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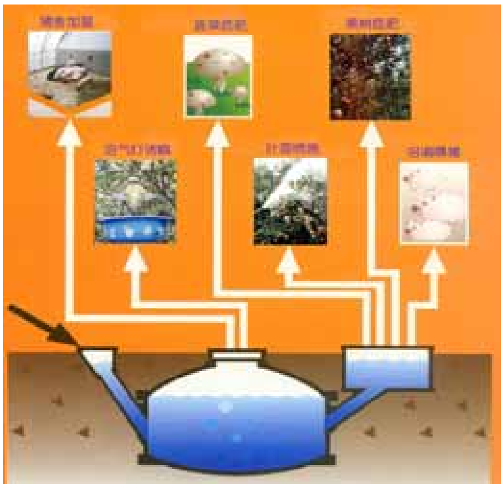
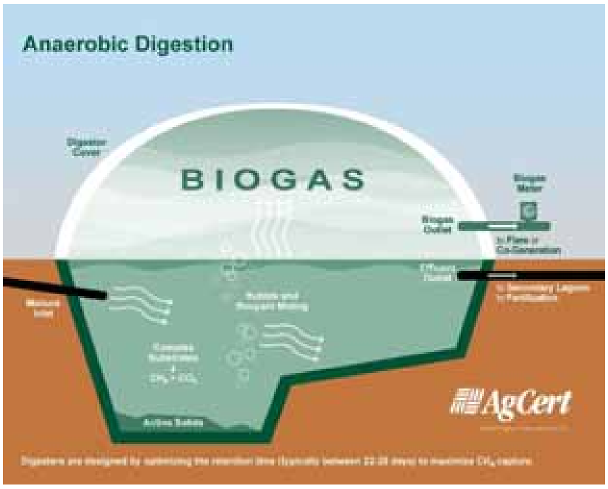
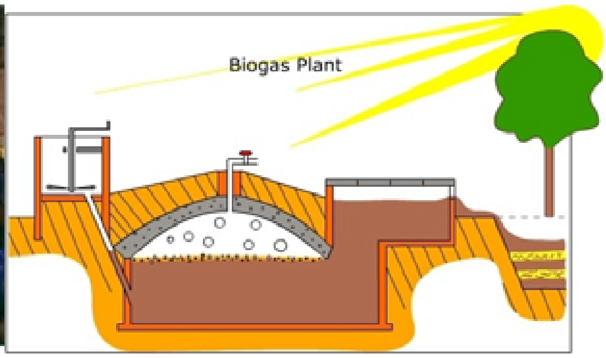
Agricultural Engineering in Support of the Kyoto Protocol

The Clean Development Mechanism for Biogas Technology

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Preface

The Kyoto Protocol specifies binding commitments by most industrialized countries to reduce greenhouse gas (GHG) emissions. The Clean Development Mechanism (CDM) is one of the three flexible mechanisms established under the Kyoto Protocol. The CDM facility provides new opportunities for the promotion of biogas to reduce the greenhouse effect, through reduction of methane emission into the atmosphere. Biogas is a proven technology in rural areas in Asia, in particular in India, Nepal, Bangladesh, and China. Over the last 25 years, different types of digesters have been developed and their installation has been commercialized. Technical assistance agencies, bilateral donors and multilateral financing institutions have supported the promotion of biogas technology, and assisted the private sector with manufacturing and dissemination of the proper technology. The World Bank signed last year a Memorandum of Agreement that facilitates the trade in emission rights from biogas technology. Biogas projects in Brazil and Chile already apply the CDM. Nepal is expected to sign the Kyoto Protocol in 2005 and biogas programmes are in place which will benefit from the sale of CERs by Nepal. Under a proper policy regime, the income from sale of CERs can be used to reduce investment costs in biogas equipment. This will accelerate purchase of biogas digesters by private households and investment in large biogas plants by commercial enterprises, further reduce pollution, and provide cheap energy. Scope exists in Asian and Pacific countries for similar CDM applications.

APCAEM conducts the study of the potential for application of the CDM facility from large scale industrial biogas plants to small household type digesters and summarise the technical, policy and institutional issues involved in the application of CDM in Asian and Pacific region. Wish you a lot of informative joy reading this report.

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Abbreviations

AD	Anaerobic Digestion
ADB	Asia Development Bank
AM	Approved Methodology
ALGAS	Asian Least Cost Gas Abatement Strategies
BP	Biogas Program (Nepal)
CDCF	Community Development Carbon Fund
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CH_4	Methane
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
COP	Conference of Parties
DNA	Designated National Authority
EB	Executive Board
EE	Energy Efficiency
ERPA	Emission Reduction Purchase Agreement
€	Euro
GEF	Global Environmental Facility
GWh	GigaWatt hour
GWP	Global Warming Potential
GHG	GreenHouse Gases
HFC	HexaFlourideChlorine
HH	Household
IBS	Integrated Biogas System
IPCC	Inter-Governmental Panel on Climate Change
kW	KiloWatt
kWh	KiloWatt hour
LULUCF	Land Use , Land-Use Change and Forestry
LU	Livestock Unit
MDG	Millennium Development Goal
MOP	Meeting of the Parties
MJ	MegaJoules
$MtCO_2e$	Million Tonnes Carbon Dioxide Equivalent
MW	MegaWatt
N_2O	Nitrous Oxide
NGO	Non Governmental Organization
PDD	Project Design Document
PIN	Project Idea Note
SNV	Netherlands Development Agency
tCO_2e	Tonnes Carbon Dioxide Equivalent
V_s	Volatile Solids
UN-APCAEM	United Nation-Asia Pacific Center for Agriculture Engineering and Machinery
UNFCCC	United Nations for Conference on Climate Change
US$	United States of America Dollar

Sources for further information

Capacity building for CDM:
http://cd4cdm.org

CDM Project Design Document (most recent version)
http://cdm.unfccc.int/Reference/Documents

CDM Guidelines
http://cdm.unfccc.int/Reference/Documents/Guidel_Pdd/English/Guidelines_CDMPDD_NMB_NMM.pdf

Decisions from EB meetings:
http://cdm.unfccc.int/EB/Meeting

Dec.17/COP7: Marrakech Accords;
http://cdm.unfccc.int/Reference/COPMOP/decisions_17_CP.7.pdf

Dec. 21/COP8, Annex II: Simplified modalities and procedures for small scale clean development mechanism project activities;
http://cdm.unfccc.int/Reference/COPMOP/decision_21_CP.8.pdf

DNV website:
http://dnv.com/certification/climatechange

Guidelines for completing CDM-SSC-PDD and F-CDM-SSC-Subm (most recent versions)
http://cdm.unfccc.int/Reference/Documents

Inter-Governmental Panel on Climate Change
www.ipcc-nggip.iges.or.jp

SSC: Global Village Energy Program:
http://gvep.org

SSC: CDM project design document for small-scale activities CDM-SSC-PDD (most recent version)
http://cdm.unfccc.int/Reference/Documents

World Bank Carbon Finance:
http://carbonfinance.org

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ABSTRACT

1. This paper discusses the main findings of research conducted by Caleb on the potential of CDM for the commercialisation of the small- to large- scale Integrated Biogas System (IBS). IBS utilises a system approach for the efficient management and conversion of agro-industrial waste into clean biogas and organic fertilizer. The methane captured could either be used for electricity generation in large/medium commercial enterprise or used for cooking, lighting and heating hot water in small scale community.

2. Unlike large industrial gases (HFC and N_2O) CDM projects, agriculture CDM project to the capture and utilize methane offers great opportunity to bring economic, social and environmental benefits to the local stakeholders and redress any sectoral and regional imbalance seen in current CDM portfolios. Large bundled CDM biogas projects are found to be highly viable project (4-7% as transaction costs/CER revenue ratio) due to the large volume of emission reduction generated. However, issues that need to be considered are: volatile content of the total solid, cost-effective technology that can meet local needs, discharge standards and temperature regime and a comprehensive good monitoring and verification plan that will guarantee delivery of high quality CER.

3. In view of the high fossil fuel prices and declining Official Development Assistance contribution to national development program, innovative carbon finance could provide a timely incentive for reinvigorating the uptake and commercialisation of small scale biogas project national development in poverty alleviation.

4. Recent EB decision at COP11 in Montreal (December 2005) has allow project activities under a national biogas program to be registered as 1 programmatic CDM project. This landmark decision will help to remove some of the constraints highlighted in this report: i) limitation on project size and high transaction cost; ii) inflexible bundling rules; iii) exclusion of non-renewable biomass from baseline; iv) perverse incentive of avoiding climate-friendly policy; v) complicating monitoring and verification plan and vi) limited upfront bankable CER.

5. Unlike small scale Photo Voltaic project (0.25 tCO2e per year with a high transaction costs/CER revenues ratio of 18.6%), small scale bundled or programmatic CDM biogas projects are found to be highly viable project (4-11% as transaction costs/CER revenue ratio) due to the large volume of emission reduction generated (2.5 to 4.99 tCO2e per year).

6. Surprisingly there is little difference in transaction costs/CER revenues ratio between single small scale (4.5%) and programmatic CDM biogas project (5.4%). In view of this highly viable project, there is no need to install biogas meter as means to reduce verification cost.

7. However, further work is needed for the presentation of CDM programs that implement climate friendly policies and measures. Host countries will now have the opportunity to positively affect the trend of carbon intensity of their economic growth, while constructing a rich learning ground for their future effective participation in the climate regime.

8. Many of the 2.1 billion people living in the rural area of Asia do not have access to clean energy. Based on 2 livestock units (1 ton live weight animal) per household biogas digester, it is estimated that approximately 20% of the entire Asian rural population could benefit from the biogas program. This meant about 83 million households with ruminant livestock and 59 million households with mono-gastric livestock could access to clean biogas for cooking, lighting and heating hot water as well as organic fertilizer for growing healthy food.

9. The clean biogas will release family from reliance on ever expensive kerosene (6.5 billion litres per year) and dirty and scarce non-renewable firewood. The energy output of the biogas

is equivalent to an electricity output of 187 billion kWh using wastes from both ruminant and mono-gastric livestock.

10. This will mitigate 414 MtCO_2e per year from ruminant population and 296 MtCO2e per year from mono-gastric population. If traded as CER, this emission reduction has the potential to raise US$ 2 billion per year for ruminant farmers and US$ 1.5 billion per year for mono-gastric farmers, a valuable source of revenue for subsidizing new national biogas program.

11. However, to attract premium investors and high CER prices, host country must show strong political will in developing clear policy on fiscal (CER surcharge, corporate taxation), finance and business structure (foreign ownership) within a transparent framework, competent and efficient DNA for approving CDM projects. This will minimize risk in project preparation, implementation and monitoring and reduce transaction cost and time.

12. The scope for biogas intervention depends on the level of national and local competency and experience in biogas technology. Country well endowed with a mature biogas market and excellent technical and financial infrastructure will be able to pick the 'lower hanging fruit' offer by the market-based CDM facility. For countries with little or no biogas experience, there is a lot catching up to do and will require urgent help in capacity building to strengthen institutional, technical and human capacity for vibrant biogas market .

1. INTRODUCTION

With rising disposal income and urbanization for the citizen in the Asia Pacific region, demand for meat protein and processed food continues to increase at a average rate of 5.9% (3.6% for India and 8.6 % for China) from 1982 to 1994 (Gerber et al, 2005). This exerts pressure on the production system to maximize returns on land and labour by capitalizing on economies of scale and production. The intensification of such production and processing systems has generated large concentration of agro-industrial wastes that requires efficient management in order to avoid polluting the local resources (air, land and water). Furthermore these untreated wastes when left in open aerobic and anaerobic conditions, tends to emit large volume of fugitive methane and nitrous oxide, which are potent[1] greenhouse gases (GHG).

Worldwide, the agriculture sector accounts for approximately 20% of the global GHG pool in 1990 (Figure 1). In 2000, 4% of the global human related (anthropogenic)[2] methane emission came from livestock manure whilst agro-industrial wastewater accounted for 10% (Figure 2).

