投稿論文/Contributions

Internalization of pollution externality costs in Public Private Partnership PPP Schemes Case of a Cattle Manure based Decentralized Biogas Production Project

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Abstract

Public Private Partnerships or PPPs are primarily designed and implemented for mega, capital intensive projects in public infrastructure and services sectors. Rural regions account for the greater part of the population of any developing country and are characterized as a provider of food and farm products to the society. Because of a significant number of cattle, buffalos, cows and other meat and milk producing animals, local and the global environment is facing an in-tangible socio-economic externality in form of animal manure produced environmental pollution. Animal manure spread in open emits carbon dioxide, ammonia, methane, nitrogen oxide and other pollutants accounting for local pollution and global warming.

Biogas technology is an efficient solution to address the issue of more stable and efficient renewable energy source through its potential ability to keep pollution free environment. Besides being a renewable energy source, the biogas digester systems would prevent the direct exposure of methane, carbon dioxide and other pollutant emissions into the atmosphere. Moreover, the combustion of biogas displaces the use of fossil fuels for energy generation hence contributes to additional emission reductions of greenhouse gases (GHG) and other air pollutants. For complimenting the increasing interest in renewable energy, an increasing number of centralized biogas plants have been installed in recent years for their cost efficiency to convert livestock manure into renewable energy products, like electricity or bio methane products. In order to assess the true efficiency of an animal manure based biogas plant under public private partnership framework, the potential environmental externalities of animal manure should be taken account of in a socio-economic analysis.

Quantification and pricing of the potential socio-economic externalities of animal manure would be used as incentive for the PPPs to take over the biogas generation sector as it would result in an improved revenue stream over the project life cycle. The complete analysis of the factors in energy input and output streams of the biogas generation process is needed for optimal and socially acceptable pricing of the socio-economic externality costs. This paper examines the possibility of devising a public policy framework to establish a taxing regime abating production of negative externalities. Such financial measures to abate free disposal of environment hazard matter will improve the intake efficiency of biogas plants and in turn would improve viability of implementation and expansion of the technology in environment friendly manner.

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Introduction

This paper examines the impact of quantified accounting of environmental externalities exposed by animal manure, on the viability parameters of a PPP concession under limited resource funding. It also suggests a policy framework to address the issues of local pollution and global warming through a socially acceptable regulatory solution. It also encompasses the effects of modified revenue streams on PPP concession. The paper is meant to address two basic issues of sustainable development at their grass root levels implying the public private partnerships. The issues are 1)- environmental externalities of animal manure 2)- sustained sourcing of basic energy needs. To grasp the underlying thesis, a conceptual model has been constructed and simulated to study the effects of various input and output parameters.

Public Private Partnerships are generally known for mega, capital intensive projects in public sector, like power, transportation, health, education, industry, commerce, trade, telecommunications just few to mention. However, the rural development, yet, have not caught enough attention of the private sector. The economies of the most developing countries are still rooted in the exploitation of natural resources at the cost of rural economy, environment and sustainability. Until now, rural development programs and policies have focused primarily on increasing agricultural productivity not the welfare of rural population. There is a growing recognition of the complex relationship between rural resilience, environment conservation and sustainable development. The potential role of private sector under such circumstances cannot be overlooked.

Few basic social needs of rural population are health, food, energy and environment. Rural areas in developing countries still accommodates a greater part of agricultural and diary food supplies networks. Ensuring an adequate rural development would lead to an efficient agricultural system sufficient enough not only to supply the food and animal proteins but also to foster the utilization of natural resources in a manner guaranteeing a sustainable environment and development. Among many underutilized natural resources available in abundance in rural areas, animal manure tops all. Biogas is an environment friendly way of utilizing animal manure to generate heating and electricity resources in rural suburbs.

Energy sourced by utilizing biomass has become an important part of the prevailing global renewable energy mix and its share is being continuously increasing in the energy stream. According to UNEP report, a total renewable power capacity worldwide went up by 8.5% to 1,470 GW in 2012 [Program, 2011]. Traditionally, in rural suburbs, biomass is primarily used for cooking and heating purposes. Some of the recent energy expert forecasts suggest the share biomass energy is likely to make up one third of the net world energy mix by 2050.

Biogas is named after its primary composition of methane and carbon dioxide, is a flammable mixture of gases that are generated when organic material undergoes anaerobic decomposition. The mixture contains 40–70% methane, carbon dioxide, and traces of other gases. When organic wastes including food, plant debris, animal manure, sewage sludge, biodegradable portions of municipal wastes undergoes decomposition in absence of free oxygen, biogas is generated. The gas has good energy value and can be directly used as fuel or indirectly converted to electricity. Figure 1 [Michael Crook, 1979] describes a few of the typical uses of biogas.

