CLEAN ENERGY A CDM PROJECT OPTION

Dra. Milka E. Escalera Chávez
Unidad Académica Multidisciplinaria Zona Media. UASLP **Z**
Dr. Gustavo Gallegos Fonseca
Unidad Académica Multidisciplinaria Zona Media. UASLP
Julio Cesar Leal Vaca
Departamento de Ingeniería de la División de Ingenierías
de la Universidad de Guanajuato

Abstract

Projects "Animal Waste Management System Green House Gas Mitigation Project (AWMS GHG Mitigation Project)" are a practical alternative solution to the pollution problem from hog farms. The project offers to reduce the high emissions of greenhouse gases (GHG) by placing the manure in closed anaerobic digesters that produce biogas, which is then burned to prevent methane emissions. However, the biogas produced can be used to generate energy, which can be utilized for the activities in the farm. The study seeks, among other things, to analyze if the energy produced by methane allows hog farm owners to obtain profits after the consumption, demand and payment of electricity. The data used in this study were obtained from the UNFCCC registered CDM projects in 2005 which are valid until today. The project feasibility was determined from the Net Present Value, Internal Rate of Return (IRR) and Benefit/Cost ratio. The results permit to explain that the inclusion of CDM projects in agribusiness impulse regional development by making use of renewable energy produced from the excreta of pigs and that the agricultural sector can use it in their

Keywords: MDL Projects, Power Generation, Benefit / Cost

Introduction

Human activities contribute to increasing the concentration of greenhouse gases, farming labors more specifically livestock emit a significant amount of these gases. The fermentation and denitrification of manure release methane and nitrous oxide into the atmosphere, when it is not collected by the farms, the gases are released into the atmosphere and pollute the environment, producing unpleasant odors (Berra and Finster 2003, p. 213).

The Food and Agriculture Organization (FAO, 2002, p.2) from the United Nations (UN) reported that pig production in Mexico increases the concentration of greenhouse gases, since there are greater amounts produced than the ones allowed. In this situation, the Federal Government has promoted using Clean Development Mechanism (CDM) projects since 2001 to mitigate greenhouse gases and reduce odors.

The projects proposed by AgCert-International and AgCert-Mexico-Environmental Service in 2005 (Animal *Waste Management System and Green House Gas Mitigation Project;* AWMS, GHG Mitigation Project) are a practical alternative solution to the problem of pollution from swine farms. The project proposes to reduce the high emissions of greenhouse gases (GHG) by placing the manure (biomass) in closed anaerobic digesters which produces biogas which is then burned to prevent methane emissions (Toenges, D. 2005, pp. 2-4).

In the present, biogas production from waste goes beyond its use as an energy source, because by using the carbon in organic matter prevents uncontrolled emissions of greenhouse gases. Nutrients in the organic matter can also be recovered and be used to replace chemical fertilizers, saving money and allowing sites to have those nutrients where they are needed instead of putting them where they cause environmental damage. Moreover, the biogas production is a decentralized energy production that can reach places where the mains power lines do not offer service yet.

The aim of this chapter: Clean energy a CDM Project option is to determine the feasibility, cost effectiveness and cost benefit of using biogas as an energy source.

Research questions answered in this paper are:

1. Is it feasible to use the biogas produced by swine farms as an energy source considered in the proposed Clean Development Mechanism (CDM) projects?
2. What is the profitability level of using biogas derived from swine farm waste?

Background

Methane (CH4) is a potent greenhouse gas (GHG), since its contribution to global warming is 21 times more than carbon dioxide (CO2), considered as a unit (FAO. 2013, p.1 Juliarena, 2013, pp.2-3). Worldwide, one of the main methane sources is livestock (30%), followed by rice cultivation (25%) and sanitary landfills (17%), among others (EPA 2010, p. 265)

In Mexico, livestock contributed 1,823 Gg (Gigagrams) methane emissions to the atmosphere in the 2004-2006 period, meanwhile the swine sector contributed 25.85 Gigagrams product of enteric fermentation and manure management. Gillari. (2000, p 1) notes that methane from enteric fermentation in herbivores is a consequence of the digestive process in which carbohydrates are broken down by the action of microorganisms into simple molecules that are absorbed into the bloodstream. INE (2009, 244) notes that some non-ruminants (pigs and horses) produce methane, but ruminants are the most important source (1630.37 Gg).The amount of methane released depends on the type, age and weight of the animal as well as the quantity and quality of fodder intake.