Figure 1: Global GHG emission. (IPCC 1996)

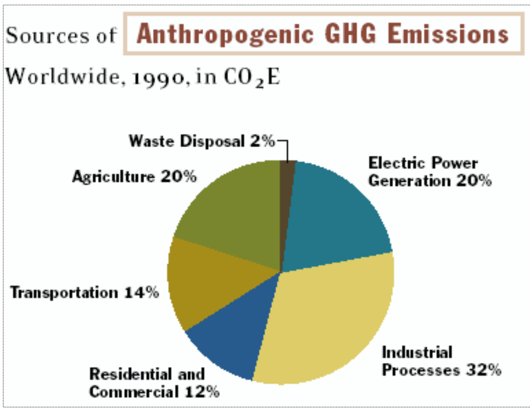
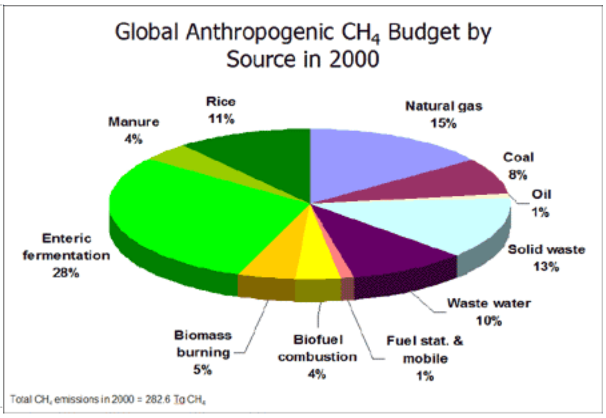


Figure 2: Global CH_4 emission caused by human activities (IPCC 2000)



[1] Methane is 21 times more potent than CO_2 as a GHG whilst Nitrous oxide is 310 times more potent.

[2] Global methane emission associated with human activities. Enteric fermentation signifies methane sources emitted from the incomplete break down of food by the bacteria in the guts of ruminants.

The Asian Least Cost Greenhouse Gas Abatement Strategy (ALGAS) commissioned by Asia Development Bank (ADB, 1998) reported enormous opportunity to reduce emission from the agriculture sector which accounted for 24% of the overall emission from the 11 Asian countries studied (Figure 3). Methane accounts for 87% of the total human related emission whilst N_2O account for 13%. Enteric fermentation accounts for 32% whilst manure management accounts for 4% of the methane source (Figure 4).

Figure 3: Agriculture sector GHGs emission. (ADB, 1998)

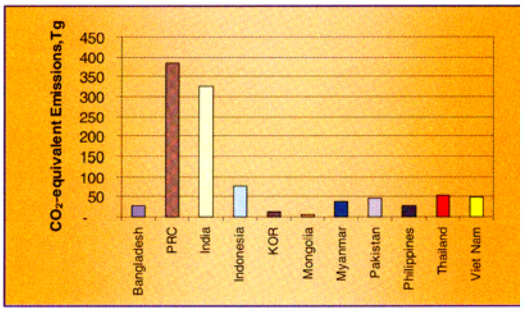
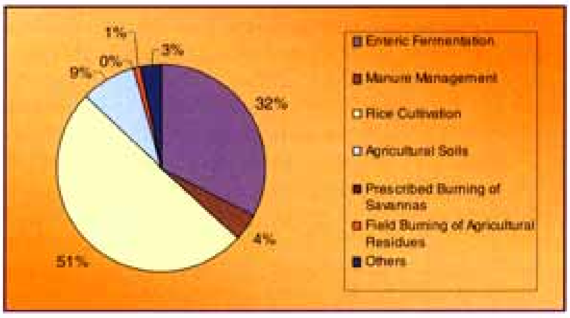


Figure 4: CH_4 budget by source in 1998. (ADB, 1998)



The major effects of livestock waste mismanagement on the environment have been summarized by Menzi (2001):

- Eutrophication of surface water (deteriorating water quality, algal growth, damage to fish) due to input of organic substances and nutrient if excreta or wastewater from livestock production get into streams through discharged, runoff or overflow of lagoons;
- Leaching of nitrate and phosphate (Gerber et al, 2005) and possible pathogens transfer to ground water;
- Accumulation of excess nutrients and caused imbalance in the soil if high doses of manure are applied;
- Natural areas of wetlands and mangrove swamps are directly impacted by water pollution, often leading to biodiversity losses.

In addition to the lakes and rivers of mounting agro-industrial wastes, the rising population in the Asia Pacific regions also posed serious human waste problem upon the environment. Due to inefficient and poor waste management and sanitation system, new pandemic livestock (Streptococcus suis, Avian bird flu) diseases are constantly threatening human health (zoonotic diseases).

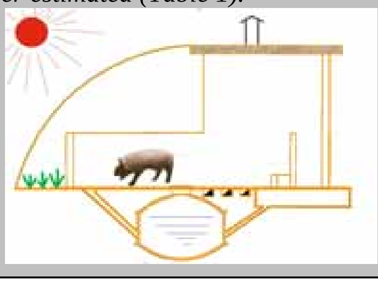
With increasing fossil fuel prices, there is renewed interest in the use of anaerobic digestion (AD) processes within an Integrated Biogas System (IBS) for the efficient management and conversion of agro-industrial wastes (livestock, paper and pulp, household waste, food processing, brewery and distillery) into clean renewable energy and organic fertilizer source. The methane (approximately 65% CH_4 and 35% CO_2) captured in the biogas is likely used for power generation purpose but also for cooking, lighting and heating of hot water for community based system (Box 1).

The Kyoto Protocol, which became effective on the 16 Feb 2005, binds Annex 1 country to reduce greenhouse gases (GHG) emissions by 5.2% to that of the 1990 levels. The Clean Development Mechanism (CDM) is one of the three flexible mechanisms established under the Kyoto Protocol. The CDM allows developed countries[3] to invest indirectly in clean and low carbon technologies in developing countries, by buying the tradable Certified Emission

[3] Those listed in the Annex 1 of the United Nations Framework Convention on Climate Change (UNFCCC)

Reductions (CERs). The CDM facility provides new opportunities for the promotion of biogas to reduce the greenhouse effect, through reduction of methane emission into the atmosphere (one of the six GHGs to which the CDM applies). The adverse effect of methane as a GHG is 21 times more potent than CO_2. When burned, CO_2 will be produced but the net effect on the atmosphere is positive. This makes methane capture project a very attractive CDM proposition.

Box 1. The impact of Integrated Biogas System in rehabilitating heavily degraded land and community transformation. C*ontinual unsustainable farming practices relying upon heavy machinery (ploughing, cultivator) and expensive inputs (inorganic fertilizer and pesticides) has caused serious land degradation in some area of China. For example, in a village in the province of Shanxi, China, no crops could be grown on their degraded un-fertile sandy land. With the introduction of the Northern 4-in-1 (Biogas, Vegetable, Greenhouse, Toilet) Integrated Biogas System (IBS - for the conversion of pig and human wastes into clean biogas and organic fertiliser) into this village using government subsidy and loans from Asia Development Bank (ADB), the well being of the whole village was improved. Not only has the IBS been able to provide clean biogas for cooking, lighting and hot water for the households but the availability of free liquid fertilizer rich in nutrients and organic matter was able to restore the fertility of the once degraded sandy land for the cultivation of the valuable lotus root crops. This has not only improved the health and well being of the villagers but the economy of the village was transformed and poverty was reduced. Hence the role of IBS project in attaining the Millennium Development Goal (MDG) cannot be under estimated (Table 1).*



A. Objectives of the Report

This paper seeks to explore how CDM could help to overcome some of the financial, economic and social barriers and in leveraging institutional, technical and human capacity for the wider adoption of the IBS. The paper will review current CDM biogas project development and highlights lessons learnt so far in order to map out future intervention for developing high quality CDM biogas project. Means for reducing the transaction cost through bundling and how risks could be managed will be discussed. Sector policy-based or program-based CDM as means to overcome some of the inherent constraints in developing small scale biogas project is proposed. Impact of the CDM project in creating additional revenues, global GHG reduction and poverty alleviation and women participation will be discussed. The potential areas in Asian countries where carbon integrity could be realized and maximized will be explored. The paper will end with recommendation for charting the way forward for developing CDM Biogas project to bring economic, social and environmental benefits to the local stakeholders. Since developing large scale biogas project is relatively straight forward, focus will be given in addressing some of the issues pertinent in developing small scale biogas project.

B. Integrated Biogas System

Despite of the multitudes of socio-economic and environmental benefits (Appendix 1) and potential for meeting the Millennium Development Goal (Table 1), the widespread adoption of IBS around the world has been rather disappointing. Except for some Asian countries (China, India, Nepal and Bangladesh), many small and large scale biogas projects have not been able to move beyond the pilot phase and the barriers to their scaling up and 'mainstreaming' has been recognized to be:

(i) Technical (biogas and animal husbandry) competence: i) Lack of competent technicians, masonry and fund to mend repairs; ii) Poor materials used leading to corrosion,

Table 1. Role of IBS in meeting the MDG through strengthening the five capitals (human, natural, social, manufacturing and financial)

Millennium Development Goals	Integrated Biogas System
Goal One: Eradicate extreme poverty and hunger: halve the proportion of people whose income is less than a $1 a day	Provide sustainable livelihood and income from diversified income generating activities to strengthen the **Human capital.** Provide extra employment opportunity.
Goal Two: Achieve universal primary education	Clean biogas lighting will allow more study time during the night to strengthen the **Human capital**
Goal Three: Promote gender equality and empower women: eliminate gender disparity at all levels of education	Create wealth and health for women and children to strengthen their **Social capital.** As 70% of the rural women are responsible for looking after the livestock, the ownership of digester will boost the women's confidence and their status.
Goal Four: Reduce child mortality: cut the under five mortality rate by two thirds	Improve mother and children health through improved healthy organic food to strengthen the **Human capital**
Goal Five: Improve maternal health: reduce by three quarters the maternal Mortality rate	Improve women health through cleaner bio-fuel and less time required for firewood and water collection thus strengthening the **Human capital**
Goal Six: Combat HIV/AIDS, malaria and other diseases: halt and begin to reverse the spread of major diseases	Access to healthy food grown with organic fertiliser may help to improve the health of the HIV-infected poor. Furthermore, intercropping Chinese sweet wormwood[4] with food crop could provide a cheap source of malarial medicine, thus building up the **Human capital**
Goal Seven: Ensure environmental sustainability	Access to good income, clean energy and fertilizer will empower the farmers to take care of the environment and manage their resources efficiently (Clean air, land and water) thus strengthening the **Natural Capital**
Goal Eight: Develop a global partnership for development: encourage countries, poor and rich, to communicate and work with each other to end poverty.	CDM instruments offer a great opportunity to strengthen the private-public-farmer partnership for building the **Financial and Technical/Manufacturing capital** of the rural community.

breakdown and biogas leakages; iii) Lack of equipment supplies and spare parts; iv) Insufficient and poor quality feedstock for the digester (potential to supplement with crop residue digester) and low temperature leading to low biogas yield; v) Poor animal husbandry due to poor feed quality and animal health and high emission of enteric methane.

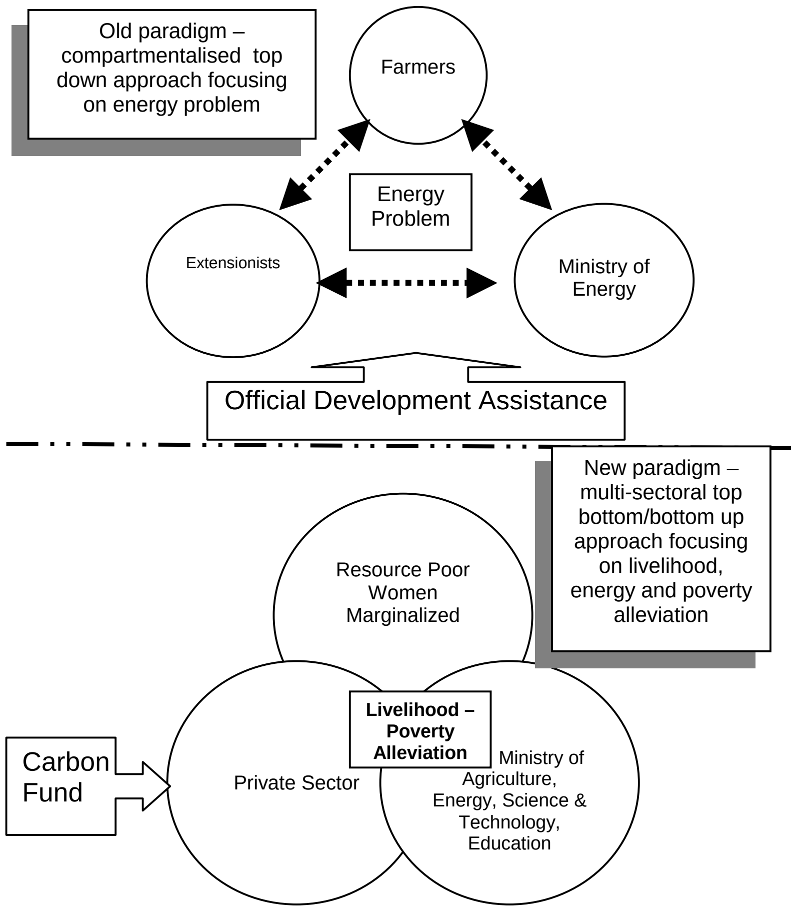
(ii) Institutional and policy Barriers: i) Sectoral, top down, compartmentalized approach in the delivery mechanism leading to lack of follow-up support services and ownership of projects (Figure 5); ii) Lack of governmental, institutional and local support to promote biogas program focusing on 'technology fix' rather than on integrated system approach (hence Integrated Biogas System); iii) Lack of sound fiscal policy to provide incentive (taxation, capital allowance) to attract investment in biogas technology.

