digester Size Calculations:	
	Volatile Solids = 249.9 Tons/Day x 2,000 lbs/Ton = 499,800 lbs/Day	
	VS:COD = 1:2, COD = 999,600 lbs/Day	
	Organic Loading lbs COD/Day/Cubic Foot = 6	
	Digester Size = 999,600/6 = 166,600 Cubic Feet	
	Digester Size In Gallons = 1,246,335 Gallons	
	Safety Factor = 1.5	
	Digester Size = 1,869,502 Gallons (120' x 120' x 20'H)	
	Estimated Constructed Cost At US$40/Gallon = $74,780,080	
	Building Size: 1 km (3,280') x 1 km (3,280') x 3 - 50' stories high w/3 side double wall construction to accommodate photobioreactor and employee housing = 50,000,000 total sq. ft. of precast concrete construction estimated @ US$1.50/sq. ft. = US$75,000,000. Project building will manufacture its own cement and will purchase a ready mix plant (3 concrete delivery/mixer trucks) to minimize precast concrete panel construction costs.	
	Remanufactured 300Tons/Day Cement Kiln Purchase Cost = US$12,000,000	
	Remanufactured Ready Mix Batch Plant Purchase Cost = US$3,000,000	
	Photobioreactor: 2,200,000 foot long 12"Ø Clear PVC schedule 40 pipe = US$100,000,000 to includes ultra high efficiency long lasting (10 years +) light emitting diode (LED) lighting for photosynthesis @ US$10,000,000 Electricity requirements = 6.0 MW	
	10 MGY Biodiesel Manufacturing Equipment Cost Estimate: US$15,000,000. Electricity Requirements = 0.5 MW	

	Two (2) 110 GPM 4:2:1 Array Reverse Osmosis Equipment Cost Estimate: US$2,000,000	
	Digester Equalization Feed Tank Cost Estimate: $2,000,000 w/Equalization Tank Size = 120' x 120' x 20' H, 2,000,000 Gallon Capacity	
	Potable Water Tank Cost Estimate: $2,000,000 w/Equalization Tank Size = 120' x 120' x 20' H, 2,000,000 Gallon Capacity	
	Anaerobic Digester Feed Tank Cost Estimate: $2,000,000 w/Equalization Tank Size = 120' x 120' x 20' H, 2,000,000 Gallon Capacity	
	Liquefied Nitrogen Storage Tank Cost Estimate: $2,000,000 w/Equalization Tank Size = 120' x 120' x 20' H, 2,000,000 Gallon Capacity	
	Liquefied Natural Gas (LNG) Storage Tank Cost Estimate: $2,500,000 w/Equalization Tank Size = 120' x 120' x 20' H, 2,000,000 Gallon Capacity	
	EAF Steel Recycling Process Equipment Cost: US$3,000,000	
	12,000,000 CFD Compressed Methane Gas (CNG) Equipment Cost Estimate = US$10,000,000. Electricity Requirements = 2 MW	
	221 Ton/Day Liquefied Nitrogen Air Separation Equipment Cost Estimate: $20,000,000. Electricity Requirements = 10 MW	
	Liquefied Nitrogen Delivery Equipment: US$500,000	
	10,000 Sows Procurement Cost Estimate @ US$500/Sow = US$5,000,000	
	220,000 pigs/year (603 pigs/day) Swine Processing Equipment Cost Estimate: US$5,000,000	
	51.5 MW Natural Gas Fueled Combined Cycle Power Generation Equipment @ US$1,260/kW = 51,500 kW x US$1,100 = US$65,000,000	
	Total Electricity Generation Requirements:	
	For each project building: 51.5 MW (includes projected demand for the next 20 years	
	For Photobiorector = 6.0 MW	
	For Compressed Natural Gas (CNG) = 2 MW	
	For Liquefied Nitrogen (LN2)(LIN) = 10 MW	
	For Liquefied Oxygen = Included with Liquefied Nitrogen	
	For Tilapia Farming = 0.5 MW	
	For Pig Farming = 2 MW	
	For General Building use = 2 MW	
	Total Electricity Installed Capacity Requirements = 51.5 MW	
	122 MW potential less 51.5 MW used = 70.5 MW remaining. At 83,779 cu. ft./MW, 83,779 cu. ft. x 70.5 MW = 5,906,420 cu. ft./Day available to marketplace at US$0.70/126.67 cu. ft. or US$32,640/Day as CNG automotive fuel. If sold to a natural gas pipeline the revenue would be slightly less by about 10%. If Argentina increases the marketplace price of natural gas some sales to natural gas pipelines would be considered.	

Schedule of Project Construction Costs:		
	Anaerobic Digester Feed Tank: US$2,000,000	
	Biodiesel Manufacturing Equipment: US$15,000,000	
	Building Size: 1 km x 1 km x 3 Stories High Constructed Cost: US$75,000,000	
	Cement Kiln Constructed Cost: US$12,000,000	
	Concrete Ready Mix Plant Constructed Cost = US$3,000,000	
	EAF Steel Recycling Process Equipment Constructed Cost: US$3,000,000	
	LED Lighting Purchase Cost: US$10,000,000	
	Liquefied Natural Gas (LNG) Storage Tank: US$2,500,000	
	Liquefied Nitrogen Air Separation Equipment: US$15,000,000	
	Liquefied Nitrogen Delivery Equipment: US$500,000	
	Liquefied Nitrogen Storage Tank: US$2,000,000	
	Methane Compression Equipment: US$10,000,000	
	Photobioreactor: US$100,000,000	
	Potable Water Storage Tank Constructed Cost: US$2,000,000	
	Power Generation Equipment: US$56,650,000	
	Reverse Osmosis Equipment: US$2,000,000	
	Sow Procurement Costs: US$5,000,000 Electricity Requirements = 2.0 MW	
	Tilapia Fish Farming Acreage: 50 hectares x 24' H Tilapia Fish Farming Production: lbs/day = 281,400 of tilapia filets Tilapia Fish Farming Electricity Requirements = 0.5 MW Fish Processing Equipment: US$500,000	
	Two-Phase Anaerobic Digester: US$37,390,000	
	Subtotal Project Construction Costs: US$353,540,000	
	Add 15% Contingencies @ 53,031,000 = US$406,571,000	
	Total Project Construction Costs:	**US$443,961,080**
Project Visible Cash Flow Revenue Streams:		
	From Sanitary Wastewater – US$0.00	
	From Municipal Solid Wastes – US$0.00	
	From Agro Wastes – US$0.00	
	From Animal Wastes – US0.00	
	From Electricity: 44 MW x 24 = 720 MWh/Day @ US$45.00/MWh = US$47,520/Day. This amount of electricity generation will provide the average demand load of the participating communities for the next 20 years.	**US$47,520/Day**
	From Biodiesel: 18,381 GPD always priced at 80% of existing marketplace retail. Current retail is US$1.67/gallon. US$1.67 x 80% = US$1.34. 18,381 x US$1.34 = US$24,630/Day.	**US$24,630/Day**
	From Liquefied Nitrogen (LN2)(LIN): 244,003 GPD priced at US$0.50/gallon = US$122,000.00/Day.	**US$122,000/Day**
	From Compressed Natural Gas (CNG) Fuel:	**US$32,640/Day**
	From Processed Pork Exports: Retail pork prices are currently around US$2.87/lb. The wholesale producer receives about 43% of this price or US$1.46/lb. The above prices represent the average for the last 3 years. As a commodity there is no guarantee they will drift up or down but will likely continue to fluctuate as they have been for the last 50 years. Current marketplace dressed pork yields are over 2,750 lbs/year/sow. A 10,000 sow farrow-to-finish operation is estimated to produce 27,500,000 lbs of dressed pork/year or an average of 75,342 lbs/Day. At US$1.46/lb the daily revenue	

	is estimated at US$110,000.00.		US$110,000/Day
	From Fresh Tilapia Filet Exports: US$613,452 at a sell price of US$2.18/lb		US$613,452/Day
	Renewable Energy and other Credits based on estimated 36 MW Project Power Generation:		
		One Certified Emission Reduction Credit = 1 Tonne CO_2 Reduction. 51.5 MW Project Power Production x 24 hour/Day = 1,236 MWh/Day. 1,236 MWh/Day x 1,100 lbs CO_2 Reduction (using natural gas)/MWh ÷ 2,000 lbs/Ton = 680 Tons/Day = 248,000 T/Year x 2,000/2,204 = 225,226 Tonnes/Year @ US$20 (range of US$20-US$40) = US$4,504,000/Year ÷ 365 = US$12,341/Day for years 2008-2012 delivery.	US$12,341/Day
Total Project Revenue Streams:			US$962,583/Day
To the extent that electricity is generated, the combustion off gases (CO_2, NOx, N_2, and H2O) will be entirely used for Spirulina microalgae production. After Spirulina microalgae production has occurred the remaining Nitrogen gas (N_2) will be liquefied and sold to the marketplace. The remaining N_2 gas stream will also contain Oxygen gas (O_2) due to the respiration of microalgae during their production in the same manner that trees and plants give off oxygen. This oxygen will be simultaneously liquefied during the liquefaction of N_2 and subsequently distilled off, compressed, and subsequently used internally as a welding gas, to enhance cement manufacturing, to enhance fish farming, and for smelting iron into steel. Some of the Nitrogen Gas will be used as a protective blanket gas in the production of methanol through syngas technology. The methanol is produced as a required feedstock in the production of biodiesel.			

Additional Notes:

1. **Land Requirements: Estimate 300 hectare**

2. **Time to design-build-install-operate is estimated at 36 months.**

3. **Lighting for tilapia must be a daily cycle of:**
   7.5 hours of total darkness
   0.5 hours of sunrise (begins at 6 a.m. w/3 ft-candles)
   15.5 hours of daylight (max 10 ft-candles)
   0.5 hours of sunset (begins at 10 p.m. w/3 ft-candles)

4. **Sufficient building room remains to add a 10,000 beef cattle operation, a 10,000 milker dairy farm, and significant poultry operations along with all of the associated processing equipment to produce value added products consisting of dressed beef, milk, and other dairy products, broilers, and eggs. All of these activities represent future economic development activities.**

Nonrecourse Project Capital Cost Structure

United Kingdom

BioWastes-To-Renewable Energy, Food, BioFuels, and Water Independence Plant

The total estimated capital and development costs of the design-build-own-operate wastes-to-renewable energy project total $3,013,608,809 (plus funding broker commissions) utilizing both new and remanufactured process equipment. The major components of capital and other costs are as follows:

Item Description	Cost in US$
Anaerobic Digester Feed Tank Constructed Cost[1]	2,000,000
Biodiesel Manufacturing Equipment Constructed Cost[2]	15,000,000
Building Size 2 km x 2 km x 200 m high Constructed Cost[3]	2,059,282,092
Cement Kiln Constructed Cost[4]	12,000,000
Concrete Ready Mix Batch Plant Constructed Cost[5]	3,000,000
EAF Steel Recycling Process Equipment Constructed Cost	3,000,000
Fish Processing Equipment Constructed Cost[6]	500,000
LED Lighting Purchase Cost[8]	10,000,000
Liquefied Nitrogen Air Separation Equipment Procurement Capital Cost	15,000,000
Liquefied Nitrogen Delivery Equipment Procurement Capital Cost	500,000
Liquefied Nitrogen Storage Tank Constructed Cost	2,000,000
LNG (Liquefied Natural Gas) Storage Tank Constructed Cost	2,500,000
Methane Gas Compression Equipment Installed Capital Cost	10,000,000
Potable Water Storage Tank Constructed Cost	2,000,000
Photobioreactor Capital Equipment Constructed Cost[7]	100,000,000
Power Generation Equipment Procurement Cost[9]	56,650,000
Reverse Osmosis Equipment Procurement Cost	2,000,000
Sow procurement Costs	5,000,000
Two-Phase Anaerobic Digester Constructed Cost[1]	74,780,080
Subtotal Project Costs	**2,375,212,172**
Add 15% Contingencies	356,281,825
Total Capital Costs	**2,731,493,997**
Finance Charges	40,000,000
Interest During Construction	60,000,000
Administration/Legal	150,000
Permitting	20,000
Technology & Development Cost	1,750,000,000
Project Development Fee @ 3% of US$2,731,493,997	81,944,812
Working Capital	100,000,000
Total All Costs	**4,763,608,809**

Nonrecourse Project Financing Will Be Structured As Follows:

Developer Equity as Technology, 70%[10]	1,750,000,000
Investor Equity as Cash, 30%	550,000,000

Finance	2,463,608,809
Loan Term, Years	10
Interest Rate	10%
Developer will contribute 70% equity in the project as the value of the technology.[10]	
Investor will contribute US$550,000,000 cash and the balance will be financed.	