In 1920, Imhoff built the first digester to obtain "biogas", which consisted of a sealed tank which was fed fermentable material. Years later several digesters that were used to produce energy were built, however, low oil prices led to its abandonment. Currently, the production of clean energy favors the promotion and implementation of digesters (Magaña Torres and Martinez, 2006. pp. 28-29).

Biomass and Waste

At present there are two major factors that have driven the increased use of fossil fuels: population growth and industrial expansion. The burning of large quantities of oil, gas, and coal have their effect on the environment. (Fetter, 1999, pp. 25-26). Undoubtedly new sources of sustainable energy to stop or reduce the negative effects caused by fossil fuels are needed. One such source, referred to in the various public policies, business and industry partnership to reduce carbon emissions and other negative impacts of petroleum is biomass. Demand for oil, gas and carbon has led to the substitution of alternative low carbon-emission sources such as water, energy, solar, geothermal and biomass-based energy (Table 1).

Table 1. Production and use of biomass as an energy source

Source	2005	2006	2007	2015	2020	2025	2030
Oil	171	173	175	179	186	197	210
Carbon	122	126	132	139	152	168	286
Nuclear	28	28	27	32	37	41	44
Biomass, solar, waste	46	48	48	64	73	82	91

Source: US Energy Information Administration (2010)

The table 1 reveals the increasing demand for alternative sources and can be seen a doubling in the year 2030, so the biomass can be considered an alternative source that requires little investment. Biomass is a renewable organic substance across both animal and vegetable origin and according to its origin it can be: natural, energy crops, and wet and dry waste.

The residual biomass that is generated from any human activity processes mainly in agriculture, livestock, forestry, industrial, and logging. One of the most common applications is as a source of energy and its importance has increased since the other methods of producing heat and energy are becoming increasingly costlier. In addition, the abundant gas produced by the anaerobic degradation of organic waste in landfills is increasingly being used to produce energy and provide companies electricity supply (McKendry, 2002b. p.47).

Anaerobic Biodegradation

Anaerobic digestion is a biological treatment where different groups of microorganisms that require certain conditions act, a pH between 7 and 7.5 and a temperature of 35° C when using mesophilic bacteria and a temperature of 55° C when thermophilic bacteria are used. The manure produced by animals in swine farms undergoes an anaerobic biodegradation process to produce a mixture of gases mainly methane and carbon dioxide. The direct burning of these gases is a useful practice that helps to mitigate the emission of greenhouse gases (Sosa, 200, pp. 5-7).

However, the biogas can be used as an energy source, Gillari (2000 p.1) indicates that this process of generating electric energy from biogas, consists of: water used daily to wash floors on livestock farms and facilities, which is carried by gravity into the biodigestor. Where it is fermented for 50 days. Later this biogas is passed through filters with calcium oxide dissolved in water and iron filings, where monoxide, carbon dioxide and hydrogen sulfide are all removed, then purified biogas is stored in another plastic bag. Then it is sucked by a compressor which deposits and maintains a low pressure within a metal tank, and then suction it and use it as fuel to power the motor which drives the electric generator.

To determine the potential of biogas production is important to know the volume of excreta that are produced, which depends on the age of the animal, feeding and production system as shown in Table 2. Muñoz (2004.134) estimates that for every ton of (dry) pig manure can produce 700 m3 of biogas with a methane content of 60%, which means that for every kilogram of pig manure, the potential for biogas production is of 0.7 $m^{3.}$ Furthermore, it is estimated that an average pig, is capable of reducing the CO_2 emissions equivalent gases (carbon dioxide) in 0.906 tons per year, if excreta is used in biodigestion systems and direct burning.