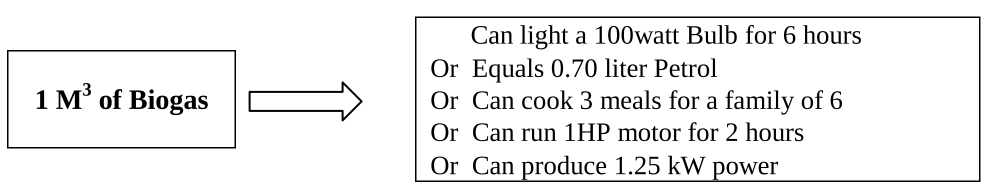

Figure 1: Tentative Commercial Value of $1M^3$ of Biogas

Biomass is any substance which could be used to produce biogas efficiently, some of the biomass sources are listed in Figure 1. For the production of 1 cubic meter biogas, quantity of biomass varies with the type, source, quality and technology used. This research emphasis the use of animal manure as biomass sources and investigates the potential participation of private sector to produce biogas on commercial scale utilizing the animal manure collected locally. The fundamental approach adopted for the dummy project will be a successful business model addressing key needs of local habitants with a greater degree of emphasis on environment.

Substrate	**Commercial Value**	**Environmental Impact**
Agricultural Crops and residues	0	Potential Hazard
Forestry crops and residues	0	No
Weeds	0	No
Biodegradable industrial waste	Negative	High Hazard
Animal manure and waste	**Negative**	**High Hazard**
Municipal solid waste	Negative	Normal Hazard
Marine algae	0	No
Sewage	Negative	High Hazard

(*Negative Commercial Value depicts taxes and cost of removal)

Table 1: Examples of substrates which can be anaerobically digested to generate biogas

Table 1 shows the tentative commercial values of the intake substrate used in biogas generation. In animal manures, the cow dung is the most common feed for biogas digesters, however good quantities of usable manure also produced by other farm animals. The most energy-efficient utilization of cow dung, efficiency 55%, is achieved through direct combustion of biogas through special purpose made biogas stoves (Tasneem Abbasi, 2012).

Implementing public private partnership framework in environmental friendly rural projects ensures a step ahead on the way to achieving sustainable development. Biogas energy projects are the best fit for PPP for their stable revenue stream, low initial cost, shorter project completion time, pre-determined energy demand and pre power purchase for the private sector on one side while offering a constant source of heat and energy, better environment and amplified employment opportunities at local level. These projects offer decentralized power and heat supply distribution network hence increasing the opportunities for private sector to apply innovative ideas and technology without being involved in conventional distribution infrastructure.

The Biogas Technology

Biogas is a modern, ecology oriented form of technology based on decomposition of organic materials at suitable and stable temperature. Biogas is a renewable form of energy which can be converted to heat, electric or mechanical power using appropriate technology. It could, as well, be purified to make bio-methane. Bio-methane are used as automotive fuel or injected directly into natural gas network. Biogas production is an energy efficient, closed and controlled process. A variety of high-tech innovations are on the way to increase production efficiency along with making the entire production cycle environment friendly. Different kinds of raw material can be used as a substrate intake with an advantage that these materials need no drying before utilization in the process. Methane, carbon dioxide, nitrogen oxide and odor emissions are low. The materials used are purified during production process, and the end product can be used as soil conditioner or as fertilizers. [Vagonyte, 2009].

Figure 2 depicts a systematic arrangement of different components of the process. The technology is equally good to take any kind of intake substrate with little systematic alterations.

The purpose of the research is to examine the financial, socio-economic and environmental attributes if cow dung is used as a substrate intake for biogas plant. The cow dung usually ferment well, produce good biogas yields and are available in ample amounts with nominal costs in rural areas. The composition and quantity of animal execrate depends on number of variables including region, temperature, fodder, digestibility, and stable location and manure collection procedures. As a thumb rule, average daily manure by a cattle or cow approximates to its 4-6% live weight [Kalwasser, 1980]. Thus a cattle weighs 500 Kg presumably produces an average daily execrate of 50 Kgs [Ulrich Stohr, 1989].