[4] Artemesinin is an extract from the shrub, Artemisia annua, or sweet wormwood, which is currently mostly grown in China and Vietnam. It is being cultivated in Kenya. (http://www.technoserve.org/news/tanzania-artemisinarticle.htm).

(iii) Social and entrepreneur barriers: i) Lack of public awareness and gender bias against women and marginalized participants; ii) Lack of successful and competitive entrepreneurial business model for the scaling up of the biogas system; iii) Cultural taboos prevent the use of animal and human as feedstock for clean biogas and fertilizer; iv) Wrong focus on dissemination rather than on market-based commercialisation modality for the 'mainstream' of the pilot project; v) Failure breed failure and disappointment abound with loss of confidence in the biogas technology.

(iv) Financial barriers: i) Lack of access to counter funding and affordable credits due to continual under-funding within the agriculture sector; ii) Lack of means of paying back loans due to under employment and income generating activities; iii) Lack of a creative financial modality for the mainstreaming of the pilot biogas project (pros and cons of term loan, leasing and equity financing) especially for overcoming the lack of collateral and property ownership rights in many poorer communities.

Figure 5: Old and new paradigm of system approach to sustainable livelihood intervention



2. LESSONS LEARNT FROM CURRENT CDM BIOGAS PROJECTS

The Marrakesh Accord[5] states that all CDM project activities must meet the additionally criteria '*whereby GHG emission from the baseline (business-as-usual) scenario would have increased in the absence of the project activities*'. The CDM project cycle activities (PDD preparation, host country approval, validation, registration, implementation, verification and certification, issuance of CER) in comparison to conventional project development are much more complex and can be confusing. The challenges are in ensuring smooth and cost-efficient operations through the cycle (Figure 6). Hindrances to this flow will add time and resource to the project and increase transaction cost.

Since the coming of the Kyoto Protocol into force on the 16 Feb 2005, there has been an increase in the number of CDM projects submitted for validation (Table 2).

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[5] Marrakech Accord – was formally adopted at COP11/MOP1 in Montreal (Dec 2005) – a package of decisions to operationalize the Kyoto Protocol – as legally binding agreements under international law: http://cdm.unfccc.int/Reference/COPMOP/decisions_17_CP.7.pdf

Figure 6: Conventional and CDM project cycle (Source: Ecosecurities)

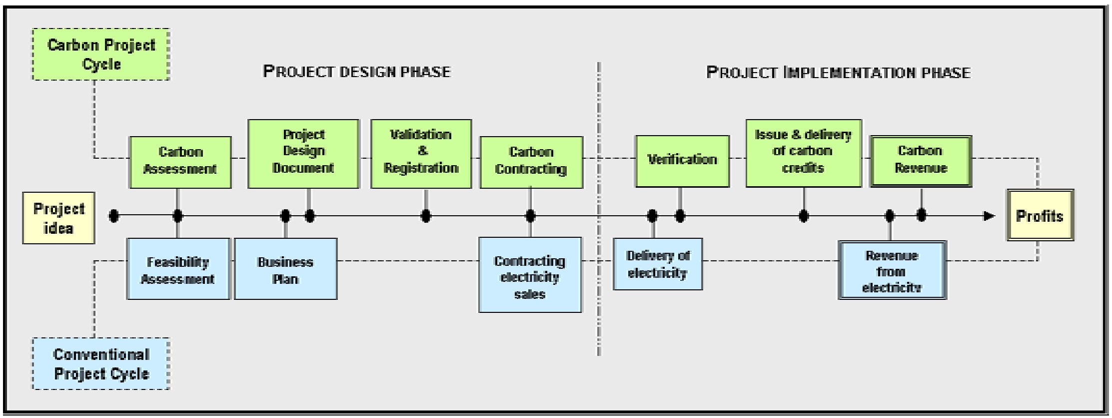


Table 2: Number of CDM project being submitted for validation and total annual and cumulative CER generated as of 16 Sept 2005. Once being validated, these projects will be submitted for registration with the EB (Fenhann, 2005).

Various types of CDM Projects	Number		CERs/yr (000)		Accumulated to 2012[6] CERs (000)	
Biomass energy	73	28%	3,531	7%	31,032	8%
Hydro	58	22%	3,202	6%	24,679	7%
Landfill gas	32	12%	8,574	17%	69,901	19%
Agriculture*	32	12%	2,554	5%	19,770	5%
Wind	17	6%	1,872	4%	13,611	4%
Energy Efficiency Industry	15	6%	418	1%	3,543	1%
Biogas	7	3%	471	1%	4,125	1%
Fossil fuel switch**	9	3%	370	1%	3,061	1%
HFCs	4	2%	12,375	24%	97,425	26%
Geothermal	3	1%	772	2%	5,979	2%
Energy Efficiency Household	3	1%	42	0%	215	0%
Solar	3	1%	44	0%	269	0%
N_2O	2	1%	15,108	30%	90,667	24%
Fugitive (oil, gas, coal, charcoal)	2	1%	912	2%	9,396	3%
Tidal	1	0%	311	1%	1,087	0%
Transport	1	0%	7	0%	59	0%
Energy distribution	1	0%	15	0%	213	0%
Total	263	100%	50,577	100%	375,032	100%
Renewable	162	62%	10,203	20%	80,782	22%
Energy Efficiency (EE)	20	8%	481	1%	4,030	1%
Fuel switch**	9	3%	370	1%	3,061	1%
CH_4 reduction	66	25%	12,040	24%	99,067	26%
HFC & N_2O reduction	6	2%	27,483	54%	188,092	50%

* Animal waste treatment (See Table 3) ** e.g. from coal to biomass or waste
EE - Energy Efficiency applies to Figure 7.

[6] Kyoto Protocol binding of the First Commitment period from 2008 to 2012.

As of 16 September 2005, there are 263 CDM projects being validated with more than half (54%) submitted for the large HFC and N_2O projects which have low Sustainable Development [7] (SD) component (Figure 7). Agriculture projects with high SD component only accounts for 5% comprising of 32 projects with an annual CER of 2.5 $MtCO_2e$ and a cumulative 19.8 $MtCO_2e$ up to 2012 [8] (Fenhann, 2005).

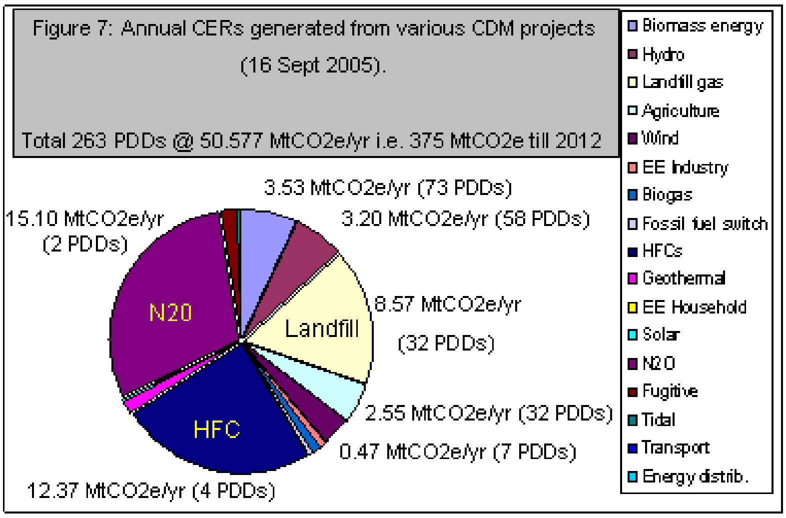


Figure 7: Annual CERs generated from various CDM projects (16 Sept 2005).

The current CDM agriculture landscape is dominated by large scale project for treating swine waste in Latin America. AgCert International PLC developed the Approved Methodology 16 (AM16)[9] has submitted 20 projects for validation with a cumulative CER of 13.7 M tCO_2e for the treatment of swine wastes in Brazil and Mexico (Table 3). In order to reduce risk for the farmers and to maintain control over CER monitoring and verification, AgCert's business model uses Build, Operate and Transfer (BOT) concept for a 10 years contract in exchange for portion of the CER.

Table 3. Agriculture CDM projects (as at 16 September 2005)

Approved PDD	Host country	PDD Developer	AD Techno-Logy	$ktCO_2e$/ yr	Crediting period (yrs)	Total cumulative $ktCO_2e$ till 2012
A. Large Scale						
19PDDs (AM16)	Brazil, Mexico	AgCert	Ambient Temperature Covered lagoon	1,862	10	13,755
6 PDDs (AM6)	Chile	Agrosuper	Temperature controlled AD	673	7	5,837
1 PDD (AM6)	Brazil	PriceWaterhouse Coopers	Covered lagoon	24	10	218
B. Medium and Small scale						
1 PDD bundled	Mexico	AgCert	Ambient temperature covered lagoon	21	10	167
6 individual PDDs (AMS-III.D) – no bundling	Philippines	2E Carbon Access	Ambient temperature covered lagoon	17	7	126
1 PDD AMS-I.C – bundled	India	Women for Sustainable Development	5,500 x $2m^3$	27	7	189
2 PDDs submitted	Nepal	CDCF	200,000 digesters	530	10	5,300

[7] Host country needs to lay down clearly their own SD criteria so that CDM project could bring long term economic, social and environmental benefits to the local stakeholders. In order to deter project with low SD component, China has imposed a CER surcharge of 60% for HFC, 35% for N_2O project and only 2% for high priority project in addition to the corporate taxation (33%).

[8] Kyoto Protocol binds annex country to the First Commitment period from 2008 to 2012. The second Period is from 2012 to 2018 where COP11 in Montreal has given the go-ahead to start negotiation.

[9] AM signifies CDM methodology approved by the Executive Board of the UNFCCC for calculating baseline and monitoring of CDM projects. Various approved methodologies are available from the website: www.cdmunfccc.org.

Agrosuper using the AM6 methodology has focus in Chile and submitted 6 Project Design Documents (PDD) with a cumulative CER of 5.8 $MtCO_2e$. PriceWaterhouseCoopers is developing a CDM project in Mexico worth cumulative 127,000 tCO_2e to 2012.

In order to reduce transaction cost, EB has allowed small scale project to adopt the simplified methodology for fast tracking[10] baseline, validation, registration, verification and monitoring procedures. So far three CDM biogas project has make use of this provision (Table 3). There are two medium scale pig CDM projects submitted for validation, one in Philippines submitted by 2E Carbon Access and one for Mexico by AgCert for a bundled project worth 21,000 tCO_2e per year. The CDM in the Philippines are 6 individual PDDs for each farm with no bundling at all whilst those of the AgCert are bundled into 1 PDD.

Currently there is only one CDM project submitted for validation for small scale project by Women for Sustainable Development to develop 5,500 digesters for households with an average of 4 cows for supplying average of 3 hours of biogas for daily cooking in India (Table 3).

A. Main issues for large scale biogas project

Overall there is less problems encounter in developing large scale biogas project given their high viability from the large emission reduction generated. Transaction costs are also reduced by bundling several project sites into 1 PDD. The baseline and monitoring methodologies (AM6 and AM16) is quite straight forward and well tested although there is call for mass balance approach to be used for calculating CER rather than using livestock population. Mass balance approach will be cheaper and simpler to monitor and verify and will reduce the discrepancy between submitted and verified data. The choice of AD technology will be determined by national discharge standards, temperature regime and land availability as covered lagoon system will required greater land bank and rely on ambient temperature (Figure 8).

Figure 8 : Large scale ambient anaerobic bio-digester in Brazil

In China's case, the main issues will be lower potential CER that could be generated from pig farms due to lower volatile solids (V_s) in the wastewater caused by solid separation. The solids are collected by farmers for use as organic fertilizer. The high quality feedstuff and high superior genetic stocks used may lead to lower nutrient recovery in the manure and hence lower CER. The insistence that the project developer must be a local entity with 51% majority share and 2% CER surcharge (see footnote 6 above) mark China out to be different from the CDM policy in Latin America. Furthermore, technology chosen must ensure that national and local discharge standard are adhered to. China does not allow the captured biogas to be flared but must be used as renewable energy for electrical or process heat.