If every day a high amount of biogas is produced then more electricity can be obtained and therefore savings will be higher. One reason to decide to generate electricity from biogas is to reduce power consumption, however, is common to find situations especially in small swine farms, which despite having a high volume of manure to generate energy produced by electrical plants power consumption is so low, that a project of this kind may not be attractive to them.

Therefore, it is advisable to analyze the cost benefit of the project, the analysis used to determine the maximum return on investment of the project, provide a rational comparison of the available options and ensure that investment decisions are taken responsibly. The analysis should take into account the capacity of the generator, which depends on the volume of excreta as well as on the size and type of pig. Table 2 shows estimates of manure production by type of pig.

Table 2 Estimation of the potential production of pig manure

Type		1	2	3	4	5	6
Animal size	(Lbs.)	35	65	150	275	375	350
Daily Production	Lbs./Day	2.30	4.20	9.80	8.90	33.00	11.00
	ft^3/Day	0.038	0.070	0.16	0.15	0.54	0.19
	Gal./Day	0.27	0.48	1.13	1.1	4.0	1.4
% of water	(%)	90.8	90.8	90.8	90.8	90.8	90.8
Density	Lbs./ ft^3	60	60	60	60	60	60
ST	Lbs./Day	0.20	0.39	0.90	0.82	3.00	1.00
SV	Lbs./Day	0.17	0.31	0.72	0.66	2.40	0.84
BOD5	Lbs./Day	0.17	0.31	0.72	0.66	2.40	0.84
Nutrient Content							
N	Lbs./Day	0.0160	0.0290	0.068	0.062	0.230	0.078
P	Lbs./Day	0.0118	0.0223	0.050	0.048	0.173	0.059
K	Lbs./Day	0.0120	0.0240	0.054	0.048	0.181	0.061
1= Breastfed pig;2=Pig in growth;3=Pig in completion; 4=Pregnant pig; 5= Pig and offspring; 6= Boar							

Source: Allen, (1996).

Sustainable Development and CDM projects

With regard to CDM projects Villavicencio (2004, p.57) mentions automatically implement these projects contribute to sustainable development in developing countries as they reduce GHG emissions. Also contribute to regional development as a source of resources to attract foreign direct investment.

With regard to local economic development the authors Coffey and Polese (1985, p.85) establish it as a process of growth and structural change in the economy of a city, county or region, highlighting three areas: a) economic; characterized by a production system that allows local entrepreneurs to efficiently use the factors of production, economies of scale and increase productivity to levels that can improve market competitiveness; b) sociocultural; system in which the relations economic and social, local institutions and values underlying the development process, and c) political and administrative; in which local initiatives create a local environment conducive to production and boost development.

From the field of sustainability Del Saz (2008, p36), part of a vision which considers humanity has at its disposal a capital stock (K) which includes two components: natural capital and man-made. Natural capital is a term introduced by Costanza and Daly (1992, p.38), referred to the different ways in which the environment feeds the production process and also how it holds many aspects of human existence. The man-made capital (KM) is one obtained through economic activity, human ingenuity and technological development.

Under this theoretical two elements concur in CDM projects, the natural resource; water (natural capital) that contributes to the production of pigs (local development) and technology; (human capital) that helps so that the wastes produced in the process are transformed in a manner to avoid contamination and by reducing greenhouse gases. In this regard, efforts are being made to reduce the use and abuse of natural resources in the production process, as well as to preserve the environment (Azar et al., 2002).

Justification

The study seeks among other things, consider whether the energy produced by methane would give swine farms owners savings on consumption, demand and on the electricity billing payment.

On the other hand, management of manure for energy production deals with the problem of environmental impact by reducing greenhouse gas emissions and the spread of odors. Even when it is required to implement a generator to produce energy, Liettin (2009, p, 49) notes that profitability and return time on investment are positive.

The research is interesting because there are few similar studies and the results will provide useful information about the cost-benefit of transforming the energy, the information can help producers make the decision to incorporate in their farms, a generator for producing electricity. Renewable energies within the Mexican agricultural production processes will become one of the projects to promote regional development and swine farms have been proposed as mechanisms to encourage and promote this type of projects aimed at achieving sustainable rural development.