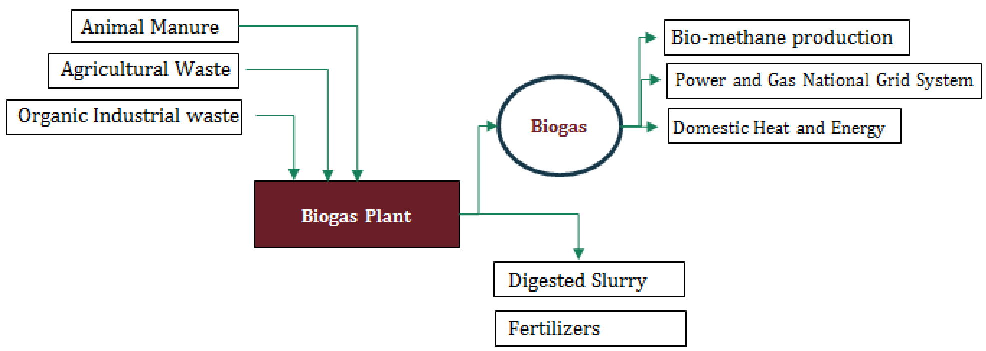

Figure 2: A Typical Bio-System Configuration

The amount of biogas per unit weight of cattle execrate depends on the regional conditions and the technology deployed. An average estimate shows a unit cubic meter of biogas utilizes 25Kg of mixed total, solid and liquid, execrate [Tasneem Abbasi, 2012].

Environmental Considerations

Extraction and consumption pattern of biomass in rural areas has created environmental problems like forest degradation and deforestation, biodiversity loss, soil degradation, and global warming. The problems such as deforestation and climate change caused by extraction of wood from forests for energy and fossil fuel combustion, need to explore more cost efficient energy resources. The biogas technology can effectively be used to supply a cost effective energy solution to rural suburb. Fossil fuel emissions form vehicles adds up environmental pollution by many folds. Again biogas technology can also be used to produce bio-methane, which can be transformed to compressed natural gas CNG. Bio-methane is an environment friendly biogas and accounts for lesser pollutant emissions if used in vehicle combustion engines. The biogas technology could efficiently be used to consume animal manure in an environment friendly way, which may else wise be an environmental hazard if allowed to rot in open.

Global warming

Global warming is another dimension of environmental deterioration getting attention globally. The green-house gases are supposed to be the key actor in this scenario. Methane is a strong greenhouse gas, and can cause 25% more warming than carbon dioxide [Pachauri, 2007]. If organic waste is not properly processed to extract methane, rather is scattered to rot in air, significant amounts of methane are produced and escape into atmosphere causing global warming. Methane produced due to anthropogenic activities over the last two centuries has contributed to the rise of tropospheric methane levels by 150% [T.J., 2009]. The biogas technology carries all the potentials to harnessed and utilize methane from waste, which may otherwise be a major source of global warming. This realization has initiated the motivation of technology innovations for the complete extraction of biogas from organic waste, such developments are called “methane capture technologies” in general.

This paper, as already mention, is devoted to analyze a theoretical or dummy PPP concession for biogas production plant. The plant is presumably to take cattle manure as intake substrate and to keep the analysis simple, thus produced total biogas is transformed to compressed biogas CBG through CBG plant. The allotted number of cattle heads for the project are 1000 with an area occupancy of 55 m2/ cattle. All the project parameters shall be adjusted accordingly.

Environmental Externalities of Animal Manure

Animal excretes if allowed to rot in open, be a hazard source of local pollution as well as global warming because of high level emissions of methane and carbon dioxide. Figure 5, below illustrates potential positive and negative externalities caused by animal manure, cow dung in our case (Methews, 1999). Experimental studies show that a herd of 1000 cows with an average weight of 635 Kgs with a unit area of influence of 55 sq. m. has the potential to produces an average emissions per cow per day as follows in Table 2, below (April B.laytem, 2010):

Pollutant	Unit emissions (/cow/day)	Total emissions (Kg /1000 cows/day)	Total emissions (tons /1000 cows/year)
NH_3	0.13 Kg	130	47.45
CH_4	0.49 Kg	490	178.85
CO_2	28.10 Kg	28100	10,285.50
N_2O	0.01 Kg	10	3.65

Table 2: Potential pollution externality of cattle manure

Quantification of manure externality to the environment is necessary to socially internalization of the negative effects. For our case, carbon dioxide CO_2 for its global warming and methane CH_4 for its local polluting environment are considered and externality agents. Table 3 shows a tentative estimate of negative externality of animal manure if allowed to rot in open air. Social cost of the subject externality has been derived for an average value of externality parameter (Alex L. Martin, 2012). Table shows that each ton of animal manure set in open has a potential to deteriorate environment in a year which may cost US$17000 to recover.