With Following Notes:

1. **The anaerobic digester and its associated feed tank will be constructed of precast concrete panels. The panels will be manufactured by Wieser Concrete Products, Inc. and barge shipped to destination project site. The Wisconsin based precast concrete manufacturer POC is Phil Miller @ phone 800.325.8456 (see http://www.wieserconcrete.com/about.html).**

2. **The biodiesel production equipment will be designed and manufactured by California based R. C. Costello & Associates, Inc. The POC is Rocky Costello, P.E. @ phone 310.792.5870 (see http://www.rccostello.com/).**

3. **The low cost of the project building is made possible by the 100% internal recycling of inorganic wastes that are produced from the anaerobic digestion process. These inorganic wastes are combined with cement and water in the production of precast concrete panels. The special purpose project company will produce its own cement to further minimize construction costs. See attached WSE Engineering Drawing No. S-6099-1 for additional details. The POC at WaterSmart Environmental is Chuck Steiner @ 913.897.2727 (see http://www.watersmart.com/).**

4. **The cement kiln will be sourced through Canada based Cement Process Consulting, Ltd. The POC is Ken Postle @ phone 403.472.4519 (see http://www.cement-process.com/index.htm).**

5. **The concrete ready mix plant will be sourced through Canada based Cement Process Consulting, Ltd. The POC is Ken Postle @ phone 403.472.4519 (see http://www.cement-process.com/index.htm).**

6. **The fish production and processing equipment will be sourced through Colorado based Fisheries Technology Associates, Inc. The POC is Bill Manci @ phone 970.225.0150 (see http://www.ftai.com/).**

7. The enclosed photobioreactor consists of 2 miles long 12"Ø clear PVC pipe. A possible supplier is Harvel Plastics, Inc. but other sources will be considered prior to procurement (see http://www.harvel.com/).

8. The artificial lighting for the photobioreactor consists of 5 miles of high efficiency long lasting (10 years or more) light emitting diode (LED) lighting that will be wrapped barber pole fashion around the clear PVC pipe. A possible supplier is Light Waves Concept, Inc. but other sources will be considered prior to procurement (see http://www.lightwavesconcept.com/).

9. The power generation equipment will be sourced through UK based Combustion, Energy & Steam Specialists, Ltd. The POC is Mike Craigie @ phone +44 (0) 1856 851177 (see http://www.cess.co.uk/).

10. The seemingly high percentage of developer equity as technology is justified on the basis that it is the only economic development technology that simultaneously achieves:

- **100% compliance with Kyoto Protocol thus helping to reverse global warming,**
- **Distributed Biofuels (biodiesel and compressed natural gas or CNG) independence,**
- **Distributed Food independence,**
- **Distributed Renewable energy independence,**
- **Distributed Water independence, and**
- **Complete internal recycling of all byproducts and waste streams thereby producing a useful product—namely precast concrete products that will be used for constructing the project building itself as well as infrastructure roads, light rail transit surface transportation system, precast concrete potable water distribution system, precast concrete wastewater collection system, and precast concrete encased renewable energy power distribution system. In doing so the community initiative project will become the very first zero carbon and zero waste community in the world.**

Climate Change has now become the most serious worldwide concern as the sustainability of our planet appears to be at rapidly increasing risk. Renewable Energy Technologies that address climate change are therefore in great demand. Technologies that address both climate change and substantial economic development are in even greater demand. The proposed waste-to-energy technology has required over 30,000 hours of research over a 10 year period to develop thus fully justifying the seemingly high percentage of developer equity as technology. It is the very first and only worldwide technology that is technically capable of simultaneous distributed energy independence, distributed food independence, distributed fuels independence, and distributed water independence with all in full compliance with Kyoto Protocol.

The proposed wastes-to-renewable energy technology consists of a suite of individual component technologies. The individual component technologies are:

- **Biodiesel Production With Associated Waste Processing. The National Renewable Energy Laboratory (NREL) pioneered the very first production of biodiesel from microalgae. The research and development was carried out under the "Aquatic Species Program" (ASP) that consisted of the first production of a biofuel called "algal biodiesel" (see http://www1.eere.energy.gov/biomass/pdfs/biodiesel_from_algae.pdf). Under the referenced program Algal Biodiesel was produced through the growing of microalgae for their lipid content. The lipid content was then converted into biodiesel through chemical transesterification in the same manner that soybeans and other vegetable oils are now being converted into biodiesel. The ASP funding totaled $25.05 million over a 20 year period that began in 1978. Continuation funding was ultimately terminated when it was officially determined that algal biodiesel could not be produced economically. The ASP obtained its research data from growing microalgae in warm open ponds (Salton Sea in Southern California) at a pH of 8.2 using atmospheric carbon dioxide. The Salton Sea is the recipient of agricultural runoff nutrients as well as additional nutrients contained in municipal sewage treatment plants discharges. The project building will produce microalgae within an enclosed photobioreactor that will operate at the optimum growing temperature of 35ºC (95ºF) and at the optimum growing pH of 9.4. Photosynthesis will occur 24/7 rather than just during daylight hours by using long lasting light emitting diode (LED) lighting. The photobioreactor will receive the total carbon dioxide output from both the anaerobic digester as well as the power generation equipment thus substantially increasing production over that obtainable from using carbon dioxide from the atmosphere. Microalgae production will be further increased by adding the micronutrients contained in the reverse osmosis concentrate stream thus substantially improving microalgae production. The total increase of these process modifications over that obtained by the National Renewable Energy Laboratory's ASP is estimated at a factor of at least 1000 to 1. By producing the microalgae within an enclosed photobioreactor the technology becomes totally compliant with Kyoto Protocol since all discharges of greenhouse gases to the environment are eliminated.**

- **Cement manufacturing as a technology has been practiced for many hundreds of years throughout the entire civilized world.**

- **Fish farming was first practiced by the Chinese over 100 years ago. Due to the over fishing of the oceans fish farming is now widespread throughout the entire civilized world.**

- **Precast concrete panels and piping have been manufactured for the last 50 years. The use of precast concrete panels has become quite popular in the building industry during the last 10 years.**

- **Liquefied Nitrogen and Liquefied Oxygen have been produced in the marketplace for the last 50 years. Names of today's largest industrial suppliers consist of Air Liquide, Air Products & Chemicals, Inc., Cryogenic Industries, Inc., Gas Systems Corporation, and Praxair, Inc.**

- **Methane gas-to-methanol alcohol through synthesis gas (syngas) technology represents the standard method of producing methanol throughout the civilized world.**

- **Microalgae production through the use of a photobioreactor (use of artificial light rather than sunlight) is now being done at several research institutions. The technology has yet to be put into full scale commercial operation.**

- **The anaerobic digestion of municipal solid wastes (MSW) was first accomplished by two-phase anaerobic digestion in 1996 (see http://lib.kier.re.kr/caddet/retb/no66.pdf). More recently the management of municipal solids wastes is being accomplished using conventional anaerobic digestion by Waste Management, Inc., a waste management company (see http://www.wm.com/WM/environmental/Bioreactor/technologies.asp).**

- **Precast concrete panels and precast concrete pipes have been manufactured for the last 50 years throughout the world.**

- **Renewable energy power generation has been practiced for at least 30 years in the EU and 20 years in the United States.**

- **Reverse osmosis treatment has been around on a commercial basis for over 30 years. During the last 5 years its marketplace costs have been halved and it is now considered very good and very affordable technology.**

United Kingdom Larger Building Prefeasibility Study, December 25, 2007	Totals
Location: United Kingdom	
Technology Provider: WaterSmart Environmental, Inc.	
Project Developer: POC: Phil Lusk Phone: 605.224.4334 email: plusk@pipeline.com	
Project Type: Economic Development through Design-Build-Own-Operate BioWastes-To-Renewable Energy, BioFuels, Organic Foods, and Potable Water Independence	
Project Dollar Size: US$3,013,608,809 billion for each 2 km x 2 km x 200m high shipbuilding-shipbreaking project building	
Number of shipbuilding-shipbreaking project buildings required: 3	
Shipbuilding-Shipbreaking Project Building Activities: 1. Extensive Agricultural Production and Processing that additionally includes renewable energy, biofuels, and water production along with 100% recycling of all byproducts into precast concrete panels and precast concrete piping for infrastructure development, and 2. The construction and sale of self-biofueled trains and locomotives, and 3. The construction and sale of self-biofueled concrete ships, and 4. The breaking of ships with concurrent waste and metals management, and 5. The construction and sale of tidal generators	
Jobs Creations Potential for each 2 km x 2 km x 200 m high shipbuilding/shipbreaking project building: 2,500	
BioWastes Treated: Biodiesel Processing Wastes, Construction & Demolition Wastes, Foods Production & Processing Wastes, Hazardous Wastes, Medical Wastes, Municipal Solid Wastes (MSW), and Petroleum Derived Shipbreaking Wastes	
Local Population Served for each 2 km x 2 km x 200 m high shipbuilding/shipbreaking project building: 50,000	
Residual Wastes to Landfill: Zero	
Greenhouse Gaseous Emissions to the Environment: Zero	
Climate Change Carbon Footprint: Zero	
Investor Internal Rate of Return: Optimal	
Note on Electricity Distribution: At the completion of the project 100% of the Nova Scotia electricity requirements will be provided thus eliminating the necessity for continued use of electric utility grid supplied electricity. After complete BioWastes-To-Renewable Energy, BioFuels, Organic Foods, and Potable Water Independence project implementation all electricity will be distributed at a sustainable US$0.045/kWh to all users regardless of kWh electricity usage amount or time of day when provided. Inexpensive electricity is absolutely necessary in every country to support meaningful industrial development. It is expected that the distribution of inexpensive electricity will strongly support much needed industrial development. Inexpensive electricity distribution is made possible by the extreme profitability of extensive agricultural production and processing in combination with extensive biofuels production.	
Detailed Project Description Extensive Agricultural Production in each project building will consist of a 100 hectare tilapia fish farming operation that is also sized to produce excess local marketplace demand for tilapia fish. The excess processed fish will be exported to distant markets to provide visible cash flow to the project. With a world population approaching 7 billion the fish output of a single project building calculates out to approximately 0.15% of worldwide demand of tilapia fish. A total of 1 ÷ 0.0015 = 666 project buildings would therefore be	

required to satisfy worldwide demand for tilapia fish. Worldwide consumption of fish data is attached. The marketing idea is to produce 100% of the local demand for fish with the entire excess of each sold to export markets for visible sales revenue.

In addition to agricultural production, each project building will produce Portland cement for the purpose of manufacturing precast concrete panels and piping for direct infrastructure development.

1. **In the production of cement considerable carbon dioxide gas is produced.**
2. **When processing biowastes using anaerobic digestion both methane gas and carbon dioxide gas are produced.**
3. **When generating renewable energy both water vapor and carbon dioxide gas are produced.**

100% of the carbon dioxide gas produced during the production of cement, the processing of biowastes, and the generation of electricity will be routed to an enclosed photobioreactor for the purpose of producing Spirulina microalgae. 75% of the Spirulina microalgae will be used as animal feed in the production of tilapia fish. The remainder 25% will be converted into biodiesel biofuel (B100) and sold locally to produce visible sales revenue.