Finally, personal interest in this research is to contribute with real information so that this group of swine farms that work under the Clean Development Mechanism are benefited from all the advantages offered by these projects, even when it seems that the wastes are a threat to the producer, they are actually an opportunity to increase their profitability and turn their farm into a socially responsible productive unit.

Methodology

Research from secondary data is those in which the information used has not been collected in the context of the investigation itself (Welti, 1997, pp. 40-44). In the present study, secondary data were used as the main source for assessing whether the amount of biogas produced by swine farms is feasible to be used as an energy source, and if it is profitable to use biogas for energy, data were obtained from CDM projects available from the United Nations Framework Convention on Climate Change UNFCCC.

Of the forty-four UNFCCC registered swine farms projects for Mexico, 5 projects were obtained: Jalisco, SLP, Nuevo Leon, Sonora and Aguascalientes. The Jalisco project includes 5 farms, the SLP project comprises of 10 farms, the Sonora project is composed of 17 farms, and finally the Aguascalientes project consists of 3 farms. The criterion for sample selection was based on the ease of obtaining information of CDM projects.

Projects are consulted on the website of the United Nations Framework Convention on Climate Change. All projects comply with the formatting (CDM PDD) Clean Development Mechanism proposed by the UNFCCC and contains the following points: a general description of the project activity, application of baseline methodology, project duration / credit period, monitoring methodology application, estimate emissions from greenhouse gases and sources plan, impact on the environment and feedback from shareholders.

Motogenerator type proposed in this study is 60 Kw x 24 hours x 30 days, which means that in theory, to use this capacity 528.03 m^3 per day of biogas are required. For methane production calculation the following variables are considered: population of animals, the amount of solids in the manure, manure production, volatile solids production in the manure, the amount of methane produced and energy.

The methods used to assess the actual cost of the selected projects are: Net Present Value; theory says that if the net present value is greater than zero investment is profitable Internal Rate of Return (IRR) and Benefit / Cost ratio.

Results

To answer the question: Is the biogas produced by swine farms feasible to be used as an energy source? Stipulated in the first place, the swine population and the amount of biogas produced by every one of the farms that make up the projects under study. In the population of farms involved in the project SLP-Jalisco, biogas produced is in a range of 15 m^3 / hr up to 28 m^3 / hour. With regard to all farms involved in the Jalisco project, the range is 16 m^3 / hour up to 25 m^3 / hour, and with regard to the Aguascalientes project, Querétaro, Guanajuato, gas production varies from 32 m^3 / h to 47 m^3 / hour .Finally, in the Sonora project, the amount of biogas produced is 46 m^3 / hour maximum and a minimum of 15 m^3 / hour.

From the amount of biogas generated the thermal and electrical potentials are obtained considering the following constants: methane density of 0.72 kg / m ^{3,} the heating value of methane 48 TJ / Gg, generation efficiency in the biogas systems of 33% and considering 1 MW equals to 0.00360 TJ.

The values obtained for the production were calculated assuming that the number of hours the generator will operate is 15, for one year (365 days), and taking into account the capacity of the generator is required to convert the methane into electricity. The results presented in Table 3 show only the highest performance of each of the projects if the methane produced is transformed into electricity, the table reveals that the maximum yield is $ 804,278.14 annually and the proposed generator capacity is 0.163 MW.

Table 3 Farm total production of KWh / year

Project	Generator Capacity MW	$ KWh/year
SLP_Jalisco	0.091	448,424.49
Jalisco	0.163	804,278.14
Aguascalientes, Querétaro, Guanajuato	0.155	762,566.07
Sonora	0.151	742,559.15

Source: self-made

Cost Benefit Analysis

The financial analysis includes the amount of energy that the producer would save if investing in a generator and installation, and also including equipment and maintenance costs. This, in order to more clearly reflect the profitability of the project in terms of the inclusion of this component. In this sense, we consider the following expenses: $ 220,225.00 Motogenerator, installation costs (average) $ 244,500.00, maintenance costs $ 30,000.00.The project scenario is set in a period of five years. It is also important to note that the life of the motor generator is in a range of 5-10 years, which is subject to its proper maintenance. Annual depreciation is $ 46,472.50 considering a useful life of 10 years, and its residual value would be equivalent to $ 232.362.50. A discount rate of 12% is considered, in order to locate the levels of the Internal Rate of Return (IRR) and Net Present Value (NPV).