Pollutant	Pollution (per head per day)	Pollution (per Kg/day)	Pollution (Ton/ Year)	*SC/Ton	SC/Ton /Year	Total Yearly SC
	Kgs	Kgs	ton	US$	US$	US$
CO2	28.10	0.70	256.41	47.25	12115.00	
CH4	0.490	0.01	4.47	1255.00	5611.00	17726.91

Table 3: Estimates of yearly social cost SC per Kg of animal manure rot in open * (Alex L. Martin, 2012)

Techno-Business Model for Biogas Energy

In developing countries, because of the shorter supply of per capita energy at comparatively higher than supportive costs, the relevance of biogas technology solutions becomes far greater than those in the developed world. The thrust has been particularly strong in recent years due to an increasing public interest to search for a more efficient and sustainable energy sources. There are numerous reasons for the technology not being successful yet, such as:

- Final product in biogas project assumed to have a limited usage and scope. It urges the need of producing some innovative products with global demands like LNG or CBG
- Limited access to capital to explore it on a mega scale, acquiring latest efficient technologies
- Lack of public policy regulation to tax the pollutant agents. A justified, socially acceptable tax regime will create an interest to innovate the pollution disposal technologies and may gear up biogas sector to reforms.

A tentative business model should comprehend the aspects of capital costs, operating costs and the sources of revenues along with socio economic costs attached to the environmental deterioration. It needs to be more specific and explanatory when a long term public private partnerships are thought of. A typical business model, reflecting the processing of events, is represented in Figure 3 below:

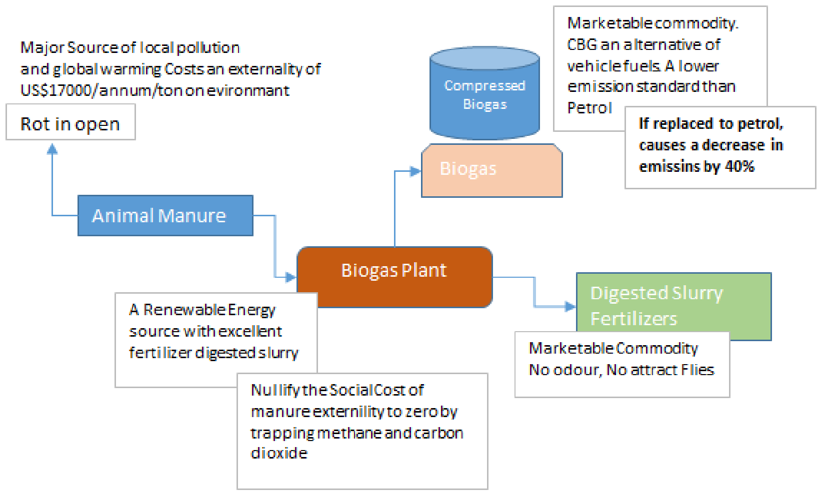

Figure 3: A typical flow chart of activities as a business model

The actual gain in greenhouse gas emissions when replacing fossil fuels with biogas depends on the substrate used. It is possible to reduce the greenhouse gas emission by more than 100% by including for example the decreased need of fertilizer. The large environmental benefit for biogas produced from manure depends on the decreased leakage of methane and nitrous oxides compared to the traditional manure storage systems.

All forms of biomass intake in our model have highly negative environmental impacts if not treated properly. Unfortunately, in rural of the developing countries, not enough attention is paid to treat the waste appropriately. In most of the cases, animal manure or the sewerage waste are free to be disposed in rivers or canals carrying irrigation waters. Taking these forms of biomass as a feeder to the biogas plant would highly positive environmental as well as health measures. In a way, biomass intake in our case will have a negative cost on users or the community but on the contrary, it will enhance the project revenue stream and will have extremely high environmental commercial value, as will be discussed in coming sections. If appropriately implemented, The CBG project is potentially capable of reducing almost 90% of the GHG load on atmosphere.

Activity/Process Stage	**Inputs**	**Out puts**	**Output Usage**	**Commercial Value**
Biomass Intake	Animal Manure		Rot in open	Non-Marketable
Gas Production		Biogas	Energy, Fuel	Marketable
		Substrate Fertilizer	Agriculture	Marketable
		Substrate Liquids	Agriculture	Marketable
CBG Plant	Biogas	Compressed Biogas	Alternate Vehicle Fuel	Marketable
			Household Heating	Marketable

Table 4: Components of the Biogas CBG Techno-Business Model

Statement of the Problem

Raw, untreated livestock waste is commonly applied directly on farmland and used as a fertilizer. Manure disposal methods are poorly monitored and documented and seldom follow standardized practices or comply with regulations. Because of higher transport costs, manure is often illegally dumped in streams and ditches. It generates an environment externality which would amount to an annual social cost equals US$17000 per ton of cattle manure. Attributing to the high manure collection costs, viability of the manure disposal projects is already been questioned.