Spirulina microalgae contain about 6% lipids (fats). The production of biodiesel produces about 6% lipid (fat) conversion into biodiesel biofuel from Spirulina microalgae. The 94% remaining biowastes are returned to the anaerobic digester to produce additional methane gas and carbon dioxide gas. The resulting methane gas produced can be used for power generation or sold as a biofuel. The resulting carbon dioxide gas produced from electricity generation will be automatically routed to the enclosed photobioreactor to enable production of additional Spirulina microalgae.

The economic development objective is to produce 100% of the local demand for electricity, 100% of the local demand for biodiesel biofuel, 100% of the local demand for natural gas (methane gas is a near equivalent to natural gas) biofuel, and 100% of the local demand for compressed natural gas (CNG) automotive biofuel. Biodiesel (B100) can be used as a direct replacement for petroleum diesel without equipment modification. CNG biofuel must be used in vehicles equipped for this fuel. Each project building will engage in the modification of gasoline automotive equipment to enable the use of CNG biofuel. Automobiles that operate on CNG biofuel enjoy extended useful life of the engine by a factor of 4 or more. Trucks that operate on biodiesel biofuel enjoy extended useful life of the engine by a factor of 2 or more. Each economic development project includes the infrastructure for local distribution of renewable natural gas. To the extent that methane gas is used for electricity generation, the production of biodiesel biofuel, and the production of CNG biofuel, each qualifies for renewable energy credits since all such uses are carbon neutral.

As background information, the production of ethanol from corn and biodiesel from beans has precipitated a massive food or fuel issue throughout the world causing the marketplace price of both corn and soybeans to increase dramatically. These increases have, in turn, caused the marketplace price of ethanol and biodiesel to increase as well the marketplace price of corn and soybean based food products. It is these increases in marketplace prices that have caused the food or fuel issue. With our business model, the production of biodiesel from Spirulina microalgae stays completely clear of the food or fuel issue as does the production of CNG biofuel from biowastes. To achieve total sales of the biofuels production outputs they will be sold at a 20% discount from existing retail. At this attractive pricing 100% of routine production will easily sell in the marketplace.

Because nutrients will be 100% recycled internally, each project building will produce substantial liquid fertilizer concentrate that will be distributed to area farmers in need on a no-charge basis. Excess liquid fertilizer, if any, would be eligible to sell to distant markets or possibly converted into value added products. To the extent that the local market does not make use of the liquid fertilizer concentrate the fertilizer product will be sold to international markets to increase additional visible cash flow to the project.

Because 100% of the water is recycled internally, potable water of the quality of bottled water will be distributed locally on a no-charge basis. Because water is required to process municipal solid wastes each project building will accept both sanitary wastewater and storm water for that purpose on a no-charge basis. Over time, additional stories will be added to each project building to enable additional agricultural activities that could include bananas, beets, black bass, beef cattle, beans, cassava, coffee, corn, cotton, dairies, lobster, onions, poultry, prawns, rice, shrimp, sugar cane, sweet potatoes, trout, and many other crops.

Throughout the prefeasibility study extensive efforts are made to provide balanced chemical equations and mathematical calculations, where appropriate, to permit extensive due diligence evaluations of the proposed sciences to be used.

No Charge For Potable Water

No Charge For Wastewater Treatment

No Charge for Stormwater Treatment

Marketplace BioWastes-To-Energy Feedstocks

A determination of the amount of volatile solids (VS) is necessary in order to calculate the amount of methane gas that can be produced from the anaerobic digestion of biowastes. Eligible feedstocks consist of municipal solid wastes (MSW), medical wastes, and construction & demolition wastes. For the purpose of arriving at conservative waste figure availability, a total of 2 lbs/person/day will be used for the purpose of calculating total feedstock biowaste amounts for developing countries and a total of 5 lbs/person/day will be used for the purpose of calculating total feedstock biowaste amounts for developed countries. For an area population of 50,000 for each project building the available biowastes calculate out to 50,000 x 2 lbs/person/Day = 100,000 lbs/day, or when divided by 2,000 lbs/Ton = 50 Tons/Day for developing countries and 50,000 x 5 lbs/person/day = 250,000 lbs/Day, or when divided by 2,000 lbs/Ton = 125 Tons/Day for developed countries.

For undeveloped countries, the calculation for municipal solid wastes is as follows:

> Assuming 25% moisture content 50 Tons/Day x 75% = 37.5 Dry Tons/Day
> Assuming 80% organic content 37.5 Dry Tons/Day x 80% = 30 Organic Tons/Day
> Assuming 80% volatile solids content 30 Organic Tons/Day x 80% = 24 Tons Volatile Solids/Day or x 2,000 lbs/Ton = 48,000 lbs/Day. This amount of waste translates into 48,000 lbs Volatile Solids/Day x 12 cubic feet of methane/lb Volatile Solids = 576,000 CFD of CH_4. At 24 cubic feet/lb, the methane production translates into 576,000 CFD CH_4/24 = 24,000 lbs/2,000 = 12.0 Tons CH_4/Day for undeveloped countries.

60 Tons VS/Day From MSW Undeveloped Countries

30 Tons CH_4/Day From MSW Undeveloped Countries

For developed countries, the calculation for municipal solid wastes is as follows:

> Assuming 25% moisture content 125 Tons/Day x 75% = 93.75 Dry Tons/Day
> Assuming 80% organic content 93.75 Dry Tons/Day x 80% = 75 Organic Tons/Day
> Assuming 80% volatile solids content 75 Organic Tons/Day x 80% = 60 Tons Volatile Solids/Day or x 2,000 lbs/Ton = 120,000 lbs/Day. This amount of waste translates into 120,000 lbs Volatile Solids/Day x 12 cubic feet of methane/lb Volatile Solids = 1,440,000 CFD of CH_4. At 24 cubic feet/lb, the methane production translates into 1,440,000 CFD CH_4/24 = 60,000 lbs/2,000 = 30.0 Tons CH_4/Day for developed countries.

150 Tons VS/Day From MSW in Developed Countries

75 Tons CH_4/Day From MSW in Developed Countries

In addition to fresh municipal solid wastes, the project will directly collect an additional 10 lbs/person/Day from existing landfills, rubbish piles, and dumps for the twofold purpose of producing additional methane gas and reclaiming additional ferrous and nonferrous metals while getting rid of existing dump/landfill sites. This activity will increase the methane gas and carbon dioxide gas production from two-phase anaerobic digestion by a factor of 5/2 or 2.5 thus increasing the volatile solids from undeveloped countries from 24 Tons/Day to 60 Tons/Day and from developed countries from 60 Tons to 150 Tons/Day. The associated methane gas is increased from 12 Tons CH_4/Day to 30 Tons CH_4/Day for undeveloped countries and from 30 Tons CH_4/Day to 75 Tons CH_4/Day from developed countries.

The 60 Tons Volatile Solids/Day from undeveloped countries can be converted into CO_2 production by multiplying the Volatile Solids by 12 to determine cu. ft. of methane gas produced. Cu. ft. of methane gas produced ÷ 24 cu. ft./lb = lbs methane gas. Lbs. methane gas multiplied by 1.375 = lbs CO_2 produced or 60 Tons VS/Day x 2,000 lbs/Ton x 12 = 1,440,000 cu. ft. CH_4/Day. 1,440,000 cu. ft. ÷ 24 cu. ft./lb = 60,000 lbs CH_4/Day. 60,000 lbs CH_4/Day x 1.375 = 82,500 lbs CO_2/Day. 82,500 lbs CO_2/Day ÷ 2,000 lbs/Ton = 41.3 Tons CO_2/Day. The 150 Tons Volatile Solids/Day from undeveloped countries can be converted into CO_2 production by multiplying the Volatile Solids by 12 to determine cu. ft. of methane gas produced. Cu. ft. of methane gas produced ÷ 24 cu. ft./lb = lbs methane gas. Lbs. methane gas multiplied by 1.375 = lbs CO_2 produced or 150 Tons VS/Day x 2,000 lbs/Ton x 12 = 3,600,000 cu. ft. CH_4/Day. 3,600,000 cu. ft. ÷ 24 cu. ft./lb = 150,000 lbs CH_4/Day. 150,000 lbs CH_4/Day x 1.375 = 206,250 lbs CO_2/Day. 206,250 lbs CO_2/Day ÷ 2,000 lbs/Ton = 103 Tons CO_2/Day. Revenue collected for management of landfill wastes, municipal solid wastes, medical wastes, and construction & demolition wastes: US$0/Day/Ton. Never a charge, ever. This service always provided as a public service activity only.	No charge for MSW disposal US$0.00/Day From MSW
Agricultural Food Production and Processing Will consist of a 100 hectare Tilapia fish farm at each project building for producing and thereafter processing organically grown Tilapia filets, mostly for the export fish market. Electricity requirements are estimated at 1.0 MW. The estimated raw fish produced per day is 1,340,000 lbs. At a filet yield of 42% a total of 562,000 lbs (281 Tons of Tilapia filets) will be produced/Day along with 778,000 lbs or when divided by 2,000 lbs/Ton = 389 Tons of biowastes/Day. At a commodity sell price of US$2.18/lb, the daily revenue is estimated at 389 Tons/Day x 2,000 lbs/Ton x US$2.18/lb = US$1,225,160/Day It is virtually impossible to obtain a buyer commitment on a current basis in the form of a purchase agreement for a product that is 36 months away from coming into existence. In terms of investor risk assessment, the existence of the very large fish commodity market itself is regarded as ample proof of probable visible cash flow from this specific food product. The 389 Tons/Day of biowastes x 2,000 lbs/Ton = 778,000 lbs of Volatile Solids/Day. This amount of waste translates into 778,000 lbs Volatile Solids/Day x 12 cubic feet of methane/lb Volatile Solids = 9,336,000 cubic feet/Day (CFD) of CH_4. At 24 cubic foot/lb, the methane production translates into 9,336,000 CFD CH_4/24 = 389,000 lbs/2,000 = 194.5 Tons CH_4/Day.	0.5 MW Electricity Required For Tilapia Fish Farming US$1,225,160/Day From Tilapia Fish 389 Tons VS/Day From Fish Processing 194.5 Tons CH_4/Day From Fish Processing
Subtotal Carbon Dioxide Gas Produced From Municipal Solid Wastes Processing:	41.3 Tons CO_2/Day
The 60 Tons Volatile Solids/Day from Municipal Solid Wastes can be converted into CO_2 production by multiplying the Volatile Solids by 12 to determine cu. ft. of methane gas produced. Cu. ft. of methane gas produced ÷ 24 cu. ft./lb = lbs methane gas. Lbs. methane gas multiplied by 1.375 = lbs CO_2 produced or 60 Tons VS/Day x 2,000 lbs/Ton x 12 = 1,440,000 cu. ft. CH_4/Day. 1,440,000 cu. ft. ÷ 24 cu. ft./lb = 60,000 lbs CH_4/Day. 60,000 lbs CH_4/Day x 1.375 = 82,500 lbs CO_2/Day. 82,500 lbs CO_2/Day ÷ 2,000 lbs/Ton = 41.3 Tons CO_2/Day.	
Subtotal Feedstocks Volatile Solids From Tilapia Fish Farming Wastes:	2.8 Tons/Day
The 1.4 Tons Volatile Solids/Day from Tilapia Fish Farming Wastes can be converted into CO_2 production by multiplying the Volatile Solids by 12 to determine cu. ft. of methane gas produced. Cu. ft. of methane gas produced ÷ 24 cu. ft./lb = lbs methane gas. Lbs. methane gas multiplied by 1.375 = lbs CO_2 produced or 2.8 Tons VS/Day x 2,000 lbs/Ton x 12 = 67,200 cu. ft. CH_4/Day. 67,200 cu. ft. ÷ 24 cu. ft./lb = 2,800 lbs CH_4/Day. 2,800 lbs CH_4/Day x 1.375 =	1.92 Tons CO_2/Day From Tilapia Fish Farming Wastes

