

FlexEnergy: Using Waste Fuels to Eliminate 25 Times the GHG Effect of CO₂

P. Fukumoto*, B. Luedde** and E. Prabhu***

*FlexEnergy, LLC, Irvine, CA, paul.fukumoto@flexenergy.com

**FlexEnergy, LLC, Irvine, CA, brett.luedde@flexenergy.com

***FlexEnergy, LLC, Irvine, CA, edan.prabhu@flexenergy.com

Abstract

Methane is a greenhouse gas that has 25 times the environmental impact of carbon dioxide. Globally, 300 million tons of man-made methane seeps into the atmosphere each year. Controlling this methane and minimizing the greenhouse gas effect has been problematic. Much of the methane seepage is too dilute for current technology to destroy.

FlexEnergy has developed the FlexPowerstation™ (the “Flex”) to convert these sources of methane emissions into electricity. This will enable the generation of clean, renewable energy while eliminating a major source of greenhouse gas emissions. Unlike other energy technologies, the Flex oxidizes a wide range of methane concentrations: gas with methane contents as low as 1.5%. The unique Flexidizer keeps NO_x and CO emissions below 1 ppm, exceeding the most stringent emission requirements.

Keywords: emissions, methane, reduction, control, renewable

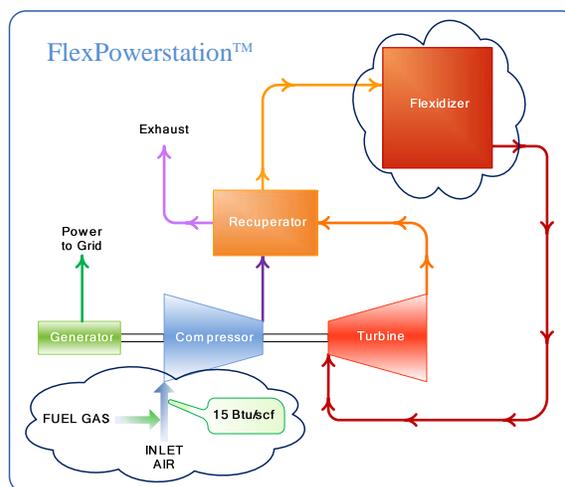
1.0 The FlexPowerstation™

The Flex is a small, modular, technology that converts low energy fuels into electricity with very low emissions. It uniquely integrates a pressurized thermal oxidizer (the “Flexidizer”) with a recuperated gas turbine. The Flex uses the oxidation characteristics of methane to produce clean, efficient gas energy capable of driving a gas turbine for the production of clean, green electricity. The process operates at low methane concentrations, 1.5% by volume. These two special characteristics provide a wide open fuel operating envelope with ultra low emissions. FlexEnergy holds a key patent relative to the use of low energy gases.

The FlexPowerstation is the only gas turbine power plant that runs directly on low Btu fuel gas.

The simple cycle diagram (Figure 1) below shows the FlexPowerstation with its unique components clouded. Fuel is aspirated with air forming a 15 Btu/cubic foot mixture that is compressed and oxidized in a pressurized

gradual oxidizer (the “Flexidizer”); the energy released is used to generate electricity. The Flex does not require a fuel compressor or fuel conditioning system. It adds the Flexidizer. No matter what the initial fuel content, it is diluted with air down to 15 Btu/cubic foot (1.5% methane, or 1.5% the strength of natural gas). The power output of the Flex is the same as from a traditional power plant. The NO_x and CO emissions from the Flex are far lower than from a traditional power plant, each well below 1 ppm. Its fuel flexibility and low emissions create the potential for several weak fuels that no other power plants can use.



Flex Cycle Diagram Figure 1

The mixing of the fuel with atmospheric air to achieve a uniform gas mixture of 15 Btu/scf allows the Flex to operate on wide range of gaseous, and potentially liquid, fuels. The Flexidizer operates in almost the same manner no matter what the base fuel. By keeping temperatures below 2000 F, the Flexidizer avoids NO_x formation. The Flexidizer also provides a long residence time, allowing both CO and VOCs to be fully destroyed. The pilot Flex unit (Figure 2) in development test is shown below.



Flex Under Development Test Figure 2

The Flex offers energy recovery where it was previously impossible. It is designed to adapt to environments where fuels vary in content and strengths. The Flex tolerates moisture and other contaminants in the gas, eliminating the problems typically associated with the use of alternative methane fuels as an energy source. No other technology offers a solution for this large untapped market.