> The research is focused on formulating a framework which can accommodate both, the profitability of the PPP concession and the internalizing of environmental externalities of manure pollution.

Research Objectives

This research analyses the potential viability of public private partnership in handling the subject externality and emphasizes a policy framework to adequately internalize the cost by introducing a socially acceptable pollution tax regime. The proposed PPP scheme will include following activities by purpose under the single concession:

1- Collection and environmentally safe transportation of potential manure pollutant within a target area
2- Treatment of the manure to produce biogas at biogas production plant
3- Converting the biogas into Compressed Biogas CBG to use as automobile fuel or household heating
4- Marketing the residue digested slurry as a fertilizers

The research primarily examines the key factors for a PPP concession success in a multi facet environment, encompassing financial, economic, social and environmental dimensions simultaneously.

Methodology

In absence of enough field data, formulation of a dummy project is recommended. The project should be based on as realistic field information as possible. In our case, a PPP concession is taken as a dummy project with the following parameters:

Parameter	Definition
Project	A Compressed Biogas generation project under PPP framework
Concession Period	30 years
Concession Type	BOOT, Build, Own, Operate, Transfer
Intake Substrate	Cattle Manure
Area Assigned	10 Km radius around proposed biogas facility
Cattle Head Count	1000 Counts
Activities	Manure collection, biogas production, CBG compression, CBG packaging

Table 5: Defining parameters of the proposed dummy project

A Monte-Carlo simulation is run MS-Excel application. The project variables and their propositional layout are discussed in further details in the section to follow. All the variables are assumed to be normally distributed, however, the model is quite able to change the desired distribution at any stage of analysis.

Assumptions and Estimates

The data in Table 6, has been derived from the assumptions listed below. The table is deemed to have applicability in the hypothetical project analysis. Following assumption from the standardized published data has been adopted to pursue the analysis further.

Cattle Heads (No)	**Expected Manure (Kg/d)**	**Biogas (m3)**	**CBG (Kg)**	**Equiv. Petrol (Liters)**
1.000	40.000	1.600	0.720	1.120
0.028	1.000	0.040	0.018	0.028
0.700	25.000	1.000	0.450	0.700
1.388	55.550	2.220	1.000	1.555
0.890	35.707	1.427	0.643	1.000
100	4000	160	72	112
1000	40000	1600	720	1120

Table 6: Biogas Commodities basic estimator

1- Average animal live-weight varies from 600-1000kgs (MWPS-18, 1993). In this study average live weight 800Kg.
2- Average Manure accumulation is 5% of Cattle live weight (MWPS-18, 1993).
3- 1 cubic meter biogas utilizes 25Kgs of Cattle manure (Tasneem Abbasi, 2012)
4- 1 cubic meter of biogas compressed to 0.45Kg of Compressed Biogas (R. Ananthakrishnan, 2013).
5- 1 cubic meter of biogas be converted to 0.70 liter of gasoline (Michael Crook, 1979)

One of the prominent ongoing debates revolves around the question of whether PPPs do indeed offer better solution than traditional public sector delivery practices particularly in multi-dimensional set ups. This research however, suggests that the role and effectiveness of PPPs can only be properly understood by carefully analyzing the horizontal and networked structures in which these partnerships operate. The key variables used to assess the project viability are assumed to be normally distributed with the parameters as listed below (Source: Author's own calculations):

Project Parameters	Mean	Standard Deviation
Project Construction Cost (US$/m3biogas)	1000	200
Manure Collection Cost (US$/m3biogas)	1	0.25
Operating Cost (US$/m3 biogas)	0.25	0.10
Cattle Head Count (No.)	1000	100
Plant Operating Capacity	90%	10%
Market Price CBG (US$/Kg)	1.75	0.5
Pollution Tax (US$/Kg)	.05	.025