3,850 lbs CO_2/Day. 3,850 lbs CO_2/Day ÷ 2,000 lbs/Ton = 1.92 Tons CO_2/Day.	
Subtotal Feedstocks Volatile Solids From Tilapia Fish Processing Wastes:	**389Tons VS/Day**
The 389 Tons Volatile Solids/Day from Tilapia Fish Processing Wastes can be converted into CO_2 production by multiplying the Volatile Solids by 12 to determine cu. ft. of methane gas produced. Cu. ft. of methane gas produced ÷ 24 cu. ft./lb = lbs methane gas. Lbs. methane gas multiplied by 1.375 = lbs CO_2 produced or 389 Tons VS/Day x 2,000 lbs/Ton x 12 = 9,336,000 cu. ft. CH_4/Day. 9,336,000 cu. ft. ÷ 24 cu. ft./lb = 389,000 lbs CH_4/Day. 389,000 lbs CH_4/Day x 1.375 = 534,874 lbs CO_2/Day. 534,874 lbs CO_2/Day ÷ 2,000 lbs/Ton = 267 Tons CO_2/Day.	267 Tons CO_2/Day From Tilapia Fish Processing Wastes
Subtotal Carbon Dioxide Gas Produced From Pork Processing Wastes:	**15.5 Tons CO_2/Day**
Subtotal Carbon Dioxide Gas Produced From Tilapia Fish Farming Wastes:	**1.92Tons CO_2/Day**
Subtotal Carbon Dioxide Gas Produced From Tilapia Fish Processing Wastes:	**389 Tons CO_2/Day**
Subtotal Carbon Dioxide Gas Produced From Electricity Generation:	**247.0 Tons CO_2/Day**
Subtotal Carbon Dioxide Gas Produced From Cement Manufacturing:	**67.2 Tons CO_2/Day**
Total Carbon Dioxide Gas Produced:	**483.0 Tons CO_2/Day**
Subtotal Methane Gas Produced From Municipal Solid Wastes:	**30.0 Tons CH_4/Day**
Subtotal Methane Gas Produced From Tilapia Fish Farming Wastes:	**0.7 Tons CH_4/Day**
Subtotal Methane Gas Produced From Tilapia Processing Wastes:	**97.3 Tons CH_4/Day**
Subtotal Methane Gas Produced From Biodiesel Processing Wastes:	**97.1 Tons CH_4/Day**
Total Methane Gas Produced:	**249.9 Tons CH_4/Day**

Two-Phase Anaerobic Digestion

Products Of Two-Phase Anaerobic Digestion

All of the wastes associated with agricultural production will be managed through two-phase anaerobic digestion technology. Traditional anaerobic digestion (often referred to as conventional high rate anaerobic digestion) produces a biogas that consists of 1/3 carbon dioxide gas by volume and 2/3 methane gas by volume as a common gas mixture. Two-phase anaerobic digestion, however, produces the same gases as two distinct gases consisting individually of carbon dioxide gas and methane gas. The separation of the two gases permits each to be managed individually.

Volatile Solids (VS) x 12 = cu. ft. CH_4

In every anaerobic digester the ratio of carbon dioxide gas produced relative to methane gas is 1:2 on a volumetric basis. The molecular weight of methane gas (CH_4) is 16 (12 for Carbon + 4 for Hydrogen) whereas the molecular weight of carbon dioxide gas (CO_2) is 44 (12 for Carbon and 32 for Oxygen). 1 x 44 = 44 weight units for carbon dioxide gas and 2 x 16 = 32 weight units for methane gas. 44 divided by 32 = 1.375. Carbon dioxide produced relative to methane produced is therefore 137.5% on a mass basis. The actual weight of methane gas produced may be found by multiplying its cubic feet by the factor 0.0423 lbs/cu. ft. to arrive at its actual weight in lbs. This weight may be multiplied by the factor of 1.375 (137.5%) to arrive at the corresponding weight of carbon dioxide produced in lbs. The amount of methane gas generated through two-phase anaerobic digestion may be found by multiplying the volatile solids weight of the biowastes in lbs by 12 to arrive at the cubic feet of methane gas produced in lbs.

cu. ft. CH_4 x 0.0423 = lbs CH_4

lbs CH_4 x 1.375 = lbs CO_2

Other sometimes handy mathematical relationships are:

1 Ton VS/Day produces 24,000 CH_4/Day from two-phase anaerobic digestion
1 Ton VS/Day produces 0.508 Tons CH_4/Day from two-phase anaerobic digestion
1 Ton VS/Day produces 0.698 Tons CO_2/Day from two-phase anaerobic digestion
1 Ton CH_4/Day used for electricity generation produces 2.75 Tons CO_2/Day
83,780 CH_4/Day produces 1 MW of simple cycle electricity power generation

Enclosed Photobioreactor for Spirulina Microalgae Production

The enclosed photobioreactor consists of a 2,200,000 foot long 12”Ø clear schedule 40 PVC pipe spiral wrapped externally with ultra high efficiency long lasting (10 years +) light emitting diode lighting for continuous photosynthesis. A small portion of the Spirulina microalgae produced will be continuously recycled to the start of the photobioreactor to provide the required seed to enable continuous Spirulina microalgae production. Electricity requirements = 6.0 MW for the lighting and associated recirculation pumping equipment.

The photobioreactor will receive 100% of the carbon dioxide gas output of the two-phase anaerobic digester and 100% of the carbon dioxide gas output from electricity generation. In addition, it will receive 100% of the output of macronutrients from the reverse osmosis treatment equipment deployed downstream from the two-phase anaerobic digester. The Spirulina microalgae require both carbon dioxide and macronutrients to maximize their rate of growth. The photobioreactor will be operated at a temperature of 35ºC (95ºF) and a pH of 9.4 to further optimize Spirulina microalgae rate of growth. Please refer to attached WSE Drawing Nos. S-6099-1 and S-9900-1 for additional information.

Spirulina will be produced using photosynthesis in the same manner that has existed for billions of years in the oceans of the world. The photosynthesis reaction is:

$$6\ H_2O + 6\ CO_2 + \text{photons} \xrightarrow{\text{Chlorophyll}} C_6H_{12}O_6 + 6\ O_2$$

water + carbon dioxide + light energy → glucose carbohydrate + oxygen

The chemical mass balance of the above equation becomes :

$$108\ \text{gm}\ H_2O + 264\ \text{gm}\ CO_2 \rightarrow 180\ \text{gm glucose carbohydrate} + 192\ \text{gm}\ O_2$$

total of 372 gm reactants → total of 372 gm products

For each 264 grams of CO_2 reacted 180 grams of glucose carbohydrate and 192 grams of O_2 will be produced. For each ton of CO_2 reacted, 180/264 or 0.682 tons of glucose carbohydrates and 192/264 or 0.73 tons of O_2 will be produced. Glucose carbohydrates equate to Spirulina microalgae, a plant type material called phytoplankton.

One Ton CO_2/Day Produces 0.682 Tons Of Glucose Carbohydrates/Day (Spirulina Microalgae)

Respiration occurs in the Mitochondria of cells. It is almost the exact opposite reaction to photosynthesis. These two reactions work together to maintain a biological balance on earth. The respiration reaction is:

$$C_6H_{12}O_6 + 6\ O_2 \xrightarrow{\text{Mitochondria}} 6\ H_2O + 6\ CO_2$$

It is generally believed that photosynthesis occurs only during periods of sunlight (or artificial light) and that respiration occurs only during periods of darkness. Horticulture studies have established that several, but not all, species of plants can be grown under continuous lighting. The same studies have established that photosynthesis and respiration can and do occur simultaneously under continuous lighting conditions. Plants are multi-cell and capable of learned behavior whereas Spirulina microalgae are single cell plants and therefore totally incapable of acquiring learned behavior. Spirulina microalgae can therefore be grown under continuous lighting conditions even though they have never been exposed to continuous lighting conditions for billions of years. Continuous lighting therefore approximately doubles total Spirulina growth relative to day/night growth rates.

One Ton CO_2/Day Produces 0.04 Tons Biodiesel/Day

The glucose produced during photosynthesis contains about 6% lipids (fats). Lipids are efficiently converted into biodiesel through a transesterification process. Each ton of CO_2 will simultaneously produce 0.68 tons glucose carbohydrates x 0.06 = 0.04 tons biodiesel and 1.0 – 0.04 = 0.96 tons of byproduct biowastes. 100% of the byproduct biowastes will consist of volatile solids. One ton CO_2/Day can therefore produce 0.04 tons biodiesel/Day. At a specific gravity of 0.88 this is equivalent to 0.04 tons x 2,000 lbs/ton divided by 0.88 specific gravity = 90.91 gallons/day. The same one ton CO_2/Day will produce 0.96 tons x 2,000 lbs/ton = 1,920 lbs volatile solids/day or 21.12 lbs volatile solids/gallon of biodiesel produced/day.

One Ton CO_2/Day Produces 0.96 Tons Volatile Solids/Day

One Ton CO_2/Day Produces 90.91 Gallons Of Biodiesel/Day

Each Gallon of Biodiesel Produced Produces 21.12 lbs of Volatile Solids

Biodiesel Production

All biodiesel produced will fully comply with American Society for Testing and Materials (ASTM) Standard Specification D 6751-03. The referenced specification is attached to the prefeasibility study.

The amount of biodiesel produced is directly dependent on the amount of Spirulina microalgae produced. The amount of Spirulina microalgae produced is directly dependent on the amount of carbon dioxide gas that is added to the photobioreactor. Since carbon dioxide gas is produced by electricity generation, two-phase anaerobic digestion, and cement production, the total amount of CO_2 produced must be determined from each source.

Source No. 1: Electricity Generation:

30 MW of electricity will be produced for the community initiative. Another 21.5 MW of electricity will be used internally for the photobioreactor, air liquefaction, methane gas compression, tilapia fish lighting, pig production, and general building use. The total amount of electricity produced therefore equals 30 MW + 21.5 MW = 51.5 MW.

When generating electricity CO_2 is produced according to the following combustion equation:

$$CH_4 + 2O_2 + 7.52\ N_2 \rightarrow CO_2 + 2H_2O + 7.52\ N_2 + \text{heat}$$

methane + oxygen + nitrogen → carbon dioxide + water + nitrogen

The chemical mass balance of the above equation becomes:

$$16\ gm\ CH_4 + 64\ gm\ O_2 + 105\ gm\ N_2 \rightarrow 44\ gm\ CO_2 + 36\ gm\ H_2O + 105\ gm\ N_2$$

total of 80 gm reactants → total of 80 gm products

1 Ton CH_4 Produces 2.75 Tons CO_2 From Electricity Generation

1 Ton CH_4 Produces 2.25 Tons H_2O From Electricity Generation

Please note that nitrogen is not a reactant as it does not participate in the reaction. For each ton of CH_4 used for electricity generation a total of 44/16 or 2.75 tons of CO_2 will be produced along with a total of 36/16 or 2.25 tons of H_2O. 2.25 tons of H_2O is, in turn, equivalent to 2.25 tons H2O x 2,000 lbs/ton = 4,500 lbs ÷ 8.34 lbs/gallon = 540 gallons of water.