[10] EB has provided simple and clear methodology for determining baseline emission, simplified monitoring rules and plan. PDD for small-scale activities CDM-SSC-PDD is available at: http://cdm.unfccc.int/Reference/Documents

B. Main issues for small scale biogas project

Unlike large scale biogas project, developing small scale project faces more constraints with regards to the determination of baseline, monitoring and transaction cost (Table 4). In order to

Table 4. CDM Projects for Small Scale Integrated Biogas System in India, China and Nepal

Project	India[11]	China[12]	Nepal[13]
Livestock per Household (HH)	4 cows	3 pigs	4 cows
Digester number	5,500	10,000	200,000
Digester size	2 m^3	8 m^3	4-10 m^3
kW/digester	1.81kW	1kW	1.16 to 2.32 kW
Certified Emission Reduction (CER)/digester/yr	4.93	1.79	4.99
CER (tCO_2e /yr)	27,111	17,967	530,000
Cumulative CER	189,905 for 7 years	179,670 for 10 years	5.3 $MtCO_2e$ for 10 years
1. Baseline	- Replace firewood from non-renewable sources - Replace inefficient wood stove - Replace 46 l/yr/HH kerosene with biogas	- Replacement of firewood from non-renewable sources - Replace inefficient wood stove with biogas - Replace smoky coal	- Replace firewood from non-renewable sources - Replace kerosene with biogas
2. Monitoring plan	- Rely on support sale service contractor to monitor on the number of digester installed and in operation	- Local Energy Bureau working alongside Village Biogas Association	- Rely on biogas contractor to monitor installed and operational digester
3. Total Transaction cost (US$) – Taken from Table 2	US$ 80,000	US$ 80,000	23 PDDs (9,000 biogas plants per PDD) x 80,000 per PDD = US$ 1,840,000
i) Upfront (US$)	US$ 50,000	US$ 50,000	23 PDDs (9,000 biogas plants per PDD) x 50,000 per PDD = US$ 1,150,000
ii) Annual Operational (US$)	US$ 30,000	US$ 30,000	23 PDDs (9,000 biogas plants per PDD) x 30,000 per PDD = US$ 690,000
Transaction cost as % of CER revenues at US$4 per tCO2e	9.4%	11.2%	4.6%
Sustainable Development Benefits in meeting the Millennium Development Goals	• **Economic:** Improved income from improved productivity and diversified activities; generate new employment and new skills, improved balance of payment. • **Social:** Improved health through clean biogas for cooking and light, hot water; less time for firewood collection, light for studying at night • **Environmental:** Access to organic fertilizer for healthy food production and rehabilitation of degraded land; less fly vectors, mitigate greenhouse gases (GHG) emissions from methane and nitrous oxide, improve water quality and opportunity to harvest rain water		

promote confidence and trust among the various stakeholders involved in developing and financing of market-based CDM projects, decisions undertaken by Executive Board (EB) of the United Nations for Conference on Climate Change (UNFCCC), have tended to follow a strict precautionary approach in relations to interpretation of CDM rules and approval of CDM projects. Inadvertently, some of the rules adopted by EB would seem to be 'inflexible'

[11] Taken from CDM PDD submitted for the Bagepalli Biogas project, under validation.

[12] Taken from a report sponsored by ADB to study the potential for developing small scale CDM projects in China.

[13] Taken from PDD submitted for Nepal Biogas Program by WorldBank's Community Development Carbon Fund.

and there is serious concern that this inflexibility may hinder the poor, disadvantaged and marginalized of the least developed countries from reaping the full benefits offered by CDM facility.

The current outstanding issues which could render small scale biogas project non-competitive and non-viable due to high transaction cost, potential low emission reduction and low revenues are:

i) Interpretation of project size (e.g. < 15 MW (electrical) or 45MW (thermal)) in relation to how many biogas plants could be bundled into 1 Project Design Document;
ii) Inflexible bundling rules in relation to crediting periods;
iii) Contentious additionality issues for the non inclusion of 'non-renewable biomass' in the baseline methodology;
iv) Inherent perverse incentives for avoiding sound climate-friendly policy;
v) Complicated monitoring and verification mechanism;
vi) [0]Limitations of CDM revenues in reducing up-front investment.

The following issues, which could apply equally to all small scale hydro, solar and wind CDM projects, highlights the current dilemma faced in developing small scale CDM biogas project as discussed below.

i**. Project size restrictions of the Simplified Small Scale methodology**

The Executive Board has approved simplified baseline and monitoring methodologies for small-scale projects - projects with a capacity of less than 15 MW(electrical), 45MW (thermal), annual energy production of less than 15 GWh, or annual emissions and emission reductions of less than 15,000 tCO_2e. These simplified methodologies should reduce the transaction costs of registering a small scale project significantly by up to 60% (US$ 80,000 compare to US$ 203,000 for normal project). Small projects may also be "bundled" up to the maximum size for a small-scale project for validation, registration and verification, to further reduce transaction costs (Table 5).

Table 5. Transaction costs for normal and small scale CDM project (US$)

(modified from Bhardwaj et al, 2004)	Normal-scale (average)	Small-scale (average)	Cost reduction [%]
A. Upfront	71,000	50,000	-29.6%
1. Project preparation and review	9,000	10,000	+11.1%
2. Project Design Document	24,000	24,000	-0.0%
3. Validation	12,000	6,000	-50.0%
4. Appraisal phase	20,000	6,000	-70.0%
5. Initial verification (start-up)	6,000	4,000	-33.3%
B. Operation	132,000	30,000	-77.3%
6. Periodic monitoring	72,000	12,000	-83.3%
7. Verification and certification (annually)	60,000	18,000	-70.0%
Total transaction costs	203,000	80,000	-60.6%

However, one of the outstanding issues relate to which project size limit (15 MW electrical, 45 MW thermal, 15GWh annual energy production) should be applied to small scale domestic biogas and how many biogas plants could be bundled into a small scale Project Design Document (PDD) (Table 6). For example, for a small scale biogas plant generating 933 m^3 of biogas per year, the annual gross energy production would be 21,553 MJ. With this assumption, four plausible scenarios are illustrated in Table 6.

Table 6: Project size limitation on the number of small scale biogas plants that could be bundled in a PDD.		
Project size	**Plausible Scenarios**	**Number of Biogas plants per PDD**
1. 45 MW thermal	Assuming 90% of the biogas is used for cooking with the remaining used for lighting and heating hot water, for a biogas plant providing biogas cooking for 24 hours, the thermal output would be 0.68 kW and this would allow 66,176 to be bundled into 1 PDD.	45 MW/ 0.68 kW = 66,176
	But more realistic the average biogas used for cooking would be 4.5 hours per day, hence the plant's gross power output would be 3.65 kW giving rise to 12,329 biogas plants per PDD	45 MW/3.65 kW = 12,329
2. 15 MW electrical	With a similar gross power level of 3.65kW per plant, 4,100 biogas plants could be bundled into 1 PDD.	15 MW / 3.65 kW = 4,109
	However, since this limit refers to electrical power, it seems more correct to calculate with a power conversion of thermal power to electrical power. Running a small generator set, it is reasonable to assume that the operating hours are more than the stove hours, say 8 hours per day. In this case the gross power output of the biogas would amount to some 2.05kW per plant. However, the efficiency of smaller generator is low, 30% would be at the high end of such a device. The electrical power output thus would amount to 0.62kW, and 24,194 plants would bundle into one small scale PDD.	15 MW / 0.62 kW = 24,194
3. 15GWh annual energy output	A biogas plant produces 6,222 kWh of energy per year. With the energy limit of 15GWh per small scale PDD, the total number of biogas plants per PDD is 2,411.	15 GWh/6,222 kWh = 2,411
4. 15,000 tCO_2e	Assuming a biogas plant could reduce 5tCO_2e per year, 3,000 plants could be bundled in 1 PDD.	15,000 / 5 = 3,000

From the above calculations, it can be seen that the number of small scale biogas plants that could be bundled into one PDD ranges from 2,411 to 24,194. This will have profound effect on the transaction cost and the practical implementation of the small scale CDM project in deciding whether to submit the PDD as a simplified small scale or normal scale project.

Submitting 1 small scale PDD with 2,411 digesters would give a transaction costs/CER revenue ratio of 16.6% when compare to only 1.7% for the PDD with 24,194 digester units.

Research conducted by Ecosecurities on transaction costs for the CDM revealed that investors will not support transaction costs that are more than 7% of the revenues generated by selling the carbon credits created by the project (Bhardwaj et al, 2004). In Table 4 the transaction costs/CER revenue ratio for the India biogas project is 9.5%; 11.2% for the China Biogas and 4.6% for the Nepal biogas project due mainly to differences in CER per digesters and number of digesters per PDD.

ii. Inflexible bundling rules of the Simplified Small Scale methodology

To make the matter worse, the rules governing the ability to bundle projects are not yet clear. Instead of making the rules more flexible so that the poor host country could reap the benefits of CDM projects, Executive Board seems to further restrict the bundling rules. As of July 2005, EB release the latest rulings[14]:

i) Project activities wishing to be bundled shall indicate as of the request for registration that they will be bundled;
ii) Once a project activity becomes part of a bundle it shall not be de-bundled i.e. project activities that are bundled at the registration should remain part of the bundle;
iii) Composition of bundles shall not change over time (i.e. the submission of projects to be used in a bundle shall be made at the same time i.e. project activities cannot be substituted for one another later on;
iv) All project activities in the bundle shall have the same crediting period.

Given the above inflexible rulings, it is likely that the development of the 23 PDDs will take times and resources in recruiting new participants and lead to loss of potential credits. This inflexibility will place unnecessary heavy burden upon the host country already scarce in resources and will deprive the poor of the multifaceted benefits offered by small scale biogas project.

iii. Exclusion of non-renewable biomass in the baseline

In order to avoid double accounting of carbon stocks and carbon pool and the difficulty in proving that the biomass used are non-renewable, a decision by EB21[15] (Sept 2005) has removed the reference to projects that replace non-renewable biomass[16] from the small-scale CDM methodologies I.c (thermal energy for the user) and I.d (Grid connected renewable energy generation). Among the CDM projects affected by this decision are a project to provide solar cooking stoves to poor communities in Banda Aceh in Indonesia, projects to improve the efficiency of wood stoves and the World Bank's Nepal Biogas Project that provides biogas energy for cooking and replaces the use of non-renewable firewood in 200,000 rural households (Schlamadinger, 2005). Schlamadinger explained that the rational of the EB's decision for the exclusion as: 'According to IPCC inventory guidance, CO_2 emissions from non-renewable biomass are reported in the LULUCF (land use, land-use change and forestry) sector of the national GHG inventory. Since the Marrakech Accords limit LULUCF in the CDM to afforestation and reforestation activities and exclude other activities such as deforestation avoidance, any savings of carbon in terrestrial carbon stocks can only be accounted for if they result from an afforestation or reforestation project. While the replacement of non-renewable biomass was seen as a way of focusing on energy-sector projects in least developed countries without a fossil-fuel baseline, the emission reductions occur in the LULUCF sector, and this has now lead to the ineligibility of this type of activities.

The EB21 decision is understandable on technical grounds, but it generates negative consequences for projects that have been developed over the last three years, and is implemented too quickly, with only a few weeks notice. These projects were developed in the belief that the EB wanted to support small-scale projects which benefit poor rural economies that want to get involved in the CDM, and therefore at least projects already in the PDD preparation phase should be allowed for registration'.

EB21 has asked for submissions by 5 December of alternative methods for calculating emission reductions for small-scale project activities that propose the switch from non-renewable to renewable biomass … while not accounting for any net increase of carbon pools

[14] These rules build upon recommendations from the recent second meeting of the Small-Scale Working Group (16-17 May 2005) -www.cdn.unfccc.int/Panel/ssc_wg/sscwg_meetings/SSCWG02_rep_ext.pdf

[15] 21st of the EB meeting

[16] exploitation of non-renewable biomass could lead to deforestation and exposed fragile ecosystem to serious soil and water erosion and loss of biodiversity.

compared to what would occur in the absence of the project activity. Therefore all new PDD that intent to take account of non-renewable biomass in their baseline calculation must follow the new methodology to be published by the EB in Jan 2006.

iv. Perverse incentive – National Biogas Development Program as a Common practice

The Marrakech Accord states that any project activities that contribute to reduction of GHG emission as a result of national policy will not be considered as additional and hence ineligible as CDM project. However, to avoid host country shying away from formulating climate friendly policy and to overcome this perverse incentive issue, recent decision of the Executive Board ruling[17], that national and/or sectoral policies or regulations that give comparative advantages to less emissions-intensive technologies need not be taken into account in developing a baseline scenario if the policy or regulation was enacted after 11 November 2001.