Based on the above data the feasibility for producers to invest in complete systems for the utilization of biogas was evaluated. The Table 4 a farm having a power saving corresponding to $ 411,697.14 was considered which corresponds to the SLP Jalisco project. Later the project evaluation that verifies the feasibility was performed.

Table 4 Financial Analysis of CDM projects in swine farms

Concept	0	1	2	3	4	5
Cost of Moto Generator	-$464,725.					
Maintenance expenses		$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00
Total Costs	$464,725.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00
Energy Savings		$411,697.14[2]	$411,697.14	$411,697.14	$411,697.14	$411,697.14
Residual value						$232,362.50
Total Income		$411,697.14	$411,697.14	$411,697.14	$411,697.14	$644,059.64

Source: self-made

The financial and economic study was considered and by identifying project income and expenses, the net present value (NPV), Internal Rate of Return (IRR) and Benefit Cost ratio (B / C) of each farm that make up the projects under study were determined. In the feasibility analysis for this project a 60KW generator h operating 15 hours a day for 365 days was proposed. The large number of farms as well as the various productions of biogas limited the performance of a particular scenario.

The financial analysis showed that in a scenario of five years (table 6 and 7) the Internal Rate of Return of the farms is greater than the discount rate of 12%, and NPV observed favorable conditions (NPV> 0) and its value ranges from very different magnitudes, this indicates that the project is profitable and the addition of an engine generator as considered in this analysis is suitable for the conversion of methane to electric power.

In the indicator Benefit / Cost is observed also presents favorable conditions (B / C> 1), which shows that for every dollar invested economic benefit is multiplied according to the characteristics of the farm, then the project will generate wealth to the safely farm and bring about a social benefit

Table 6 Financial analysis of farms

Jalisco - SLP					
Granja	Población	$ KWh/Año	TIR (%)	VAN	B/C
1	6,933	411,697.14	69.46	875,533.53	5.86
2	3,965	286,589.32	40.71	424,547.84	4.23
3	5,055	398,590.79	82.94	828,288.07	5.69
4	3,161	249,247.37	61.33	289,938.46	3.74
5	*3,362*	243,004.61	30.34	267,434.71	3.66
6	5,190	409,235.64	61.98	866,660.37	5.83
7	5,070	399,773.55	58.56	832,551.65	5.71
8	5,687	448,424.49	77.71	1,007,927.40	6.34
9	5,338	420,905.56	71.53	908,727.82	5.98
10	4,794	262.663.79	35.05	676,402.89	4.5

[2] La cantidad de ahorro de energía depende de cada granja

			Jalisco		
1	5,204	410,339.56	69.15	870,639.76	5.84
2	6,950	401,540.68	67.16	838,921.76	5.73
3	10,200	804,278.14	155.89	2,290,700.70	11
4	5,060	398,985.04	66.58	829,709.25	5.7
5	6,789	255,788.93	33.41	313,519.32	3.82
		Aguascalientes, Querétaro y Guanajuato			
1	9,445	516,762.41	92.94	1,254,270.31	7.24
2	7,856	516,107.71	92.79	1,251,910.27	7.23
3	9,671	762,566.07	146.82	2,140,337.50	10.45
4	9,445	516,762.41	92.94	1,254,270.31	7.24