1 Ton CH_4 Produces 540 Gallons Of Water From Electricity Generation

If 51.5 MW of electricity is produced to provide energy independence within the Community Initiative, a total of 51.5 MW x 83,780 CH_4/Day/MW = 4,314,670 cubic feet of methane gas will have to be used each day. At 24 cubic foot/lb, the methane usage translates into 4,314,670 cu. ft. CH_4/24 = 179,778 lbs/2,000 = 89.89 Tons CH_4/Day. Since each ton of CH_4 produces 2.75 Tons of CO_2 the generation of 51.5 MW of electricity produces 89.89 x 2.75 = 247.0 Tons of CO_2/Day due to the generation of electricity. Since each ton of CH_4 produces 2.25 Tons of H_2O, the generation of 51.5 MW of electricity also produces 89.89 x 2.25 = 202 Tons of H_2O/Day.

51.5 MW Of Electricity Produces 247.5 Tons Of CO_2/Day

51.5 MW Of Electricity Produces 89.89 Tons Of CH_4/Day

Source No. 2: Two-Phase Anaerobic Digestion:

To determine the amount of CO_2 produced first requires a determination of the amount of CH_4 produced as CH_4 production directly determines CO_2 production by a factor of 1.375.

To determine the amount of CH_4 produced first requires the amount of volatile solids that are treated as each lb of volatile solids x 12 = cu. ft. CH_4 produced.

The volatile solids available from MSW processing are 60.0 Tons/Day as listed above. The volatile solids available from tilapia fish farming are 1.4 Tons/Day as listed above. The volatile solids available from tilapia fish processing are 194.5 Tons/Day as listed above. The total volatile solids available as listed above = 60.0 + 27.0 + 22.6 + 1.4 + 194.5 = 305.5 Tons CH_4/Day. 305.5 Tons CH_4/Day x 1.375 = 420.1 Tons CO_2/Day.	
The project building will engage in the manufacturing of cement. Carbon dioxide is produced in cement making as a result of the production of a process ingredient called 'Clinker'. Clinker is made when limestone is heated to produce lime. Substantial amounts of carbon dioxide are simultaneously formed during this reaction. The final amount of carbon dioxide produced varies depending on the type of cement being made. Each project building will be manufacturing 300 Tons/Day of Portland type cement.	
According to the *Annual Review of Energy and the Environment,* (Vol. 26: pp 303-329, November 2001) average CO_2 emissions/Ton from cement production = 448 lbs. At a cement production rate of 300 Tons/Day the total carbon dioxide emissions = 300 Tons/Day x 448 lbs CO_2/Ton = 134,400 lbs/Day ÷ 2,000 lbs/Ton = 67.2 Tons CO_2/Day. Adding this amount of CO_2 to the above total of 420.1 Tons CO_2/Day = 487.3 Tons CO_2/Day that will be produced from electricity generation, two-phase anaerobic digestion of volatile solids feedstocks, and cement production.	
Since each ton of CO_2 produces 0.682 Tons of Spirulina microalgae 487.3 Tons CO_2/Day produces 487.3 x 0.682 = 332.3 Tons Spirulina microalgae/Day.	
75% or 249.2 Tons Spirulina/Day will be used for feeding tilapia fish and pigs. The remaining 25% or 83.1 Tons Spirulina/Day will be used in the production of biodiesel (B100). 83.1 Tons Spirulina production is the equivalent of 25% of 487.3 Tons CO_2/Day or 121.8 Tons CO_2/Day. 249.2 Tons Spirulina production is the equivalent of 75% of 487.3 Tons CO_2/Day or 365.5 Tons CO_2/Day.	332.3 Tons Spirulina Microalgae Produced/Day
Since one ton CO_2/Day produces 0.682 Tons of Spirulina microalgae, 108.3 Tons CO_2/Day produces 108.3 x 0.682 = 73.86 additional tons of Spirulina microalgae increasing its production from 295.5 Tons/Day to 369.4 Tons/Day.	
Since one ton CO_2/Day produces 0.04 tons biodiesel/day, 121.8 Tons CO_2/Day produces 121.8 x 0.04 tons = 4.87 tons biodiesel/Day. At a specific gravity of 0.88 this is equivalent to 4.87 tons x 2,000 lbs/ton divided by 0.88 specific gravity = 11,073 gallons/day.	
Since each gallon of biodiesel produced generates 21.12 lbs of volatile solids, 11,073 gallons x 21.12 = 233,856 lbs. Volatile Solids/Day. 233,856 lbs Volatile Solids/Day ÷ 2,000 lbs/Ton = 116.9 Tons Volatile Solids/Day. The 116.9 Tons Volatile Solids/Day from biodiesel production can be converted into CO_2 production by multiplying the Volatile Solids by 12 to determine cu. ft. of methane gas produced. Cu. ft. of methane gas produced ÷ 24 cu. ft./lb = lbs methane gas. Lbs. methane gas multiplied by 1.375 = lbs CO_2 produced or 116.9 Tons VS/Day x 2,000 lbs/Ton x 12 = 2,806,272 cu. ft. CH_4/Day. 2,806,272 cu. ft. ÷ 24 cu. ft./lb = 116,928 lbs CH_4/Day. 116,928 lbs CH_4/Day x 1.375 = 160,776 lbs CO_2/Day. 160,776 lbs CO_2/Day ÷ 2,000 lbs/Ton = 80.4 Tons CO_2/Day.	18,381 Gallons Of Biodiesel Produced/Day 58.5 Tons CH_4/Day
Since one ton CO_2/Day produces 0.04 tons biodiesel/day, 80.4 Tons CO_2/Day produces 80.4 x 0.04 tons = 3.22 tons biodiesel/Day. At a specific gravity of 0.88 this is equivalent to 3.22 tons x 2,000 lbs/ton divided by 0.88 specific gravity = 7,308 gallons biodiesel/day thus increasing biodiesel production from 11,073 GPD to 18,381 GPD.	plus 38.6 Tons CH_4/Day
Since the basic waste-to-energy process fully satisfies electricity demand the excess methane gas will be beneficially used for: 1. The production of methanol through syngas technology that is used as a required feedstock in the production of biodiesel biofuel,	= 97.1 Tons CH_4 Produced/Day From Biodiesel Production

2. The production and sale of compressed natural gas (CNG) biofuel surface transportation fuel, and
3. The production and sale of renewable natural gas biofuel to the marketplace.

Tilapia Fish Feed Requirements:

The production of tilapia fish is 670 Tons/Day. It takes about 1.2 lbs of feed to increase the fish weight by 1.0 pound. The 670 Tons of finished fish will require 670 x 1.2 or 804 Tons of feed per Day. Spirulina microalgae production at 332 Tons feed/Day will mostly satisfy tilapia fish feed requirements. As the MSW volume increases the volume of Spirulina microalgae will automatically increases. It won't take much of an increase in MSW volume to fully satisfy total feed requirements.

The preferred initiative is to increase collection of MSW biowastes by excavating area landfills and dumps for the purpose of treating their contents with two-phase anaerobic digestion to increase the associated production of Spirulina microalgae.

Manufacturing Activities

Self-Biofueled Trains & Locomotives	The shipbuilding/shipbreaking project building will be designed to accommodate the manufacture of 100 self-biofueled trains & locomotives per year at an estimated marketplace price of US$3,500,000/unit. Visible revenue produced = US$3,500,000 x 100 = US$350,000,000/year or ÷ 365 = US$958,900/Day.	US$958,900/Day
Self-Biofueled Ships	The shipbuilding/shipbreaking project building will be designed to accommodate the manufacture of 10 self-biofueled ships per year at an estimated price of US$250,000,000/unit. Visible revenue produced = US$250,000,000 x 10 = US$2,500,000/year or ÷ 365 = US$6,849,315/Day. Maximum size of manufactured ship = 1,200 ft long x 120 ft wide.	US$6,849,315/Day
Tidal Generators	The project building will be designed to accommodate the manufacture of 20 tidal generators per year at an estimated price of US$500,000,000/unit. Visible revenue produced = US$500,000,000 x 20 = US$10,000,000,000/year or ÷ 365 = US$27,397,260/Day. Tidal generators will be sold on a fully installed basis.	US$27,397,260/Day
Subtotal Methane (CH_4) Gas Production From Municipal Solid Wastes (MSW):		
	60 Tons/Day Total Volatile Solids x 2,000 lb/Ton x 12 Cubic Feet (CF)/lb = 1,440,000 cu. ft./Day. 1,440,000 cu. ft. CH_4/Day ÷ 24 lbs/cu. ft. = 60,000 lbs. 60,000 lbs ÷ 2,000 lbs/Ton = 30 Tons CH_4/Day	1,440,000 cu. ft. CH_4/Day = 30 Tons CH_4/Day From MSW
Subtotal Methane (CH_4) Gas Production From Biodiesel Processing Wastes:		
	4,659,366 cu. ft. CH_4/Day ÷ 24 cu. ft./lb = 194,140 lbs. 194,140 lbs ÷ 2,000 lbs/Ton = 97.1 Tons CH_4/Day	97.1 Tons CH_4/Day From Biodiesel Wastes
Subtotal Methane (CH_4) Gas Production From Tilapia Fish Farming Wastes:		
	2.8 Tons/Day Total Volatile Solids x 2,000 lb/Ton x 12 Cubic Feet (CF)/lb = 67,200 cu. ft./Day. 67,200 cu. ft. CH_4/Day ÷ 24 lbs/cu. ft. = 2,800 lbs. 2,800 lbs ÷ 2,000 lbs/Ton = 1.4 Tons CH_4/Day	67,200 cu. ft. CH_4/Day =1.4 Tons CH_4/Day From Tilapia Fish Farming Wastes
Subtotal Methane (CH_4) Gas Production From Tilapia Fish Processing Wastes:		
		9,336,000 cu. ft.

	389 Tons/Day Total Volatile Solids x 2,000 lb/Ton x 12 Cubic Feet (CF)/lb = 9,336,000 cu. ft./Day. 9,336,000 cu. ft. CH_4/Day ÷ 24 lbs/cu. ft. = 389,000 lbs. 389,200 lbs ÷ 2,000 lbs/Ton = 194.6 Tons CH_4/Day		CH_4/Day = 194.6 Tons CH_4/Day From Tilapia Fish Processing Wastes
Total Methane (CH_4) Gas Generation from all sources:			249.9 Tons CH_4/Day
OAT Process Power Generation Potential:			
	249.9 Tons CH_4/Day x 2,000 lbs/Ton = 499,800 lbs/Day. 499,800 lbs/Day x 24 cu. ft./lb = 11,995,200 cu. ft./Day. 11,995,200 cu. ft./Day ÷ 83,780 cu. ft./MW = 143 MW. 143 MW less 15% parasitic digester plant use = 122 MW Net		122 MW Net
	Two-Phase Anaerobic Digester Size Calculations:		
		Volatile Solids = 249.9 Tons/Day x 2,000 lbs/Ton = 499,800 lbs/Day	
		VS:COD = 1:2, COD = 999,600 lbs/Day	
		Organic Loading lbs COD/Day/Cubic Foot = 6	
		Digester Size = 999,600/6 = 166,600 Cubic Feet	
		Digester Size In Gallons = 1,246,335 Gallons	
		Safety Factor = 1.5	
		Digester Size = 1,869,502 Gallons (120' x 120' x 20'H)	
		Estimated Constructed Cost At US$40/Gallon = $74,780,080	
	Building Size: 2 km (3,280') x 2 km (3,280') x 200 m high w/3 side double wall construction to accommodate photobioreactor and employee housing = 50,000,000 total sq. ft. of precast concrete construction estimated @ US$5.50/sq. ft. = US$275,000,000. Project building will manufacture its own cement and will purchase a ready mix plant (3 concrete delivery/mixer trucks) to minimize precast concrete panel construction costs.		
		Remanufactured 300 Tons/Day Cement Kiln Purchase Cost = US$12,000,000	
		Remanufactured Ready Mix Batch Plant Purchase Cost = US$3,000,000	
	Photobioreactor: 2,200,000 foot long 12"Ø Clear PVC schedule 40 pipe = US$100,000,000 to includes ultra high efficiency long lasting (10 years +) light emitting diode (LED) lighting for photosynthesis @ US$10,000,000 Electricity requirements = 6.0 MW		
	10 MGY Biodiesel Manufacturing Equipment Cost Estimate: US$15,000,000. Electricity Requirements = 0.5 MW		
	Two (2) 110 GPM 4:2:1 Array Reverse Osmosis Equipment Cost Estimate: US$2,000,000		
	Digester Equalization Feed Tank Cost Estimate: $2,000,000 w/Equalization Tank Size = 120' x 120' x 20' H, 2,000,000 Gallon Capacity		
	Potable Water Tank Cost Estimate: $2,000,000 w/Equalization Tank Size = 120' x 120' x 20' H, 2,000,000 Gallon Capacity		
	Anaerobic Digester Feed Tank Cost Estimate: $2,000,000 w/Equalization Tank Size = 120' x 120' x 20' H, 2,000,000 Gallon Capacity		