Table 7: List of dummy project variables with distribution parameters

Print Output							
Costs				**Revenues**			
Desired Digester Volume		0.5	m3/m3 of biogas	Revenues from CBG			
EstimatedProject Cost		400	US$/m3 biogas	CBG Produced		0.45	Kg/m3 biogas
Considered Cost per m3 biogas capacity		1000	US$/m3 biogas	CBG Produced per 1000 Cattles		720	Kg/d
Production Capacity for 1000 Cow Heads		1600	m3 biogas	CBG market price		1.5	US$/Kg
Total Project Cost		1,600,000	US$	CBG Revenues / day		1080	US$
				CBG Revenues / Annum		394200	
Manure Cost		0.01	US$/Kg	Revenues from Digesed Slurry			
Transpoertation Cost		0.03	US$/Kg	Slurry Production m3		0.5	m3 biogas
Collection Costs		0.04	US$/Kg	Annual Production		292000	m3
		1	US$/m3 biogas	Market Price US$/m3		0.5	US$/m3
Daily Collection Cost (1000 Cow Heads)		1600	US$/day	Revenues Slurry/Annum		146000	US$
Yearly Collection Cost (1000 Cow Heads)		584000	US$/Annum				
				Total Expected Revenues		540200	US$
Other operating cost		0.15	US$/m3 biogas				
Yearly Operating Cost		87600	US$/Annum	Suggested Pollution Tax		60	US$/Ton
				Manure collection cost Tax		10	US$/Ton
Total Incurring Costs		671600	US$/Annum	Manure Collection cost with 0 tax		40	US$/Ton
				Capital Cost Recovery period(Years)			
Net Revenues	0 tax regime	-131400	US$/Annum	**Net Revenues**	0 tax regime	α	
Net Revenues	with Tax regime	306600	US$/Annum	**Net Revenues**	with Tax regime	5	
Net Revenues	0 collection cost	452600	US$/Annum	**Net Revenues**	0 collection cost	4	
Pollution Estimates							
Net emissions		**CO2**	**CH4**	**Net emissions**		**CO2**	**CH4**
As is Situation	0 tax regime	0.2564	0.004475	**With PPP Concession**	0 tax regime	0.03841	0.0000875
(mil. Ton/Annum)	with tax regime	0.2048	0.003576	(mil. Ton/Annum)	with tax regime	0.005241	0.00000451
	0 collection cost	0.03846	0.000087		0 collection cost	0.0000546	0.00000154

Figure 4: A typical model output for the dummy project

Results and Discussions

The World Bioenergy Association, WBA advocates priority of Biogas production efforts be an important part of the public strategy to reduce greenhouse gas emissions and improve environmental sustainability. As biogas production uses feedstock and other wastes that otherwise are not useful but instead emits greenhouse gases through decay and are a major cause of environmental deterioration. Biogas can replaces fossil fuels for automobiles which in-turn further reducing emissions of greenhouse gases. The deployment Public Private Partnerships in the production of biogas. The resilience and sustainability of such multi-facet and multi-sector concessions needs a decentralized approach involving many new entrepreneurs. The successful operation of biogas concessions needs an integrated support policy by the public sector governments. An integrated approach from public as well as the private sector for the development of biogas technology would enhance the energy security, reduce un-employment and positively contribute to the climate change mitigation.

The WBA recommendations for each country to sets up a biogas development plan to trap at least 30% of the country's biogas potential by 2030 (Heinz Kopetz, 2013) is welcomed. These plans should not only fix certain quantitative targets but also include system of monitoring the targets. The global approach on sustainable development is ongoing, has driven by environmental concerns and economic opportunities. While public sector have reaffirmed its commitments towards environmental sustainability, the private sector as well, is responding to new business opportunities.

This research has three objectives. Firstly, to establish a base of analysis corresponding to a decentralized biogas plants environment by creating a dummy project standing on as realistic parameters as possible. Secondly, to carry out corporate analysis to ensure project feasibility under multi facet environment and lastly, to carry out a comprehensive socio-economic analysis to investigate need of a policy framework to impose pollution tax for disposal of animal manure to ensure public participation in a socially acceptable manner.