Nevertheless, there is still concern whether a vibrant national biogas program with upfront subsidy of up to 30% (e.g. Nepal, India and China) could still be eligible as CDM project. Such concerns for non CDM eligibility may deter potential CER buyers from investing in such project. Hence to avoid this problem, many host countries will be tempted to postpone or shy away from putting in place sound climate-friendly policy.

v. Monitoring and verification plan for programmatic CDM project

Monitoring and verification is important because if CER were awarded in error, emission in annex 1 countries would be 'offset' by non-existent emission abatement, which means that global emission would rise because of the CDM project activity. If the bundle consists of technologies without a meter, the EB guidelines stipulates that verification must be done by means of an annual check of the operational status of a representative sample (e.g. 1% of the bundle) of the systems included in the bundle. This, however, involves much more effort than simply reading the meter and verification costs therefore are substantially higher.

In order to reduce on transaction cost, most of the monitoring plan shown in Table 4 involved using the sale service maintenance and operation contract as the main contact point to carry out some of the ground work. The monitoring plan entails recording the numbers of digester that has been installed and those are still in operation on a six monthly basis. Monitoring of small projects scattered over a wide areas remains a challenge and will add burden to the transaction cost.
Installing small biogas meter for monitoring biogas production from individual digester or selected group of biogas digesters could reduce verification cost. But it remains to be seen whether such biogas meter could be manufactured locally and be reliable (corrosion from hydrL-sulphide gases) and cheap enough for widespread use.

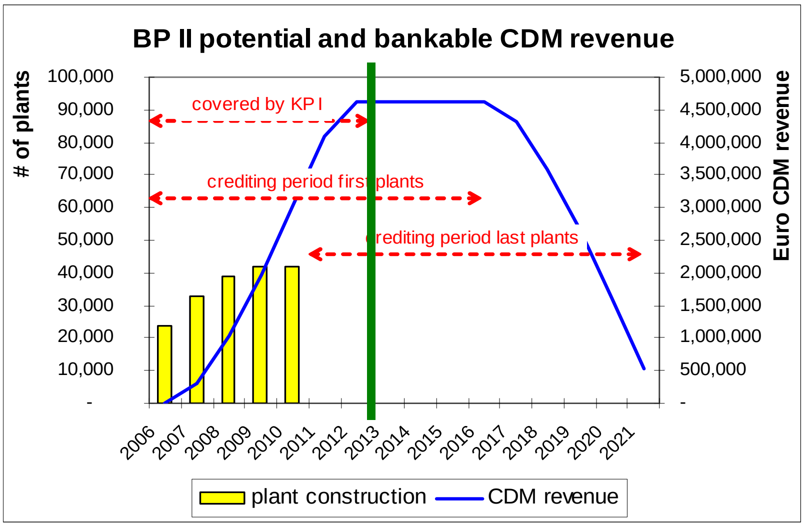
However, analysis adapted from Bhardwaj et al (2004) in Section 4 below has shown that there is no need to install biogas meter. Unlike small scale Photo Voltaic project where the transaction costs/CER revenues is 18.5%, the ratio for bundled biogas project with biogas meter is only 0.6% when compared to bundled project with no biogas meter of 5.4% (see Table 7 in page 27). Because of the high CER yield of the small scale biogas project, the low ratio of 5.4% for the non-metered bundled project is still well below the threshold of 7% (the project is considered non-viable above this threshold), making non-metered bundled project viable and competitive for investors. This is discussed in more detail in Section 4.B.ii.

[17] Annex 3, EB meeting #22

vi. Lmitation of CDM revenues in the raising of up-front investment within the first commitment period

As the window of opportunities for developing CDM projects are closing as we approach the Kyoto Protocol first commitment periods of 2008 to 2012, ter Heegde (2005) has calculated that only 42% of the total CDM revenues could be secured as upfront equity loans from the[0] bankable" CERs (Figure 9).

Figure 9: Rising of upfront loan from bankable CERs (ter Heegde, 2005)



One aspect of the problems with small scale rural technology such as biogas and CDM is in relation to the crediting period (10 years or 7 years with two renewals). For developing small scale biogas project, it is likely that:

- No farmer could make a € 250 investment within such a timeframe. More realistically, the farmer would expect to realize his/her benefits over a period of 5 years.
- As CER is only available upon proof of actual reduction, the real value of the CERs after these 5 years will diminish significantly. Not only is the Kyoto Protocol commitment period 1 effectively making any CERs after 2012 non-bankable, but getting the revenue more upfront only works against (very) significant discount costs.
- Furthermore, a project developer is faced with a monitoring / verification requirement that could linger on years after the actual "implementation part" of the project is over. Unlike large thermal energy plant that will work at one physical place for the next 20 years, the small biogas plants are scattered and spread all over the country.

Therefore, for this type of small-scale projects, one might like to consider a shorter crediting period of e.g. 5 years against a higher CER price. It would benefit both investor (less risk and uncertainty) and developer (easier and more manageable monitoring duties), and avoid the need to get CDM revenue up front.

3. SECTORAL POLICY BASED OR PROGRAM-BASED APPROACH

In order to overcome the above perverse incentive (from deterring host country from developing sound, sustainable and climate-friendly national policy), additionality issues and high transaction cost, there is a need to explore the feasibility of developing CDM project based on sector policy-based or program-based approach (programmatic CDM) as advocated by Samaniego and Figueres (2002), Schmidt et al (2004), Sterk and Wittneben (2005) and Figueres (2005). The small scale biogas projects offer an exciting possibility to test out the sectoral policy approach (Yapp et al, 2005).

A. Sectoral policy based CDM

A policy-based approach is a government-driven mechanism that enables non-annex 1 countries to develop national or local policy or program initiatives that discernibly lower GHG emissions in a particular sector e.g. agro-industrial waste, municipal waste, small scale biogas digester for crop-livestock farming system. The CERs flow directly to the host government that will thus be compensated for its efforts and may choose to pass some of the benefits on to industry and households affected by the measures in the form of tax incentives, subsidies or other fiscal instruments. This provides an innovative tool for government to finance climate-friendly policy measures.

However, at this point it is still difficult to ascertain exactly how the CER rewards will be distributed between the private and public actors. If the total CER price is too high, then market participants would be reluctant to follow the new policy or investors would hesitate to take advantage of the CDM opportunity. On the other hand, if the CERs were passed on directly to private investor in the sectoral CDM scheme, taxpayers would be left with the burden of the transaction cost of setting up such project without the financial benefits of the CDM. The balance in this distribution has to be struck early in the process of setting up the sectoral CDM project to avoid conflict or disappointment later. There must be in-built safeguard to ensure that the CER revenue should be invested into the sector to support the implementation of the climate friendly policy. Diverting this carbon revenue to other sectors or for other national programs could be self-defeating, as the lack of appropriate resources investment could impede implementation and generate disincentive.

Defining the sector establishes the CDM project boundary. For example, the agro-industrial waste stream, municipal waste or small scale biogas digester in a country, region or district could be set as a sector with a baseline established for each sector. This will be less prone to leakage. It needs to be decided whether the baseline is set as absolute or a relative emission volume (i.e. tCO_2e per Gross Domestic Product or per output) and whether a baseline should be binding with sanctions attached to non-compliance. Relative baseline could be linked to economic growth, which eliminates the uncertainty of how this growth is going to impact future emission (Sterk and Wittneben, 2005).

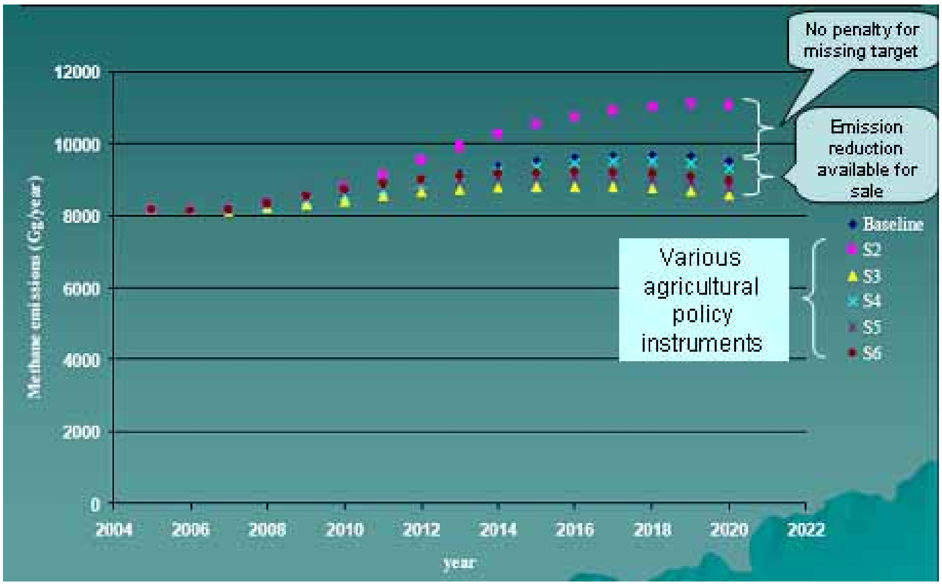
More recently, Schmidt and Helme (2005) proposed a **'No-lose pledge'** whereby i) **no penalty** will be imposed for public or private entities who do not meet their baseline (absolute) or benchmark targets (carbon intensity – relative reduction) but ii) public or private entities will be **rewarded** if their project activities lead to emission reduction below their established baseline (absolute) or benchmark (relative). For example, this concept is being tested in Brazil to reduce methane emission from the cattle industry (Figure 10). Emission reduction below the baseline in response to certain agricultural policies (S3 to S6) will be available for sale whilst no penalty will be imposed if a particular policy (S2) leads to emission above the baseline.

A policy-based CDM for the Agriculture sector could entail project activities undertaken within a sound Sustainable Agriculture policy which would promote sustainable practices beyond the climate agenda. Such project activities would include IBS, conservation agriculture, zero tillage, growing of bioenergy crops (e.g. Jathropha), reduction of enteric methane emission from ruminant that will culminate in the reduction of GHG.

Existing CDM projects could be incorporated into the sector CDM in order to avoid double accounting. Project approval could still follow current CDM procedures with bottom up baseline assessment. The sectoral approach still requires having reliable emission inventories and projections for the host countries.

Since the Sustainable Agriculture policy would become the project itself, all the project activities within the policy would be deemed additional and reduce transaction cost because of economy of scale. This policy based project will prevent host country from shying away from climate protection strategies for fear of CDM ineligibility. On the contrary the host country should be rewarded for creative and innovative climate change strategies to bring multi-benefits to the local stakeholders. However this will require a lot of capacity building in the non-annex 1 countries. Technical capacity would be easier to focus and built up to compliment and enhance national development program.

Figure 10: No-lose pledge for Sectoral CDM in Methane Emission Reduction (Schmidt et al 2004)



Since the Sustainable Agriculture policy would become the project itself, all the project activities within the policy would be deemed additional and reduce transaction cost because of economy of scale. This policy based project will prevent host country from shying away from climate protection strategies for fear of CDM ineligibility. On the contrary the host country should be rewarded for creative and innovative climate change strategies to bring multi-benefits to the local stakeholders. However this will require a lot of capacity building in the non-annex 1 countries. Technical capacity would be easier to focus and built up to compliment and enhance national development program.

A National Sectoral CDM Biogas Working Group could be set up to develop agricultural sectoral policy based CDM for maximize sustainable development integrity. Annex 1 countries could help to build up local capacity in exchange for CERs. Since sectoral approach could form part of the post 2012 strategies, it is pertinent to further investigate this potential as this will help non annex 1 countries to gradually move towards emission limitation commitments and gain valuable hands-on experience in designing and implementing large-scale national climate protection policies. This is being tested for the CDM transport in Chile and CDM mandatory energy efficiency standard project in Ghana and is awaiting approval from the EB.

B. Program-based or Programmatic CDM

The EB has decided at the recent COP11 meeting in Montreal (Dec 2005) that ***"a local/regional/national policy or standard cannot be considered as a clean development mechanism project activity, but that project activities under a programme of activities can***

***be registered as a single clean development mechanism project activity*"** provided that CDM methodological requirements are met. In other words, the adoption of a policy or standard in and of itself cannot be submitted as a CDM project, however, the activities that constitute the actual implementation of that policy or standard can be submitted as a single programmatic CDM project activity in the form of a program.