	Liquefied Nitrogen Storage Tank Cost Estimate: $2,000,000 w/Equalization Tank Size = 120' x 120' x 20' H, 2,000,000 Gallon Capacity		
	Liquefied Natural Gas (LNG) Storage Tank Cost Estimate: $2,500,000 w/Equalization Tank Size = 120' x 120' x 20' H, 2,000,000 Gallon Capacity		
	EAF Steel Recycling Process Equipment Cost: US$3,000,000		
	12,000,000 CFD Compressed Methane Gas (CNG) Equipment Cost Estimate = US$10,000,000. Electricity Requirements = 2 MW		
	221 Ton/Day Liquefied Nitrogen Air Separation Equipment Cost Estimate: $20,000,000. Electricity Requirements = 10 MW		
		Liquefied Nitrogen Delivery Equipment: US$500,000	
	Fish Procurement Cost Estimate = US$5,000,000		
	51.5 MW Natural Gas Fueled Combined Cycle Power Generation Equipment @ US$1,260/kW = 51,500 kW x US$1,100 = US$65,000,000		
	Total Electricity Generation Requirements:		
		For each project building: 51.5 MW (includes projected demand for the next 20 years	
		For Photobiorector = 6.0 MW	
		For Compressed Natural Gas (CNG) = 2 MW	
		For Liquefied Nitrogen (LN2)(LIN) = 10 MW	
		For Liquefied Oxygen = Included with Liquefied Nitrogen	
		For Tilapia Farming = 0.5 MW	
		For General Building use = 2 MW	
		Total Electricity Installed Capacity Requirements = 51.5 MW	
	122 MW potential less 51.5 MW used = 70.5 MW remaining. At 83,779 cu. ft./MW, 83,779 cu. ft. x 70.5 MW = 5,906,420 cu. ft./Day available to marketplace at US$0.70/126.67 cu. ft. or US$32,640/Day as CNG automotive fuel. If sold to a natural gas pipeline the revenue would be slightly less by about 10%.		
Schedule of Project Construction Costs:			
	Anaerobic Digester Feed Tank: US$2,000,000		
	Biodiesel Manufacturing Equipment: US$15,000,000		
	Building Size: 2 km x 2 km x 200 m High Constructed Cost: US$1,475,000,000		
	Cement Kiln Constructed Cost: US$12,000,000		
	Concrete Ready Mix Plant Constructed Cost = US$3,000,000		
	EAF Steel Recycling Process Equipment Constructed Cost: US$3,000,000		
	LED Lighting Purchase Cost: US$10,000,000		
	Liquefied Natural Gas (LNG) Storage Tank: US$2,500,000		
	Liquefied Nitrogen Air Separation Equipment: US$15,000,000		
	Liquefied Nitrogen Delivery Equipment: US$500,000		
	Liquefied Nitrogen Storage Tank: US$2,000,000		
	Methane Compression Equipment: US$10,000,000		
	Photobioreactor: US$100,000,000		
	Potable Water Storage Tank Constructed Cost: US$2,000,000		

	Power Generation Equipment: US$56,650,000	
	Reverse Osmosis Equipment: US$2,000,000	
	Fish Procurement Costs: US$5,000,000 Electricity Requirements = 2.0 MW	
	Tilapia Fish Farming Acreage: 50 hectares x 24' H Tilapia Fish Farming Production: lbs/day = 281,400 of tilapia filets Tilapia Fish Farming Electricity Requirements = 0.5 MW Fish Processing Equipment: US$500,000	
	Two-Phase Anaerobic Digester: US$74,780,080	
	Subtotal Project Construction Costs: US$1,790,680,080	
	Add 15% Contingencies @ 268,602,012 = US$2,059,282,092	
	Total Project Construction Costs:	US$2,059,282,092
Project Visible Cash Flow Revenue Streams:		
	From Sanitary Wastewater – US$0.00	
	From Municipal Solid Wastes – US$0.00	
	From Agro Wastes – US$0.00	
	From Animal Wastes – US0.00	
	From Electricity: 44 MW x 24 = 720 MWh/Day @ US$45.00/MWh = US$47,520/Day. This amount of electricity generation will provide the average demand load of the participating communities for the next 20 years.	US$47,520/Day
	From Biodiesel: 18,381 GPD always priced at 80% of existing marketplace retail. Current retail is US$1.67/gallon. US$1.67 x 80% = US$1.34. 18,381 x US$1.34 = US$24,630/Day.	US$24,630/Day
	From Liquefied Nitrogen (LN2)(LIN): 244,003 GPD priced at US$0.50/gallon = US$122,000.00/Day.	US$122,000/Day
	From Compressed Natural Gas (CNG) Fuel:	US$32,640/Day
	From Fresh Tilapia Filet Exports: US$1,226,900 at a sell price of US$2.18/lb	US$1,226,900/Day
	From Self-Biofueled Trains & Locomotives:	US$958,900/Day
	From Self-Biofueled Ships:	US$6,849,315/Day
	From Tidal Generators:	US$27,397,260/Day
	Renewable Energy and other Credits based on estimated 36 MW Project Power Generation:	
	One Certified Emission Reduction Credit = 1 Tonne CO_2 Reduction. 51.5 MW Project Power Production x 24 hour/Day = 1,236 MWh/Day. 1,236 MWh/Day x 1,100 lbs CO_2 Reduction (using natural gas)/MWh ÷ 2,000 lbs/Ton = 680 Tons/Day = 248,000 T/Year x 2,000/2,204 = 225,226 Tonnes/Year @ US$20 (range of US$20-US$40) = US$4,504,000/Year ÷ 365 = US$12,341/Day for years 2008-2012 delivery.	US$12,341/Day
Total Project Revenue Streams:		US$34,258,916/Day
To the extent that electricity is generated, the combustion off gases (CO_2, NOx, N_2, and H2O) will be entirely used for Spirulina microalgae production. After Spirulina microalgae production has occurred the remaining Nitrogen gas (N_2) will be liquefied and sold to the marketplace. The remaining N_2 gas stream will also contain Oxygen gas (O_2) due to the respiration of microalgae during their production in the same manner that trees and plants give off oxygen. This oxygen will be simultaneously liquefied during the liquefaction of N_2 and subsequently distilled off, compressed, and subsequently used internally as a welding gas, to enhance cement manufacturing, to enhance fish farming, and for smelting iron into steel. Some of the Nitrogen Gas will be used as a protective blanket gas in the production of methanol through syngas technology. The methanol is produced as a required feedstock in the production of biodiesel.		

Additional Notes:

1. Land Requirements: 1,200 hectare for Shipbuilding-Shipbreaking Project Building.

2. Time to design-build-install-operate is estimated at 36 months.

3. Lighting for tilapia must be a daily cycle of:
7.5 hours of total darkness
0.5 hours of sunrise (begins at 6 a.m. w/3 ft-candles)
15.5 hours of daylight (max 10 ft-candles)
0.5 hours of sunset (begins at 10 p.m. w/3 ft-candles)

4. Sufficient project building room remains to add a 10,000 beef cattle operation, a 10,000 milker dairy farm, and significant poultry operations along with all of the associated processing equipment to produce value added products consisting of dressed beef, milk and other dairy products, broilers, and eggs. All of these activities represent future economic development activities.

PROJECT KEY PROFESSIONAL STAFF

Curriculum Vitae

7030

***Employee:* C.G. (Chuck) Steiner, BS, JD**

Education

St. John's University, Collegeville, Minnesota. B.S. Degree in Chemistry, 1959

Wm. Mitchell College of Law, St. Paul, Minnesota. J.D. Degree in Law, 1969

Publications

Steiner, C. G., "Take a New Look at the RBS Process, "Water & Wastes Eng., 41, (May, 1979)

Steiner, C. G., "The Biological Approach to the Rotating Disc Process," Presented at the First National Symposium on Rotating Biological Contractor Technology at the Seven Springs Mountain Resort, Champion, PA, (February 4-5, 1980).

Steiner, C. G., "A Primer on Separators and Particle Separation", Pollution Equipment News, Vol.18, No.3, (June, 1985).

Steiner, C. G., "Plate Separation--Budding Conventional Technology?", WATER/Engineering & Management, (March, 1986).

Steiner, C. G., WSE Publication No. 380, "Silica Contamination Removal From Spent Fuel Pools And Refueling Water Storage Tanks At Nuclear PWR Power Generation Plants", (June 1993).

Steiner, C. G., "Advanced Aqueous Waste Treatment Concepts", Presented at the Environmental Management and Technology Conference & Exhibition International at Atlantic City, NJ, (June 9-11, 1993).

Steiner, C. G., WSE Publication No. 394, "A Historical Review of Oil/Water Separator Designs", (March 1994).

Steiner, C. G., WSE Publication No. 796, "Design Manual and Tutorial – Particle/Liquid Separation Systems", (May, 1996).

Steiner, C. G., "Energy From Wastes", Asia Water, (October, 1999).

Steiner, C. G., "Understanding Anaerobic Treatment", Pollution Engineering, (February, 2000).

Steiner, C. G., "Biofuels For Energy Independence", REFOCUS, (March/April, 2003).

Steiner, C. G., "Kyoto Protocol-compliant waste-to-renewable energy with zero air, water, and solids pollution", The Bulletin on Energy Efficiency, (December, 2004).

Steiner, C. G., "Waste-to-Energy Plan", Pollution Engineering, (March, 2005).

Steiner, C. G., "Biodiesel – The Probable Only Fuel of the Future, Renewable or Otherwise", Earthtoys - Emagazine, (October, 2005).

Steiner, C. G., "Economic Development Through Biomass Waste-To-Energy Technology", Earthtoys - Emagazine, (December, 2005).

Steiner, C. G., "Energy Independence For Everyone, To Include Food, Natural Gas, Biodiesel, And Water As Well", The Bulletin on Energy Efficiency, (December, 2005).

Steiner, C. G., "THERE'S GOLD IN THEM THAR WASTE HILLS", Earthtoys - Emagazine, (April, 2006).

Steiner, C.G., "Reversing Global Warming Through A Worldwide Waste-To-Energy Policy", Earthtoys - Emagazine, (October, 2006).

Steiner, C. G., "**SuperGreen** Buildings Technology With Zero Greenhouse Gas (GHG) Emissions To The Environment", Earthtoys - Emagazine, (December, 2006).

Steiner, C. G., "**SuperGreen™**, Self-Fueled, Double Hull, **Dual-Biofuel™** Powered SuperStrong Concrete Barges and Ships That Exhibit Zero Greenhouse Gas (GHG) Emissions and Include Onboard Ballast Water Treatment", Earthtoys - Emagazine, (February, 2007).