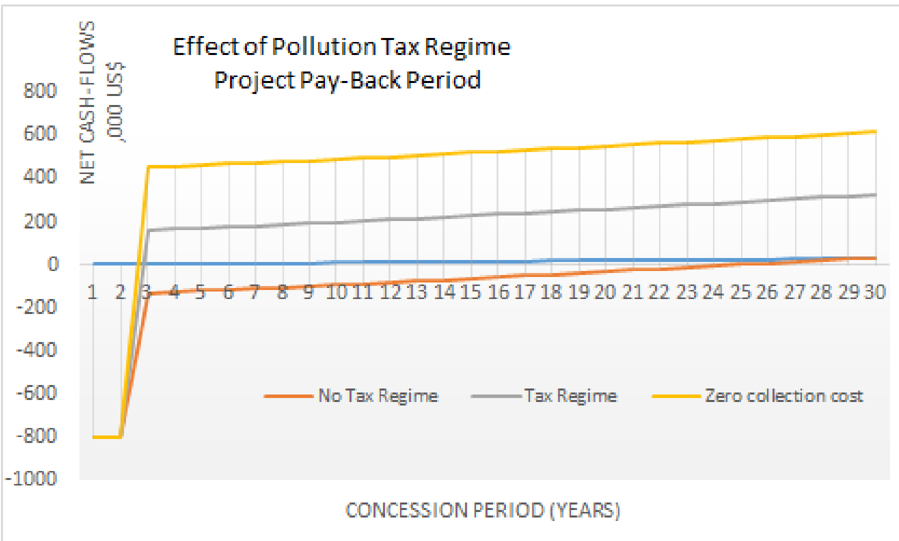

Figure 5: Effects of Pollution Tax Regime on Project Revenue Stream

A decentralized biogas plant is an installation that receives animal manure from a number of farmers and cattle stables for anaerobic treatment. From the anaerobic digestion process biogas emerges, which is converted into compressed biogas for automobile or heating purposes.

Figure 4 depicts a sample output for the simulation report. Project parameters has been detailed out in Table 5 and Table 7. It is an imaginary project encompassing 10Km radius around the plant location. Within this area, the project company has the license to collect the manure from cattle farms. If such cattle farms are not existing, the relevant authorities should encourage formation of cattle farms to facilitate manure handling as a step forward to cleaner environment. Presumably, a herd of 1000 cattle head counts supposedly exists in subject area. All the project calculations are based on per cattle head or per cubic meter of biogas production.

Figure 4 and 5 shows tentative net cash-flows of the project over its concession period. The point of concern is the negative net cash-flows over the entire concession life. It depicts an urgency of addressing issue of cattle manure collection be appropriately addressed in connection with environmental concerns. The hypothetical significance of pollution tax imposition explains the following scenarios:

1- No pollution tax: This is do-nothing scenario, which shows public non interest of environmental concerns. Under this scenario, all the risks of environmental mitigation shall be transferred to private sector who is supposed to carry out manure collection task on its own. The simulation results show that under such a situation, chances of meeting project resilience is near to impossible. Manure disposal methods seldom follow standardized practices and because of higher transport costs, manure is often illegally dumped in streams and ditches. In absence of a socially justified pollution abatement tax, cattle farm holder would be inclined to sell the manure to project company at higher prices. This will not only destabilize the project sustainability but will continuously keep challenging environment.
2- Levy socially acceptable pollution abatement tax: It urges a call for public policy framework for imposing a socially acceptable pollution tax. The form and mode of such an abatement measure would be arguable, however, it must be higher than the average manure collection costs. Imposing such a tax will ensure a sustainable and volunteer manure collection at much lower costs. The model suggests a cut of up to 50% reduction in manure collection costs. Handing the manure to the authorized entity will not ensure documented, environment friendly disposal but also ensure a steady amount of intake substrate.
3- Zero manure collection cost: It is the most favorable scenario from project view point and the model results show a higher degree of revenue stream stability. The scenario depicts a condition where the farm holders are supposed to transport the manure up to facility. This condition may arise if the pollution taxes are very high, however, is rather difficult to be accepted socially.

The biogas technology in itself represents a strategically important step away from dependence on fossil fuels which would contribute to the development of a sustainable energy supply and an enhanced energy security. Methane is a fuel in demand by industry because of its precisely controllable high quality combustion. It burns with a pure clean flame, ensuring that the boilers and other equipment do not get clogged. Another important use of biogas methane is in automobile combustion engines. In our dummy project, 100% of the biogas production is transformed into compressed biogas CBG and is marketed for automobile consumption. Table 8 details a summary of possible GHG emission reduction by utilizing CBG in automobiles.