A CDM program of activities is one in which **emission reductions are achieved by multiple activities executed over time as a result of a government measure or private sector initiative.** Examples given by Figueres (2005) include energy efficiency upgrades, fuel switching activities, or installation of renewable energy sources that occur as the result of a regulation, efficiency standard, and/or a grant or soft loan program. The basic characteristics of a CDM program are:

- It occurs as the result of a deliberate public sector measure (voluntary or mandatory), or a private sector initiative;
- It results in a multitude of dispersed activities that are induced by the program and would not occur but for the implementation of the program. These activities must be measured and monitored according to approved methodologies to ascertain their contribution to the emission reductions achieved by the program;
- The GHG reducing activities do not necessarily occur at the same time or in the same location. This will remove the restrictive and inflexible bundling ruling mentioned in Section 2.B.ii and allows vintage CER to be developed to suit local resources;
- The type, the size and the timing of the emission reducing activities induced by the program may not be known at the time of project registration. However, the types and sizes of the expected activities must be identifiable ex ante, attributable to the program, and verifiable ex post;
- The various activities under the CDM program are submitted to validation and registration through one single Project Design Document.

i. Implications for national biogas program

This is tremendous good news for the national biogas program in Nepal (200,000 units) and Vietnam (180,000 units) which could be registered as 1 programmatic PDD. Vintage CER would be developed to match with local resources and capacity. The programmatic CDM project must use approved baseline and monitoring methodologies, inter alia, define the appropriate boundary, avoid double accounting and account for leakage[18], ensuring that the emission reductions are real, measurable and verifiable, and additional to any that could have occur in the absence of the project activity.

ii. Running transaction costs for programmatic CDM project

As mentioned earlier in Section 3.B.iv, analysis adapted from Bhardwaj et al (2004) has shown that there is no need to install biogas meter for bundled programmatic project as transaction costs/CER revenues ratio is 5.4% still well below the threshold of 7% (the project is considered non-viable above this threshold), making non-metered programmatic project viable and competitive for investors.

The analysis in Table 7 also includes the original transaction costs for small scale Photo Voltaic project for comparison with biogas project. The followings are observed from the analysis:

- Biogas project are much more profitable than PV project i.e. each biogas system yield about 2.55 to 4.99 tCO_2e per year (4-10 m^3 size) compare to only 0.25 tCO_2e per year for a single PV system;

[18] Leakage defines as increase in emission that occurred outside the project boundary.

- For PV project, bundled project with no metering will be unprofitable as the verification cost will increase the transaction cost to 72% of the CER revenues;
- Unlike PV project, there is no need to install biogas meter to reduce verification cost because of the high CER yield for the biogas project i.e. the ratio for metered programmatic project is 0.6% compared to 5.4% for non-metered project;
- There is very little difference in transaction cost/CER revenues ratio between single small scale (4.6%) and programmatic CDM (5.4%) when compare to 18.5% for the PV project;
- Hence the main benefit of registering programmatic project is the avoidance of the crediting restriction so that vintage CER could be developed to match local resources.

Table 7: Comparison of indicative CDM transaction costs for single small scale projects, bundled and programmatic projects for Biogas and Photo Voltaic (PV) Project.

	Small Scale Biogas Project			Small Scale Photo Voltaic Project (Taken from Bhardwaj et al, 2004)		
	Small-scale	Programmatic Metered project	Programmatic project without meter	Small-scale low end project	Bundle of metered projects	Bundle of projects without meter
A. Upfront establishment cost						
1. Development of registry		9,000	9,000		4500	4500
2. Building capacity		18,000	18,000		9,000	9,000
3. General costs		6,000	6,000		3,000	3,000
B. CDM project cycle Upfront						
4. Project preparation and review	10,000	9,000	9,000	4,800	5,400	5,400
5. Project Design Document	24,000	24,000	24,000	10,800	12,000	12,000
6. Validation	6,000	12,000	12,000	6,000	7,200	7,200
7. Appraisal phase	6,000	20,000	20,000	8,000	13,000	13,000
8. Initial verification (start-up)	4,000	6,000	6,000	3,000	3,600	3,600
Sub-total (i)	50,000	104,000	104,000	32,600	57,700	57,700
C. Yearly running costs						
9. Verification	2,000	7,200	200,000*	1,200	1,800	78,000**
10. Certification	1,000	6,000	6,000	3,000	3,000	3,000
Sub-total (ii)	30,000	132,000	2,060,000	42,000	48,000	810,000
Total transaction costs (i + ii)	80,000	236,000	2,164,000	74,600	105,700	867,700
CER revenue at US$ 4/tCO2e	1,800,000	40,000,000	40,000,000	400,000	1,200,000	1,200,000
CER revenue at US$ 7/tCO2e	3,150,000	70,000,000	70,000,000	700,000	2,100,000	2,100,000
Transaction cost as % of CER revenues at US$ 4/tCO2e	4.45%	0.59%	5.42%	18.65%	8.81%	72.31%
Transaction cost as % of CER revenues at US$ 7/tCO2e	2.54%	0.34%	3.10%	10.66%	5.03%	41.32%

Notes: * Based on 1% of the 200,000 biogas digesters x US$ 100 per digester to verify.

** Based on 1% of the 120,000 PV units x US$ 65 per unit to verify.

4. COMMUNITY DEVELOPMENT CARBON FUND (CDCF) AND EMISSION REDUCTION PURCHASE AGREEMENT (ERPA)

As of April 2003 the World Bank's CDCF, which will concentrate on small-scale projects, had received about 30 project ideas representing projects between 0.6 and 1.2 $MtCO_2e$ of total reductions. Finland is expected to sign contracts to purchase about 500,000 tCO_2e of CERs from three or four small-scale projects at prices from €2.70 to €6.30/tCO_2e. Those prices are comparable to the prices for CERs from larger CDM projects, suggesting that the simplified methodologies reduce the transaction costs enough to keep small-scale projects competitive in the market.

Included in the CDCF portfolio is the biogas project to develop 200,000 digesters to generate biogas to replace kerosene and firewood in Nepal as shown in Table 4. It is expected to generate 5.3 $MtCO_2e$ for 10 years with delivery starting in 2005 and CDCF has committed to purchase 1 $MtCO_2e$. This project hopes to generate 15,000 new employees per year. This are highly profitable CDM project as the transaction cost only account for 4.6% of the total CER revenues (Table 7).

It is important to ensure that the d**ue diligence checklist** for country, project proponent and sponsor eligibility and competence are in place for the delivery of high quality CER at high premium price:

A. Host Country eligibility

The proposed CDM project activity has to be implemented in a host country that:

i. is a Party to the United Nations Framework Convention on Climate Change (UNFCCC);
ii. has ratified the Kyoto Protocol;
iii. has established a Designated National Authority (DNA) or a Focal Point that is delegated to coordinate and approve local CDM project proposals;
iv. has clear Sustainable Development criteria (see Table 9 for the Gold Standard) in place;
v. has clear legal framework on CER ownership, project developer status;
vi. ha clear fiscal policy on taxation and ownership of CER and bankability of CER;
vii. has easy access these information e.g. website.

B. CDM project eligibility

All proposed CDM Project activities must:

a. have the potential to comply with the UNFCCC CDM project activities' validation, registration and verification guidelines (see http://cdm.unfccc.int/. for more details);
b. generate CERs at least during the 2008-2012 commitment period;
c. have baseline and monitoring methodologies that are being reviewed or have already been approved by the CDM Executive Board.

C. Project sponsor/developer eligibility

The project sponsor and/or the project developer of the CDM project:

a. must have a proven track record in the development of similar project activities;
b. must have the financial capability and competence to realize the project activity as outlined in the project documents;
c. must be an accredited business organization in the host country and hold good legal standing.

D. CER price and Types of financial options

The price of the CER will be determined by the risk appetite of the project developer and owner. Higher price will be allocated to projects that have been registered whereas those with validation risk will fetch the lowest price. The issues involved in the negotiation of the ERPA may consider the following type of financing options for the purchase of CERs:

1. **Payment on Delivery for unilateral project:**

   CERs buyer would consider a "Payment on Delivery" ERPA for the direct purchase of CERS from a project activity whereby the buyer would pay on the delivery of CERs.

   A payment on delivery purchase contract is defined by which the buyer and its counter-party would agree on the pre-negotiated price, volume, and delivery schedule of CERs to be delivered into a dedicated buyer's account upon the issuance of the CERs by the CDM Executive Board. Selling of registered CERs from this type of unilateral CDM project will fetch the highest price as the project developer and owner is absorbing all the upfront project risks.

2. **Pre-paid Purchase Contract for bilateral project:**

   The CERs buyer would be willing to advance funds incrementally into a CDM project activity based upon the completion of specific, pre-negotiated project milestones such as achieving CDM project validation, host country approval, registration and CERs issuance.

   The exact terms and conditions of the advanced payments for the purchase of CERs would be documented in an ERPA. In order to qualify for a pre-paid structure, the CDM project has to meet the following criteria:

   a. the counter-party must provide satisfactory performance guarantees and demonstrate satisfactory credit quality or credit enhancement (such as a performance letter of credit) to support their delivery obligation;
   b. the buyer will receive the first right of creation on any CERs generated by the project activity.

3. **Debt Financing CDM Projects for bilateral project:**

   The CERs buyer would consider debt financing CDM project activities in the form of either senior or subordinated debt under the following conditions:

   c. at least a portion of project debt service would be paid in kind in CERs;
   d. the seller must provide liquidated damages (with related credit support) for debt service obligations which are paid in kind (CERs);
   e. the debt financing must be secured by a security interest in the project or supported by other collateral, such as an acceptable surety or equivalent guarantee in the amount of buyer's financing;
   f. the project must conform to customary project finance credit criteria, such as sponsor representations, conditions, precedents, covenants, and pledges.

5. BARRIERS AND RISK MANAGEMENT IN DEVELOPING CDM POJECT

A. Introduction

This section highlights the barriers involved in developing large and small scale biogas project and how risks (policy, project, financial, fiscal, intellectual property and institutional) could be identified and minimized in order to reduce transaction cost and so that there is strong carbon integrity. In order to attract premium CDM investors the host country must exhibit strong political leadership in the setting up of functional and effective CDM institutions within a clear and transparent policy framework. Strengthening this capacity will not only reduce approval time and transaction cost but help to minimize the country, project and implementation risks for project owner, developer and investors.

B. Country commitment

There is still some uncertainty and reluctance by Asian countries to take advantage of the CDM instruments whilst some take a 'wait and see' attitude. This could be due to: i). Low and uncertain CER price; ii) uncertain CDM market caused by uncertain post-2012 commitment[19]; iii) lack of resources to develop competent DNA staff and facility to entertain foreign investors; iv) lack of upfront capital and financial services and products and v) lack of access to reliable clean technology. This lack of commitment by national government has caused regional imbalance in the number of projects submitted which are dominated by Brazil and India.

C. Institutional barriers

Brardwaj et al (2004) define institutional barriers as 'barriers that are embedded in the institutional structure of the government or of the international agreement that governs the CDM.' Lack of competent national staff and clear guidelines does not only delay project approval process but also increase transaction cost and often deter and discourage potential investor. There is also a need to strengthen the communication between national and local CDM entity in order to ensure smooth CDM transaction and implementation.

Unilateral projects are submitted by host country for validation and registration with no involvement from Annex 1 country in the preparation or financing of the project. As the project proponent bears most of the validation and registration risk, higher prices could be negotiated for CER from unilateral project. However, there is concern that some of these unilateral projects submitted for validation e.g. in India may not be developed due to lack of upfront equity, debt financing or inappropriate technology. On the other hand, some host country e.g. Malaysia only approve bilateral project where clean technology, the financial and business structures have already been secured from the developed countries.

In order to encourage full participation by local stakeholders, local NGO could be provided with training on CDM concepts particularly for less CDM literate countries. NGO could help in organizing local meeting for gathering clear comments from stakeholders for ensuring maximum benefits and publicity from the CDM project.

D. Financial and fiscal barriers

As already mentioned above in Section 2, high transaction cost has been the main deterrence for developing small scale project. Table 5 illustrates the difference in transaction cost between normal and small scale CDM project. Simplified methodologies are already in place to overcome this barrier. Lack of upfront capital for data gathering and project PDD preparation could hinder the successful implementation of any CDM project. This is the main concern for many unilateral projects being submitted for validations especially in India. Various financial options for raising upfront fund have been discussed in Section 4 above.

[19] COP11 (1-6 Dec 2005) meeting in Montreal has reached an important decision to start negotiation for the Second Commitment periods (2012-2018). This will send a clear signal to all stakeholders to continue to invest in the CDM market.

Lack of clear corporate taxation and CER surcharge law will deter potential investors and increase the country risk. The host country must spell out clearly their taxation laws, property and intellectual property and CER ownership rules and who should be the upfront project developer. National staff must be well trained to handle biogas project that will attract potential investors. A high surcharge tax on CER will deter investor from investing. Given the high sustainable development component, it is proposed that biogas should not be taxed at all. There must be clear CER ownership rules and how CER could be used outside the host country.