2.0 Emissions Regulations

Emission regulations are driving the exhaust emissions signatures to significantly lower levels. Nationally, the EPA has already proposed tighter regulation on reciprocating internal combustion engines.

California has enacted Distributed Generation regulations for which the 2013 criteria emissions limits for generators operating on waste gas sources (landfills, digesters, and oil fields) will now be the same as a pipeline natural gas combined cycle power plants. California emission regulations are closely watched internationally and are generally accepted as some of the most stringent regulations in the world.

The Flexidizer uses the oxidation characteristics of methane to produce clean, efficient gas energy capable of driving a recuperated gas turbine. Flex Emissions Table (Table 1) shows the Flex development test data on 1.5% methane. It compares the Flex measured emissions to key standards that will regulate the waste gas to energy technology emissions.

Emissions Standards PPMV @ 15% O2	NOx		CO	
	Current	2012/ 2013	Current	2012/ 2013
FlexPowerstation	<1	<1	<2	<2
CARB Dist Gen Waste Gas Rule*	<10	~1	120	<3
SCAQMD Landfill/Digester IC Engines	36 /45	11	2000	250
EPA Landfill/Digester IC Engines			2000	177

Flex Emissions (Development Test) Table 1

3.0 Market Opportunity

FlexEnergy will enable the utilization of a whole host of low Btu fuels that today are a considerable source of greenhouse gas emissions. These low Btu fuels will become a source of clean, green energy with minimal greenhouse gas emissions

Sources of problematic methane emissions include landfills, digesters, oil & gas fields, coal mining operations, chemical plants, refineries and other industrial processes. Dilute tail gas from biogas processing, biofuels plants, and ethanol plants can also power the Flex.

Applying the Flex in each of these market segments expands the traditional opportunity or creates a new solution to methane destruction and GHG control. For landfills, as an example, the Flex can double the useful output from a landfill, generating energy for decades after the fuel quality is no longer acceptable for other technologies.

The methane emissions opportunity table based on the U.S. EPA data is shown below (Table 2). Over 14,000 billion of cubic feet (BCF) of methane are

being generated by human activity each year.[1] Many of these potential energy sources are currently being flared or just vented as greenhouse gas emissions.

World Wide Methane Emissions	Equivalent Billion of Cubic Feet (BCF) Per Year		Electricity Capacity Opportunity (MW)
	U.S.	Rest of World	Combined
Landfills	507	1,553	18,223
Waste Water	74	1,418	13,198
Manure	98	463	4,963
Coal Mine	185	1,010	10,571
Natural Gas Fugitive	335	2,233	22,717
Oil Fugitive	52	113	1,460
Enteric	328	4,417	41,975
Rice	16	1,655	14,782
Total	1,599	12,864	127,888

Methane Emission Opportunity Table 2

Currently the U.S. EPA greenhouse gas estimates discount the possibility for recovery and use of most dilute methane. Capturing and limiting the GHG effect of these methane emissions sources is a 100,000 MW world-wide opportunity. The Flex with its low methane content capability has the potential to spur the capture and conversion of a significant portion of the dilute methane sources.

The domestic market opportunity in landfills, using the U.S. EPA methane source data[2], is over 1500 MW for the gas which is flared or oxidized. This collected gas represents an opportunity of about \$3 billion in just one segment of the U.S. methane market. (Table 3)

Domestic Landfill Methane Emissions	Equivalent Billion of Cubic Feet (BCF) Per Year	Electricity Capacity Opportunity (MW)
Vented/Not Recovered	367	2920
Flared	177	1270
Oxidized	45	320
Existing Gas to Energy	197	1410
Total	786*	4510*

Domestic Landfill Methane Emission Table 3

The FlexPowerstation is the cleanest power platform in the world. The Flex oxidizes gases especially weak and waste gases previously unusable to produce clean, green electricity. Today's emissions problem becomes a green energy source. The Flex Powerstation is simply the cleanest, most versatile emission elimination through energy generation solution in the world.

References

- [1] United States Environmental Protection Agency (US EPA), "Global Anthropogenic Non-CO₂ Greenhouse Gas Emissions:1990 - 2020", Appendix B-1 to Appendix B-12, 2006
- [2] US EPA, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007", 8-3, 2009