Externality Estimates

1- 40 Kg 0f cattle Manure (If allowed to rot in open-No biogas production)

Pollutant	Per cow/day	Per Kg/day	Ton/Yr	SC/Tonne	SC/Ton/Year	SC/Kg/Year
	Kg	Kg	Tonne	US$	US$	US$
CO2	28.10	0.70	256.41	47.25	12115.49	12.12
CH4	0.49	0.01	4.47	1255.00	5611.42	5.61
				Total Cost/year	**17726.91**	**17.73**

2- Gasoline Combusted in Vehicle Usage

Pollutant	Kg/liter	Tonne/Liter	SC/Tonne	SC/liter	SC/Cow Equiv.	SC/Kg Manure Equiv.
			US$	US$	US$	US$
CO2	2.31	0.00231	47.25	0.1091475	0.1222	0.00305

3- LBG Combusted in Vehicle Usage

Pollutant	Kg/liter	Tonne/Liter	SC/Tonne	SC/liter	SC/Cow Equiv.	SC/Kg Manure Equiv.
			US$	US$	US$	US$
CO2	1.61	0.00161	47.25	0.0760725	0.0852012	0.00213003

Table 8: Tentative Social Cost (US$) of Manure Externalities on Environment and GHG Emissions

Quantification of externality of costs of manure exposure to the environment is an important element to decide upon the internalizing the externality. A trial has been carried out to assess the scope of potential damage due to direct exposure of manure to the environment. In this regard, a limited number of studies are available and all these are pointing a wide range of variability of such external costs. A most recent advancement is the study carried out by US Environmental Protection Agency (Alex L. Martin, 2012) has been referred for the purpose.

> Concentrated animal feeding operations emit trace gases such as ammonia (NH3), methane (CH4), carbon dioxide (CO2), and nitrous oxide (N2 O). The implementation of air quality regulations in livestock-producing states increases the need for accurate on-farm determination of emission rates. The objective of this study was to determine the emission rates of NH3, CH4, CO2 and N2O from three source areas (open lots, wastewater pond, compost) on a commercial dairy located in southern Idaho. Gas concentrations and wind statistics were measured each month and used with an inverse dispersion model to calculate emission rates. Average emissions per cow per day from the open lots were 0.13 kg NH3, 0.49 kg CH4, 28.1 kg CO2 and 0.01 kg N2O (April B.laytem, 2010).

Higher manure collection cost, low feed-in tariffs and the inefficient use of waste have led numerous biogas plants struggle for their economic existence. In order to make the biogas sector attractive for private investment, concerned governments needs to establish a policy framework which would help biogas producers not only to attain a cost effective steady supply of raw substrate in the form of manure but also ensure on the other hand, a sustainable environment. Both the interconnected valuable targets could be achieved if a socially acceptable environmental pollution abatement tax are levied.

Assessment of a socially acceptable amount and mode of pollution tax is a debatable issue and needs a separate research on the subject. However, for adoption in the model, a series of such taxation amount are given trials to assess the financial impacts on project viability and to see judge their implications on environment emissions. Such a tax is proposed to be at least higher than the manure collection cost as a primer value.

Methane CH_4 is a greenhouse gas more than 25 times as effective in trapping heat in the atmosphere as carbon dioxide CO_2 and act as a is tropospheric ozone precursor. The dummy project is assumed to convert 100% of the produced biogas into compressed form to facilitate usage. Results show overwhelming environmental friendly outputs of using compressed biogas CBG as a substitute fuel for automobiles. Table 8 depicts the level of emission reduction per liter replacement of petrol by CBG.

Conclusions

To achieve a satisfactory evaluation of a decentralized biogas plants, a thorough socio economic analysis with particular emphasis on environmental concerns is required. Such investigation has been accomplished, and the results are presented in this paper. New political and technical incentives are necessary for the future development of the biogas sector. The decentralized energy supply plays an important role for the regional development by reducing the dependence on centralized energy resources, help reducing the fuel imports and raises the regional added value. Residues of the biogas process contains large amounts of phosphor, which can be circulated back into the fields. Nutrients become more expensive, and in the near future there will be lack if phosphorous nutrients.

Conventional economic and corporate investment analyses do not take into account the externalities. Externalities are subject of zero expense and income for the corporate or private entity. However, externalities are important economic effects from a social welfare point of view, since such costs or benefits will accrue to the society or some elements of the society. The socio economic analysis looks from the prospective of the society in its entirety. A project may inflict negative contribution or gains for the society pollution of the environment or the empowerment through fair employment opportunities. Biogas projects have implications in agricultural, industrial and the energy sectors. Among the environmental consequences, potential pollution control, greenhouse gas (GHG) emission reduction and reduced eutrophication of ground water are important external externalities.

To internalize the externality cost of manure pollutants, a call to policy framework endorsing a socially acceptable pollution abatement tax is recommended. Which in author's suggestion, may act as a catalyst to attract private sector to the extremely environmental friendly sector of biogas generation. Involving private sector ensures the technological innovations and environmental sustainability.

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