China and Nepal has relies on governmental subsidy of up to 30% of capital cost to spearhead the biogas project. But it is important that subsidy does not distort market forces which could lead to unhealthy competition. Moreover it is important that subsidy will not make the proposed project non-additional and hence ineligible as a CDM project. Providing attractive fiscal incentive (taxation) could be provide means to attract the private sector and local financial institution to be involved in CDM project. Providing favorable or guaranteed feed-in tariff for selling to on-grid electricity generated from biogas could provide an attractive incentive for investors.

In order to develop create financial modality to support CDM development, national financial institution must be well trained in assessing CDM upfront or equity loan application efficiently. Financial officers must be able to identify the project risks and develop attractive and competitive financial services and packages that will stimulate the CDM market in the host country.

E. Technical and managerial barriers

The lack of competent technicians in providing timely and cost effective repair will put project at risk and not meet project CER targets. Although intellectual theft and competition will occur, it is important to ensure that the new clean technologies and intellectual properties are protected and that enforcement of the law is reliable. The ability to strengthen the host country technical and managerial and entrepreneurial capacity to reduce project risk so that the CER could be delivered as contracted. Building materials, equipment ad spare parts must of high quality and certified in order to ensure minimum breakdown and down time. Marketing to recruit new participants and screen out weak participant early in the selection process is crucial. Campaign must be effective to penetrate a wide audience on the benefit of CDM and biogas system.

F. Social barriers

In some cultures, the use and handling of animal and human waste as energy and fertilizer source can be regarded as offensive. Education and training and study tour could help to explain and win community over to partake in biogas project. Special effort must be made to ensure that women are able to partake in CDM projects through multimedia awareness campaign, capacity building and study tour. Providing crèche facility to look after young children would release the mother to attend CDM and biogas training courses.

6. POTENTIAL IMPACT OF CDM BIOGAS PROJECT

A. Impact of GHGs emission and revenues

The Integrated Biogas System could offer the 2.1 billion people living in the rural area in Asia access to clean biogas for cooking, lighting, heating of water and organic fertilizer. It is estimated that 83 million households (family of five) with ruminant livestock (Table 8) and 59 million households with mono-gastric livestock (Table 9) could benefit from the biogas program in Asia with the potential to displace 3.8 billion and 2.7 billion liters of kerosene per year respectively. This will reduce emission by 350 MtCO2e per year and could raise US$ 500 billion per year from the sale of CER.

The Mekong delta (Kampuchea, Laos, Myanmar) and South Asian (India, Pakistan, Nepal), countries showed higher ruminant livestock units (LU) per rural household (HH) than China, Malaysia, Philippines and Indonesia (Table 8). For the mono-gastric LU/HH the reverse is true (Table 9) which is a reflection of culture and religious affiliation and to some degree economic growth. As urbanization increases, mono-gastric growth seems to become more important.

The number of potential biogas digester that can be developed from ruminant waste ranges from the smallest 41,404 units for Bhutan to largest 39.7 million units for India based on 45% of the LU available for digester development (Table 8). This has the potential to reduce annual emission by 207,000 tCO_2e for Bhutan and 198 $MtCO_2e$ for India. This could generate potential revenue of US$ 1 million per year for Bhutan and US$992 million for India based on US$5 per tCO_2e. Nepal has a potential of 1.37 million digesters generating CER of 6.8 $MtCO_2e$/yr worth US$34 million. Pakistan could generate an annual CER of 34.7 $MtCO_2e$ worth US$173 million from 6.9 million digesters. China could generate 116.6 $MtCO_2e$/yr worth US$583 million from 23.4 million digesters.

The Mekong delta countries show great potential for developing biogas digester project because of their higher ruminant LU/HH density. For the mono-gastric species, China, Vietnam, Indonesia and the Philippines show greater potential in developing large and small scale CDM biogas project (Table 9, Figure 11). The transaction cost for developing these CDM projects is based on existing inflexible bundling rulings where the upper limit is fixed at 15 MW.

Figure 11. Poultry and Pig density in Asian countries (Gerber et al, 2005).

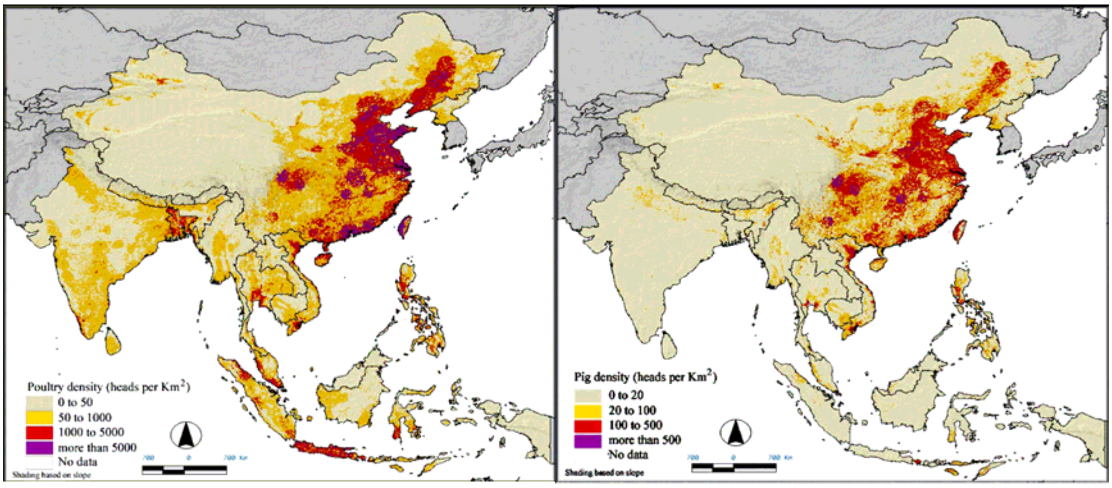


Table 8. Estimated number of small scale biogas digesters, annual carbon emission reduction and Revenues generated from the ruminant (cattle, dairy, buffalo and goat) livestock units in Asia.

Country (2002)	Total Ruminant Livestock Units (LU*)#	Rural Population#	Rural Households (HH) with 5 people	LU/ HH	LU suitable for Digester (2LU/ digester)	Potential HH biogas digester (45%)*	Total Electricity Generated (kWh) at 1.32 kWh per digester	Total Transaction cost** (US$000)	CER @4.99tCO_2e/ digester (ktCO_2e/ yr)	Yearly Revenues @ US$5/ t$CO_2$e (US$000) ***
Bangladesh	16,384,400	106,176,000	21,235,200	0.77	8,192,200	3,686,490	4,866,167	32,769	18,396	91,978
Bhutan	184,018	2,023,100	404,620	0.45	92,009	41,404	54,653	368	207	1,033
Cambodia	2,339,036	11,303,100	2,260,620	1.03	1,169,518	526,283	694,694	4,678	2,626	13,131
China	103,904,296	806,657,000	161,331,420	0.64	51,952,148	23,378,467	30,859,576	207,809	116,659	583,293
India	176,780,000	754,819,000	150,963,800	1.17	88,390,000	39,775,500	52,503,660	353,560	198,480	992,399
Indonesia	11,046,588	123,473,000	24,694,600	0.45	5,523,294	2,485,482	3,280,837	22,093	12,403	62,013
Laos PDR	1,560,335	4,414,000	882,800	1.77	780,168	351,075	463,419	3,121	1,752	8,759
Malaysia	630,468	9,871,000	1,974,200	0.32	315,234	141,855	187,249	1,261	708	3,539
Myanmar	9,491,884	34,877,000	6,975,400	1.36	4,745,942	2,135,674	2,819,090	18,984	10,657	53,285
Nepal	6,084,477	21,526,000	4,305,200	1.41	3,042,239	1,369,007	1,807,090	12,169	6,831	34,157
Pakistan	30,958,300	99,381,000	19,876,200	1.56	15,479,150	6,965,618	9,194,615	61,917	34,758	173,792
Philippines	4,469,501	31,279,000	6,255,800	0.71	2,234,751	1,005,638	1,327,442	8,939	5,018	25,091
Sri Lanka	924,145	14,485,000	2,897,000	0.32	462,073	207,933	274,471	1,848	1,038	5,188
Vietnam	4,530,440	58,527,780	11,705,556	0.39	2,265,220	1,019,349	1,345,541	9,061	5,087	25,433
Total	369,287,888	2,078,812,000	415,762,416	0.77	184,643,944	83,089,775	109,678,503	738,576	414,618	2,073,090

* 1 LU = 500 kg live weight. ** Assume 45% of the LUs are suitable for IBS digester development. *** Based on 9,000 digesters per PDD for small scale simplified methodology at US$80,000 per PDD. (# Sources: Global Livestock Production and Health Atlas. Livestock Information and Policy Branch, FAO HQ, Room C510, Viale delle Terme di Caracalla, 00100, Rome, Italy. (http://www.fao.org/ag/aga/glipha/index.jsp)

Table 9. Estimated number of small scale biogas digesters, annual carbon emission reduction and revenues generated from the mono-gastic (pig, poultry, ducks) livestock unit in the Asia.										
Country (2002)	Total Mono-gastric Livestock Units (LU*)#	Rural Population#	Rural Households (HH) with 5 people	LU/ HH	LU suitable for IBS Digester (2LU/digester)	Potential HH digester ** (64%)	Total Electricity generated (kWh) @ 1.32 kWh per digester	Total Transaction cost*** (US$1000)	CER @4.99tCO2e/ digester ($ktCO_2e$/yr)	Yearly Revenues @US$5/$tCO_2e$ (US$1000)
Bangladesh	1,515,000	106,176,000	21,235,200	0.07	757,500	484,800	639,936	4,309	2,419	12,096
Bhutan	10,590	2,023,100	404,620	0.03	5,295	3,389	4,473	30	17	85
Cambodia	756,139	11,303,100	2,260,620	0.33	378,070	241,964	319,393	2,151	1,207	6,037
China	140,371,056	806,657,100	161,331,420	0.87	70,185,528	44,918,738	59,292,734	399,278	224,145	1,120,723
India	11,970,000	754,819,000	150,963,800	0.08	5,985,000	3,830,400	5,056,128	34,048	19,114	95,568
Indonesia	14,125,802	123,473,000	24,694,600	0.57	7,062,901	4,520,257	5,966,739	40,180	22,556	112,780
Lao PDR	524,790	4,414,000	882,800	0.59	262,395	167,933	221,671	1,493	838	4,190
Malaysia	2,194,480	9,871,000	1,974,200	1.11	1,097,240	702,234	926,948	6,242	3,504	17,521
Myanmar	1,761,970	34,877,000	6,975,400	0.25	880,985	563,830	744,256	5,012	2,814	14,068
Nepal	404,682	21,526,000	4,305,200	0.09	202,341	129,498	170,938	1,151	646	3,231
Pakistan	1,565,000	99,381,000	19,876,200	0.08	782,500	500,800	661,056	4,452	2,499	12,495
Philippines	4,304,775	31,279,000	6,255,800	0.69	2,152,388	1,377,528	1,818,337	12,245	6,874	34,369
Sri Lanka	132,968	14,485,000	2,897,000	0.05	66,484	42,550	56,166	378	212	1,062
Vietnam	5713525	58,527,780	11,705,556	0.49	2,856,763	1,828,328	2,413,393	16,252	9,123	45,617
Total	185,350,777	2,078,812,080	415,762,416	0.32	92,675,389	59,312,249	78,292,168	527,220	295,968	1,479,841

* 1 LU = 500 kg live weight. ** Assume 64% of the LUs are suitable for IBS digester development. *** Based on 9,000 digesters per PDD for simplified methodology at US$80,000 per PDD. (# Sources: Global Livestock Production and Health Atlas. Livestock Information and Policy Branch, FAO HQ, Room C510, Viale delle Terme di Caracalla, 00100, Rome, Italy. (http://www.fao.org/ag/aga/glipha/index.jsp).

B. Impact poverty alleviation and gender

CDM biogas projects have the greatest potential to meet the Millennium Development Goals and in combating poverty and should be promoted by national government to CER buyers as high quality CDM projects as means to fetch higher premium. This could be achieved by using the standards (template) developed by the World Wildlife Fund for monitoring and evaluating Sustainable Development indicators (Table 10). Hence it is vital for host country to put in place a set of sound Sustainable Development criteria.