Patents

Two-Phase Anaerobic Digestion Process Utilizing Thermophilic Fixed Growth Bacteria (US Patent No. 5,630,942)

Certifications

40 Hour OSHA Course, 1990-1997

Memberships

American Council On **Renewable Energy**

American Institute of Chemist (Professional Chemist - Accredited)

American Meat Institute

American Society for Testing and Materials

American Water Works Association

Global Village Energy Partnership

Incinerator Institute of America, Member T-6 Testing Committee

National Air Pollution Control Association

National Canners Association

USEPA Combined Heat and Power (CHP) Partnership

Wastewater Equipment Manufacturers Association

Water Environment Federation

Experience Summary

Thirty Five years in design, marketing, new product development, plant operation, and general management of water purification equipment manufacturing and supply.

Employment History

President, Chief Executive Officer, and Principal Scientist of WaterSmart Environmental, Inc., a manufacturer of water and wastewater treatment equipment and a worldwide provider of next generation waste-to-**renewable energy** and other climate change technologies.

Chief Process Engineer for Smith & Loveless, Inc., a manufacturer of water and wastewater treatment equipment.

Product Manager for Pielkenroad Separator Company, a manufacturer of particle/liquid separation equipment.

Director of Environmental Services for Geo. A. Hormel & Company with P&L responsibility over its two pollution control equipment manufacturing divisions.

Director of Marketing for Cherne Industrial, Inc., a national supplier of packaged laboratories for the water and wastewater treatment industry.

Director of Environmental Control for Fire Engineers, Inc., a manufacturer of solid waste disposal incinerators.

Department Manager for Twin City Testing & Engineering Laboratories, Inc., a large regional independent testing laboratory.

Chief Analytical Chemist for Federal Cartridge Corporation, a munitions manufacturer.

R&D Chemist for 3M Company, a diversified manufacturer.

PROJECT KEY PROFESSIONAL STAFF
Curriculum Vitae

8001,

Employee: **Philip Donovan Lusk, B.A., M.A.**

Education

University of North Carolina, Chapel Hill, North Carolina, B.A. Degree in Energy and Environment, 1978

University of South Carolina, Columbia, South Carolina, M.A. Degree in Economics, 1988

Virginia Polytechnic Institute and State University, Blacksburg, Virginia, Energy Management Diploma, 1992

Publications

Lusk, P.D., *Iowa Feedlot Bioenergy Project*, Prepared for private client, (In progress.)

Lusk, P.D. and Palmer, *Tampa Bay Ethanol Consortium Feasibility Study* prepared for BioPower Technologies using funds provided by the Tampa Bay Ethanol Consortium, (2007).

Lusk, P.D. and Palmer, *Pine Island Forms Anaerobic Digestion Feasibility Study* prepared for Neighborhood Power using funds provided by the Massachusetts Technology Collaborative.

Lusk, P.D. and Palmer, *Feasibility Study for Proposed Financing of Bartow Ethanol, L.L.C.* prepared for Bartow Ethanol, L.L.C. (2006).

Lusk, P.D., *Eastern Organic Resources Waste Management Pre-Feasibility Study* prepared for Eastern Organic Resources, L.L.C. (2005).

Lusk, P.D. and Palmer, *Western Meat Processors Waste Management Pre-Feasibility Study* prepared for Western Meat Processors, Inc. (2005).

Lusk, P.D., *Biogas Systems for Commercial Uses in Uzbekistan, Greenhouses and Agriculture Business*. Project Number MC-UZB-53 prepared for Winrock International Central Asia Farmer-to-Farmer Program on behalf of Mercy Corps (2005).

Lusk, P.D., *Economic Evaluation of Recovering Shallow Microbial Natural Gas in South Dakota* prepared for BioRockGas Exploration, L.L.C. (2005).

Lusk, P.D., *Huron County Bioenergy Development Project* prepared for the Huron County Economic Development Corporation using funds provided by the Michigan Economic Development Corporation (2005).

Lusk, P.D., DSM Environmental Services, Inc. *Hunts Point Food Distribution Center Organics Recovery Feasibility Study* prepared for the New York City Economic Development Corporation (2005).

Lusk, P.D., *Feasibility Study for Constructing a Centralized Anaerobic Digestion Facility at South Dakota State University* prepared for South Dakota State University (2004).

Kerbo, Zimmerman, Bird, and Lusk, *Centralized Anaerobic Digestion Feasibility Study for Myrtle Point, OR* prepared for the City of Myrtle Point via the Dyer Partnership using funds from the Oregon Energy Office (2003).

Craggs, Lusk and Wellinger, *Anaerobic Digestion Feasibility Study for Linn County, Iowa* prepared for the Bluestem Solids Waste Agency using funds from the Iowa Department of Natural Resources (2003).

Lusk, P.D., PRIME Technologies: "Commercializing a Better Biorefinery". Paper presented at Bioenergy 2002 Conference, Boise, ID (2002).

Lusk, P.D., *PRIME Technologies Phase IIIA Final Report* prepared for the U.S. Department of Energy under Cooperative Agreement DE-FC36-01go11064 (2001).

Lusk, Holmberg, and Schlesinger, "Integrated Farm Energy Systems: Commercializing a Better Biorefinery" paper presented at Fifth Biomass Conference of the Americas, Orlando, FL (2001).

Lusk, P.D., *PRIME Technologies Final Report* prepared for the South Dakota Governor's Office of Economic Development under Value-Added Sub-Fund Grant 00-24-AG (2001).

Holmberg, Lusk and Schlesinger, Integrated Farm Energy Systems: "Building A Better Biorefinery prepared for the American Coalition for Ethanol Under Department of Energy Instrument No. DE-FG01-99EE10689" paper presented at Bioenergy 2000 Conference, Buffalo, NY (2000).

Lusk, P.D., *Regional Biomass Energy Program Blueprint for Progress: 2000 – 2005* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. KXL-9-29061-00 (2000).

Lusk, P.D., *Review Report of the Regional Biomass Energy State Projects* prepared for the National Renewable Energy Laboratory and sponsored by the U.E. Department of Energy under NREL Subcontract No. KXL-9-29061-00 (2000).

Lusk, P.D., *Review Report of the Regional Biomass Energy Program's FY2000 Budget* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. KXL-9-29061-00 (2000).

Bryan, Wiltsee, Patel and Lusk, *Fuel Cell Feasibility Study at the High Plains Ethanol Facility, York, Nebraska* prepared for the Western Regional Biomass Energy Program (1999).

Lusk, P.D., *Review Report of the Regional Biomass Energy Program Technical Projects* prepared for the national Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Task Order No. KXL-9-29061-00 paper presented at the Fourth Biomass Conference of the Americas, Oakland, CA (1999).

Lusk, P.D., *Review Report of the Regional Biomass Energy Program's FY1999 Budget* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. KXL-9-29061-00 (1999).

Lusk, P.D., *Analysis of International Anerobic Digestion Deployment* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. ECG-8-17098-01 (1999).

Lusk, P.D., *Review Report of the Regional Biomass Energy State Grant Projects* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. ECG-8-17098-01 (1998).

Lusk, P.D., *Methane Recovery from Livestock Manures: A Current Opportunities Casebook, 3rd Edition* prepared for the national Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. DCG-8-17098-01, NREL Publication SR-25145 (1998).

Lusk, P.D. and Mattocks, *Prefeasibility Study for Establishing a Centralized Anaerobic Digester in Adams County*. Report prepared for the Adams County Office of County Commissioners and sponsored by the Northeast Regional Biomass Energy Program, the Adams County Office of Solid Waste and Recycling, and the Adams County Conservation District. Paper presented at the Fourth Biomass Conference of the Americas, Oakland, CA (1998).

Lusk, P.D., *Biogas and More! Systems and Markets for Anaerobic Digestion* booklet prepared for the IEA Bioenergy Task XIV Anaerobic Digestion Activity and sponsored by the United Kingdom Atomic Energy Authority through ETSU (1998).

Lusk, P.D., *Co-Fueling an Ethanol Fuel Cell Power Plant with Digester Gas: A Preliminary Evaluation* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. CAE-3-13383-01 paper presented at Biomass Fuel Cell Power for Rural Development, Nebraska City, NE (1997).

Lusk, P.D., *Near-Term Ethanol Production from Lignocellulosics: A Survey of Potential Producers* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. CAE-3-13383-01 (1997).

Lusk, P.D., *Methane Recovery from Animal Manures: The 1997 Opportunities Casebook* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. CAE-3-13383-01 paper presented at the Third Biomass Conference of the Americas, Montreal, Quebec, Canada (1997).

Lusk, P.D., *Anaerobic Digestion and Opportunities for International Technology Transfer* prepared for the IEA Bioenergy Task XIV Anaerobic Digestion Activity and sponsored by the United Kingdom Atomic Energy Authority through ETSU paper presented at the Third Biomass Conference of the Americas, Montreal, Quebec and Organic Recovery and Biological Treatment '97, Harrogate, United Kingdom. Also published in CADDET Renewable Energy News letter issue 2/98 (1997).

Lusk, P.D., *Economic Evaluation of a Hypothetical Georgia Swine Farm Anaerobic Covered Lagoon Digester* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. CAE-3-13383-01 paper presented at the Southeastern Sustainable Waste Management Conference, Tifton, GA (1997).

Lusk, P.D., *Performance Metrics of the Regional Biomass Energy Program* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. CAE-3-13383-01 paper presented at Bioenergy '96, Nashville, TN (1996).

Lusk, P.D., *Economic Evaluation of a Swine Farm Anaerobic Digester* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. CAE-3-13383-01. Paper presented at Bioenergy '96 Nashville, TN (1996).

Easterly, Burnham, and Lusk, *Workable Power Sales Approach Between Rural Electric Cooperatives and On-Farm Anaerobic Digestion Facilities* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. CAE-3-13383-01. Paper presented at Bioenergy '06, Nashville, TN (1996).

Lusk and Moser, "Anaerobic Digestion Yesterday, Today and Tomorrow." Paper presented at 9th European Bioenergy Converence, Copenhagen, Denmark (1996).

Lusk, P.D., *Biogas from Municipal Solid Waste: Overview of Systems and Markets for Anaerobic Digestion of MSW booklet* prepared for IEA Bioenergy Task XIV Anaerobic Digestion Activity and sponsored by the United Kingdom Atomic Energy Authority through ETSU (1996).

Lusk, P.D., *Deploying Anaerobic Digesters: Current Status and Future Possibilities* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. CAE-3-13383-01. Paper presented at 20th World Energy Engineering Congress, Atlanta, GA. Also published in CADDET Renewable Energy Newsletter Issue 1/96 (1996).

Sax and Lusk, *"Anaerobic Digestion of Municipal, Industrial, and Livestock Waste for Energy Recovery and Disposal"* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. CAE-3-13383-01 paper presented at the Second Biomass Conference of the Americas, Portland, OR (1995).

Lusk, P.D., *Animal and Industrial Waste Anaerobic Digestion: USA Status Report* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. CAE-3-13383-01. Paper presented at the Second Biomass Conference of the Americas, Portland OR (1995).

Lusk, P.D., *Project Outline for Installation of an Anaerobic Digestion Facility to Process Putrescible Garbage in Quito, Ecuador* prepared for the Empresa Metropolitana de Aseo and sponsored by the Corporacion OIKOS (1995).

Lusk, P.D., *Methane Recovery from Livestock manures: A Current Opportunities Casebook* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. CAE-3-13383-01 paper presentated at the International Solar Energy Conference, Maui, HI. Published in *Solar Engineering 1995:1.* Revised and reprinted by the US Department of Energy as publication DOE/EE-0063 (1995).

Lusk, P.D., *Suggested Guidance for the Preparation of the Regional Biomass Energy Program Annual Operating Plans* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. CAE-3-13383-01 (1994).

Lusk, P.D., *Review Report of the Regional Biomass Energy State Grant Projects* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. CAE-3-13383-01 (1994).

Lusk, P.D., "Anaerobic Digestion of Livestock Manures in the USA." CADDET Renewable Energy Newsletter Issue 4/94 (1994).