Source: self-made

Table 7 Financial analysis of farms Sonora

Granja	Biogás m3/hora	$ KWH/año	TIR %	VAN	B/C
1	18.80	305,270.43	45.08	491,889.06	4.47
2	34.32	557,100.47	101.86	1,399,679.99	7.76
3	12.98	210,757.95	0.23	151,192.72	3.23
4	14.64	237,629.85	29.05	571,956.21	3.07
5	15.28	248,064.61	31.56	285,674.88	3.72
6	13.57	220,276.00	24.83	185,503.16	3.36
7	41.24	669,542.23	126.54	1,805,007.37	9.23
8	37.93	615,861.34	114.78	1,611,499.78	8.53
9	45.74	742,559.15	142.74	2,068,217.03	10.19
10	23.51	381,634.25	62.65	767,163.54	5.47
11	30.39	493,320.80	87.73	1,169,768.55	6.93
12	36.63	594,709.63	110.10	2,061,765.56	8.48
13	21.44	348,088.74	54.99	1,032,813.13	4.75
14	41.12	667,564.24	126.11	2,365,729.79	9.58
15	27.84	451,972.78	78.51	1,466,238.44	6.32
16	24.00	389,590.49	64.46	1,205,966.86	5.37
17	30.57	496,282.13	88.28	1,651,106.05	6.99

Source: self-made

Feasibility study shows the cost of obtaining energy from biogas through the inclusion of a power generator in swine farms to convert methane to electricity and that is used in full on the farms and make them self-sufficient. The motor-generator proposed in this study generates monthly 43,200 kW of electricity. This means you must have a constant power of 22.0013Kw / hour.

If you want the motor generator to work 24 hours, 528.03 m3 of biogas are required and the vast majority of farms that have been studied produce that amount and even more. Furthermore it should be noted that feeding, the type of pig, and climate influence the production of biogas. It is noteworthy that farms with lower production of biogas are recommended to use a smaller capacity engine generator.

Conclusion

The results of this research allow, in more formal terms, affirm that the amount of biogas produced from swine farms in Jalisco, San Luis Potosi, Sonora and Aguascalientes is feasible to be used as an energy source.

The maximum amount of biogas produced on farms under study are: Jalisco (15.7557 m^3/hour), San Luis Potosi (16.1791 m^3/hour), Sonora (4628 m^3/hour) and Aguascalientes (31.7903 m^3/hour) that exceeds the amount required for the generator proposed in this paper that is 528.03 m^3 per day, for a 24 hour-work range.

However, the capacity of the motor-generator necessary to transform the methane into energy is in function of the biogas produced and the energy needs of each one of the farms. If one considers that the generator will operate 15 hours for one year (365 days), the San Luis Potosi farms require a generator with a capacity of 0.091MW, regarding Jalisco farms recommended generator capacity of 0.163 MW, in Aguascalientes the generator capacity is 0.151 MW and 0.151 MW in Sonora. It is important to mention that for farms with lower production of biogas, a smaller capacity engine generator would be advisable.

With respect to the profitability of projects it is concluded that of them are profitable as the Net Present Value (NPV> 1), and Internal Rate of Return (B / C> 1) are higher in each of the farms and Internal Rate of Return (IRR) is greater than the discount rate (12%) as shown in Table 8

Table 8 Net Present Value, Internal Rate of Return and Internal Rate of Return

Project	NPV >0		IRR >12%		B/C> 1	
	Min.	Max.	Min.	Max.	Min.	Max.
SLP_JAL	267,434.71	1,007,927.40	30.34	88.08	3.06	6.34
Jalisco	211,581.77	2,290,700.17	37.73	165.98	3.45	11.00
Nuevo León	19,468.25	2,389,294.08	24.93	171.91	2.93	11.35
Ags_Qro.Gto	808,391.29	2,140,337.50	75.72	171.91	5.62	10.45
Sonora	151,192.72	2,533,252.75	24.83	152.58	3.23	10.19

Source: self made

The feasibility study shows that it is profitable to include a power generator on swine farms to transform methane into electricity, which can be used in its entirety on farms and thereby make them self-sufficient If the motor generator works 24 hours, is required of 528.03 m3 of biogas and the great majority of farms that have been studied generate this amount, even some the exceed.

One limitation in this study was that it only examined project information that are available in the United Nations Framework Convention on Climate Change (UNFCCC) and, for exact effluent production, it is necessary sampling and specific studies on swine farms taken as reference in this study. Even when data have been taken as a reference may be less precise in estimating emission reductions; it is feasible to apply the information obtained from projects registered with UNFCCC.

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