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Lusk, P.D., *Review and Categorization of the Regional Biomass Energy Program's Resource Assessment and Information System Needs* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. CAE-3-13383-01. NREL/TP-421-7577 (1993).

Lusk, P.D., *Review Report of the Regional Biomass Energy Program Technical Projects* prepared for the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy under NREL Subcontract No. CAE-3-13383-01. Also published in Biologue 12:3, 3rd Quarter 1994. (1993).

Lusk, P.D., *Northeastern States Sharpen Biomass Focus* paper presented at the First Biomass Conference of the Americas, Burlington, VT (1993).

Lusk, P.D., *The Use of Clean Transportation Fuels in State-Owned Vehicles*. Special Report prepared for the General Assembly of the State of North Carolina (1992).

Lusk, P.D., *"Comparative Economic Analysis: Anaerobic Digester Case Study."* Bioresource Technology 36:223-228. Also presented at the 1991 International symposium on Energy and Environment, Espoo, Finland; the 4th National Biofuels Conference and Exhibition, Coeur d'Alene, ID; Fifth Southern Biomass Energy Research Converence, Blacksburg, VA (1991).

Safley and Lusk, *Low Temperature Anaerobic Digester*. Energy Division, North Carolina Department of Economic and Community Development (1991).

Sud, Dalton and Lusk, *Comparative Performance of Conventional Cooling System in Supermarkets* paper presented at Winter International Conference, American Society of Heating, Refrigeration and Air-Conditioning Engineers, Las Vegas, NV and at Electrical Dehumidification: State of the Art Humidity Control for Supermarkets, sponsored by the Electric Power Research Institute, New Orleans, LA (1991).

Roberson, Lyons and Lusk, *Farm Machinery: Management, Operation and Maintenance* paper presented at the International Winter Meeting, American Society of Agricultural Engineers, Chicago, IL (1990).

Safley and Lusk, *Development and Marketing of an Innovative Low Temperature Lagoon Biogas Digester System* paper presented at the Energy from Biomass and Wastes XIV, Lake Buena Vista, FL (1989).

Lusk, P.D., *Procuring Energy Efficiency in Public Buildings*. Master's Thesis. Also presented at the International Symposium on Energy Options for the year 2000: Contemporary Concepts in Technology and Policy, Wilmington, DE (1988).

Lusk and Pollock, *Biomass Gasification for Economic Development*: The Prospects for South Carolina. Energy Research Foundation Special Report #002, Columbia, SC. Also presented at the Fourth Southern Biomass Energy Research Conference, Athens, GA (1993).

Lusk, P.D., *Energy Options for Agriculture in North and South Carolina*. Energy Research Foundation Special Report #001, Columbia, SC. Also presented at the Fourth Southern Biomass Energy Conference, Athens, GA (1982).

Lusk, P.D., *Joint-Ownership Facilities and the North Carolina Eastern Municipal Power Agency*, Energy Research Foundation Issue Brief #002, Columbia, SC (1982).

Lusk, P.D., *Investing in Residential Energy Efficiency*, Energy Research Foundation Issue Brief #003, Columbia, SC (1982).

Lusk, P.D., *"Alcohol as an Alternative Fuel"*, The Professional Engineer, 13:3, November-December (1980).

Lusk, P.D., *Other Considerations in Fuel Ethanol and South Carolina – A Feasibility Assessment*. Energy Research Institute, Columbia, SC (1980).

Lusk, P.D., *Preliminary Estimates of Alternative Fuels Derived from Agricultural Feedsto*cks. Special Report prepared for the North Carolina Energy Policy Council, (1980).

Lusk, P.D., *The Potential for Alcohol Fuels from Waste Biomass Resources: A Prospectus for North Carolina*. Unpublished Manuscript (1979).

Experience Summary

April 1992 to date, Consultant

2003-date, Provide a range of technical and analytic support services for selected clients, including AgriClean, Bartow Ethanol, BioPower Technologies, BioRock Gas Exploration, Neighborhood Power, Deere & Company, Dyer Partnership, DSM Environmental on behalf of the NY City Economic Development Corporation, Shaw Environmental & Infrastructure, Huron County Economic Development Corporation, MaxYield Cooperative, RW Beck, the South Dakota Farmer's Union, South Dakota State University, The University of Tennessee on behalf of the Natural Resource Conservation Service, and WeirFoulds. Specific duties included business case and plan development, scenario analysis for various financial strategies, trending analysis, capital investment analysis, and due diligence. This was accomplished via quantitative analysis and analytical modeling, including cost/benefit analysis, and budget and forecast development. In 2005, Mercy Corps and WinRock International volunteer assignment in Fergana Valley, Uzbekistan exploring the potential for small-scale biogas systems to provide greenhouse heating and fertilizer needs and a renewable gas supply to remote residents. In 2005, received the President's

Volunteer Service Award by the President's Council on Service and Civic Participation. Since 2000, served on the Editorial Board of *BioCycle*, a journal of composting and recycling.

2001-2002

Project Director of U.S. Department of Energy (USDOE) Cooperative Agreement Phase III activities for PRIME Technologies. In addition to providing technical and analytic support services, was responsible for total contract management of $7.5 million in federal and private matching funds. The PRIME complex is a "closed-loop" system that produces beef or milk, fuel ethanol, methane, and biochemical fertilizers. **1993-2001**, under subcontract to the National Renewable Energy Laboratory, provided support to the Regional Biomass Energy Program (RBEP) funded by the USDOE. Among other duties, provided technical and economic expertise in the area of biogas recovery from waste biomass resources, and participate in the development and implementation of a national climate change prevention program. Developed format for assessing and summarizing RBEP's energy, environmental, and economic impact performance metrics, as well as its strategic planning requirements. Developed model for submitting annual operating plans and budgets that uniformly summarized RBEP financial and technical data. Produced review reports of RBEP and state-funded activities in areas such as economic impacts and alternative liquid fuels. Reviewed and categorized RBEP resource assessment and information system needs, and evaluated the potential for Geographic Information Systems to meet RBEP and user needs.

2000, Power Supply Coordinator for all Earth Day activities on the National Mall, the world's most diverse and concentrated micro-utility demonstration of alternative generation and renewable energy technologies (wind, propane & natural gas microturbines, photovoltaics, and reciprocating engines running on biodiesel (B20) blends and neat (B100) biodiesel). Duties included estimating electricity supply and demand distribution requirements, equipment and fuel supply procurement, on-site logistics and scheduling, public relations and customer service, and permitting negotiations with local and federal officials.

1995-97, Leader of the International Energy Agency Bioenergy Task XIV Activity on the Anaerobic Digestion of Municipal Solid Waste. Responsible for managing the conduct of seven countries participating in the Activity and all coordination and administrative actions, including preparing work programs, progress reports, scientific reports and financial reports. Also produced pre-feasibility studies for installing biogas facilities to process municipal solid waste in Quito, Ecuador and animal manures and other organic residues in Adams County, PA.

NOVEMBER 2006 TO JUNE 2007, WREGIS ADMINISTRATOR, WESTERN ELECTRICITY COORDINATING COUNCIL, SALT LAKE CITY, UTAH

The Western Renewable Energy Generation Information System (WREGIS) enables tracking of Renewable Energy Certificates (RECs) throughout the Western Interconnection. The WREGIS Administrator is responsible for all administration, budgeting, oversight, and coordination between numerous entities including: industry participants, state/provincial and voluntary programs. The WREGIS Administrator develops and implements necessary procedures and guidelines to accomplish the WREGIS goals and strategic objectives.

OCTOBER 2005 TO OCTOBER 2006, EMERGING TECHNOLOGIES ANALYST, SOUTH DAKOTA PUBLIC UTILITIES COMMISSION, PIERRE, SOUTH DAKOTA

Investigated technical issues related to emerging technologies and served as a technical resource to the three-member elected commission, executive director and staff as to developments in cutting edge technologies in the utility industries. Developed a working knowledge of utility business practices and technologies that included, but was not limited to, renewable energies, power delivery systems, power generation, telecommunications, and wireless applications. Drafted technical summaries and presentations, interpreted federal and state statutes and administrative rules, and dissected new utility technologies for potential public policy implications. Served as lead staff for PURPA-related issues, the Midwest Renewable Energy Tracking System and energy efficiency efforts.

JUNE 1992 TO MARCH 1993, NRBP DIRECTOR, COALITION OF NORTHEASTERN GOVERNORS POLICY RESEARCH CENTER, WASHINGTON, D. C.

The Northeast Regional Biomass Program (NRBP) director had lead responsibility for managing the activities of eleven states participating in a cooperative renewable energy development program funded by the USDOE. Prepared Annual Operating Plans, grant requests, and project and budget justification. Prepared and managed technical subcontracts and state grants. Monitored program activities of participating states. Maintained program financial integrity and provided the USDOE with required technical and financial reports. Staffed program steering committee. Represented the NRBP with USDOE, other federal agencies, and other programs affecting north-eastern interests in energy, environment, and economic development.

OCTOBER 1987 TO MAY 1992, COMMERCIAL/AGRICULTURAL PROGRAM MANAGER, ENERGY DIVISION, DEPARTMENT OF COMMERCE, RALEIGH, NORTH CAROLINA

Identified and implemented cost-effective demonstration and technology transfer projects to promote specific energy resources. Provided technical and economic expertise related to energy efficiency and renewable energy resources. Developed related subject material, planned and marketed projects to target audiences. Coordinated all Division policy and projects related to renewable energy, with total project responsibility for more than $2.0 million. Served as staff to the Research and Development Committee of the NC Energy Policy Council, and as a member of seven other committees or boards. Project examples include ambient temperature anaerobic digestion, aquaculture, commercial lighting, desiccant dehumidification, farm machinery management, NC Solar Center, post-harvest management of fruit & vegetables, and the use of clean transportation fuels in state-owned vehicles. Two demonstration projects received a National Award for Energy Innovation from the USDOE.

JULY 1985 TO SEPTEMBER 1987, ENERGY ADMINISTRATOR, ENERGY AND ENVIRONMENT DIVISION, OFFICE OF THE GOVERNOR, COLUMBIA, SOUTH CAROLINA

Conducted advanced research and evaluation of the economic aspects of SC□s energy and energy-related issues. Administered the state's petroleum violation escrow accounts, worth roughly $35 million. Served as the Governor's liaison with federal, state and local agencies, and private organizations involved in energy matters. Compiled, evaluated, and produced special studies and proposals for energy policy action by the Governor. Provided constituency service and responded on behalf of the Governor to citizens and organizations on energy-related concerns.

SEPTEMBER 1980 TO JULY 1985, PRINCIPAL, RESOURCE DEVELOPMENT ASSOCIATES, COLUMBIA, SOUTH CAROLINA

Developed a number of analytical models showing the links between energy and its economic and environmental impacts. Prepared several economic and technical feasibility analyses of energy efficiency and renewable energy production facilities for funding solicitation. Served on the SC State Energy Policy Planning Analysis panel.

JANUARY 1979 TO AUGUST 1980, CONTRACT EMPLOYEE

Worked under temporary subcontract for a number of organizations, including:

- **ACT-79 FAIR AND CONFERENCE,** worked on various renewable energy displays used during the fair;

- **CITIZEN'S ENERGY PROJECT,** researched and developed draft USDOE documents on photovoltaic technology for publication, and for public review and comment.

- **ENERGY RESEARCH INSTITUTE,** researched portions of a feasibility assessment for fuel ethanol production from carbohydrates within the state of South Carolina;

- **NORTH CAROLINA ENERGY DIVISION,** duties were program support, state and regional coordination, state energy agency support, planning and institutional assessment, and information collection;

- **ORANGE-CHATHAM COMMUNITY ACTION AGENCY,** provided a method for prioritizing available efficiency and renewable energy technology programs for low-income dwellings;

- **VISTA,** helped develop a cost-effective program in efficiency and renewable energy applications for low-income dwellings, grantsmanship, and farm-scale ethanol production.