Table 10. Matrix of Sustainable development indicators by which a IBS project activity must be assessed for the World Wildlife Fund Gold Standard
Local/regional/global environment • Water quality and quantity • Air quality • Other pollutants • Soil condition • Biodiversity (species and habitat conservation)
Social sustainability and development • Employment (quality) • Livelihood for the poor • Access to energy services • Human and institutional capacity
Economic and technological development • Employment (job creation) • Impact on balance of payments • Technological self reliance

7. RECOMMENDATIONS AND GUIDELINES FOR STAKEHOLDERS

The following activities are scope for intervention to further expand the biogas technology over a deeper and wider area (Figure 12). Netherlands Development Agency (SNV) is one of the leading development agency involved promoting biogas program with national government. SNV has developed very comprehensive biogas dissemination program in many Asian countries[20] and is actively involved in developing CDM projects with investors from Europe. Two categories of country can be identified i) Countries with little or no biogas experience e.g. Laos, Myanmar and Kampuchea and ii) Countries with substantial e.g. Vietnam, Philippines and Indonesia and mature biogas market e.g. China, India, Nepal and Bangladesh.

A. Develop Pilot Biogas Project in Country with Low Biogas Experience

i. Option 1: Feasibility study to identify barriers

To conduct feasibility study to identify barriers (institutional, technical, social, financial) for the commercialization of biogas project in countries with little or no biogas experience e.g. Laos, Myanmar, Kampuchea and some of the Pacific island states. Potential sponsor for this type of project could be Global Village Energy Program (GVEP)'s GAP fund which has a maximum grant of US$100,000. This program will help new countries to explore the feasibility of introducing biogas system for their community using South-South bilateral

[20] www.**snv**world.org

cooperation. Fund from Energy Sector Management Assistance Program[21] managed by WorldBank could be used for this purpose.

ii. Option 2: Pilot Biogas Project

Once the barriers have been identified, a pilot project could be developed to construct 10 biogas plants and to train 20 hands-on technicians. This pilot project will serve as training centers for demonstrating the benefits of CDM biogas project. Business model and CDM concept will be developed to strengthen the private-farmer partnership with the possibility of setting up a micro-finance program for administering biogas services. Bilateral funding could be sought from Annex 1 country.

B. Develop CDM Project for Country with Mature Biogas Market

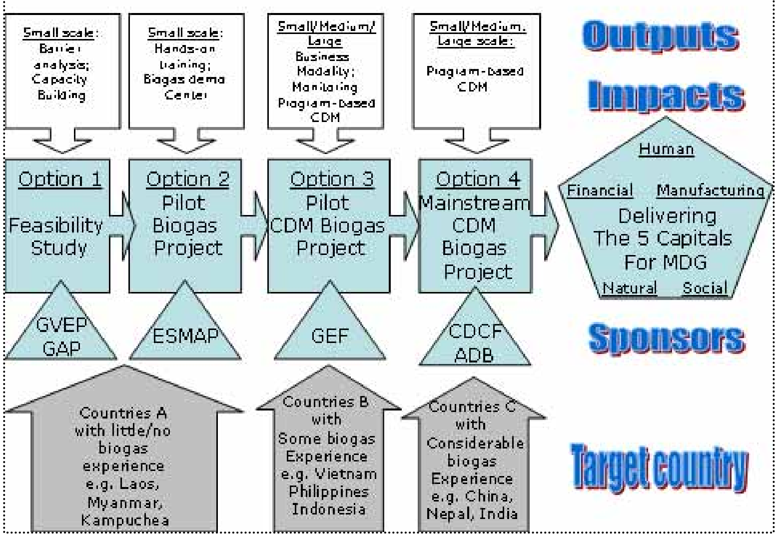
iii. Option 3: Pilot CDM project

Where there is already substantial biogas capability such as Vietnam, Philippines and Indonesia, pilot CDM project for large and small scale biogas project could be proposed to serve as 'learning by doing' program. Lessons learnt could be disseminated to other countries. SNV is actively developing CDM programs in Vietnam with potential buyers from German investors.

iv. Option 4: Develop program-based CDM

Countries that have mature biogas market (e.g. China, India, Nepal and Bangladesh) offer the greatest opportunity to pick the 'lower hanging fruit' for the full development of large to small scale CDM biogas project. For the small scale biogas project, full CDM could be developed using the program-based approach as discussed in Section 4. However, there remains many unanswered questions and a follow up research is required to tackle the procedural issues in how program-based CDM could be incorporated as part of the national climate policy: i) review current lessons learnt from the sectoral approach undertaken for the energy efficiency project in Ghana and the transportation sector in Chile; ii) how to develop national baseline inventory and monitoring plan; iii) defining the roles of various stakeholders and how to allocate the CER between private and public sector; and iv) how to ensure high project additionality.

Figure 12: Options for developing biogas projects



[21] www.worldbank.org/html/fpd/**esmap/esmap**.html

C Research and Development on CDM Biogas Technology

- Conduct information outreach to educate communities, policy makers and biogas; industry on opportunities and benefits associated with CDM biogas development in host country;
- Conduct solicitation on biogas development ;
- Establish a forum to coordinate, plan and evaluate biogas development in host country;
- Help assist in technology development, environmental responsiveness and community oriented financing of biogas projects;
- Encourage research activities on improving biogas yield, biogas meter for monitoring yield, electricity conversion efficiency, and reducing cost of biogas technology;
- Encourage research activities on small-scale engine generator to fit the need of a typical size using biogas technology;
- Development of biogas using advantaged technologies (i.e., high rate at high solid concentration, thermo-philic temperature, advantaged digester design).

D. Conclusions and guidelines for Potential Developers

In view of the high fossil fuel prices and declining Official Development Assistance contribution to national development program, innovative carbon finance could provide a timely opportunity for reinvigorating the uptake and commercialisation of IBS for national development in poverty alleviation. However the followings must be considered when designing any CDM projects:

- It is important to identify and understand the barriers (market size, delivery system, local acceptance, business model, local competence, rural energy consumption pattern, local policy, CDM institutional capacity) and the risks involved in developing CDM in a particular country;
- Creative effort must be made to reduce transaction cost and reduce risk – how to bundle cost effectively – utilize existing delivery mechanism – organizational cost and monitoring cost, utilize as much of the local effort as possible using bottom-up participatory approach to create a solidarity of ownership and comradeship;
- Minimize all risks by tackling the following problems:
    - Using standard digester sizes and certified hardware for bundled projects;
    - Thorough participatory baseline analysis for resource, social, wealth and health mapping;
    - For verification of CERs, monitoring can be combined with the Operation and Maintenance using the service contracts (24 hours respond to complaint and repair within 2 days) built into the dealerships for the equipment;
    - Limiting the crediting period to lower risk of non delivery of CER;
    - Drawing on international experience and progress to design baseline and monitoring plan that will allow the carbon integrity to be maximized and realized.

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Appendix 1: The Socio-economic and environmental benefits of IBS

Integrated Biogas System (IBS) when applied at the small farm level has the potential as intervention tools to bring the following economic, socio and environmental benefits:

Economic benefits –

- Improved crop yield by 30-40% due to better soil fertility;
- Reduced inorganic fertilizer input thus a saving of RMB 1,000 per year;
- Improved income through improved gross margin and diversified cultivation and production;
- Potential to earn higher premium from certified organic food;
- Improved livelihood lead to a greater capacity and incentive to adopt more sustainable Conservation Agriculture practices for ensuring efficient resource management.

Environmental benefits –

- Better health through avoidance of using of smoky low quality coal and firewood for cooking and hygienic disposal of human waste;
- Reduce GHG emission (6.24 tCO_2e per pig per year) by switching from electricity and firewood to Sulphur-scrubbed biogas lamp and stove;
- Reduce pollution of surface and ground water through the recycling of the pig and human wastes and digested sludge;
- Agronomically, liquid fertilizer and sludge improved plant health (more tolerant to pest and diseases) and land productivity by improving soil organic matter and humic acid buildup especially for reclaiming heavily degraded land;
- Potential to reduce enteric methane emission through improved animal husbandry (high quality feed and health);
- Potential to reduce nitrous oxide emission from replacement of imported fertilizer with organic fertilizer;
- Increased in carbon sink through soil and biomass carbon sequestration from reduced tillage and cultivation traffic under Conservation Agriculture practices.

Social Benefits –

- Generate new employment e.g. use of small tractor spreader to carry liquid fertilizer onto field;
- Greater synergy, cooperation and solidarity between villagers through the village Biogas Association and job sharing during the construction of the biogas system;
- Improvement in local capacity building through participation in training, study tours and workshops;
- Women-friendly technology – women relief of the need to look for firewood for cooking (3-4 hours per day) and strengthening of their position in the village through full participation in the biogas system;
- Potential to build a water cellar in a 5-in-1 biogas system for harvesting rain water for household use and crop irrigation.

Appendix 2: Examples of methodologies used for calculating baseline and project emission from small scale biogas projects in A) India, B) China and C) Nepal

A. Submitted PDD to develop 5,500 digesters in Kolar district, India (1.81 kw x 5,500 = 9.95 MW)		
Size biogas digester		
2 m^3	4.93 tCO_2e/ digester	Average yearly wood consumption for a household x emission coefficient for non-renewable woods + average yearly kerosene consumption of a household x emission coefficient for kerosene
1 PDD	5,500 digesters x 4.93 = 27,115 tCO_2e /year x 7 yrs = 189,805 tCO_2e	

B. ADB study to develop 10,000 digesters in Guangxi Zhuang Autonomous Region		
	Baseline	**Project**
8 m^3	i. CO_2 from wood stove: EFco2= 0.45 x 0.87 x 44/12 = 1.4355 kg CO_2/Kg wood ii. 1.24 t wood x 1.4355 = 1.78 tCO_2e/yr iii. CH4 from wood stove: EFch4= 0.45 x 0.87 x 16/12 x 21 = 0.132 kg CO_2/Kg wood iv. 2.19 t/yr x 0.132 = 0.288 tCO_2e/yr x 10,000 = 2,881 tCO_2e/yr v. CH_4 from pig: 3 pigs x 2.24 kg CH_4/pig = 6.72 kgCH_4 vi. EFch4= 141.12 kg CO_2e x 10,000 = 1411 tCO_2e/yr vii. Total = 1.78 +0.288 +0.141 = 2.209 yCO_2e/yr x 10,000 = 22,092 tCO_2/yr viii. Total = 2.209 – 0.4125 = 1.797 x 10,000 = 17,967 tCO_2e/yr	8 m^3 = 350 m^3 biogas/yr x 60% = 210 m^3 CH_4/yr = 150 kg/yr = 412.5 kg CO_2/yr = 10,000 x 412.5 = 4,125 tCO_2e/yr
1 PDD	**10,000 digesters x 1.797 = 17,967 tCO_2e x 10 = 179,670 tCO_2e**	

Baseline emission	**Activity**	**Emission per household**	**Project (tCO_2e/yr)**
	Wood cook stove CO_2 emission	1,780 kg CO_2e	17,800
	Wood cook stove CH_4 emission	288 kg CO_2e	2,881
	CH_4 emission of manure	141 kg CO_2e	1,411
	Sum	2,209 kg CO_2e	22,092
Project emission	CO_2 of biogas combustion	412.5 kg CO_2e	4,125
GHG emission reduction		1, 796 kg CO_2e	17,967

C. Community Development Carbon Fund's Nepal Biogas Project			
	Emission source	**Baseline**	**Project**
	Manure treatment	CH_4 emissions from storing and burning cow dung and from cow dung applied in the field	Leakage of biogas from digester
	Fuel use	CO_2 emissions from kerosene	
		CO_2 emissions from burning unsustainable fuel wood	
		CH_4 emissions from burning of fuel wood	
Nepal	**Terai (tCO_2e/digester/year)**	**Hills (tCO2eq/digester/year)**	**Mountain (tCO_2e/digester/year)**
4 m^3	2.65	3.13	3.21
6 m^3	6.00	4.54	4.62
8 m^3	7.76	5.38	5.48
10 m^3	6.21	4.35	4.05

Appendix 3: Baseline methodology for developing small scale biogas project.

Step 1: Identification of baseline and project emission sources

Emission source	Baseline	Project
Manure treatment	CH_4 emissions from storing and burning cow dung and from cow dung applied in the field	Leakage of biogas from digester
Fuel use	CO_2 emissions from kerosene	
	CO_2 emissions from burning unsustainable fuel wood	
	CH_4 emissions from burning of fuel wood	

Step 2: Identification of Emission Factors (EF)

i) Manure: EF for dairy, non-dairy and buffaloes from TIER 1 (IPCC); ii) Fuel-(IPCC)

Step 3: Identification of emission volumes per digester per region

- Amount of cow dung fed into digester
- Amount of slurry used in the fields
- Amount of inorganic fertilizer displaced
- Amount of fuel saved per household (kerosene)
- Amount of methane leakage from biogas digesters into the air

Step 4: Calculation of emissions per source per digester per region

By combining the EF with the volumes the emissions per source have been calculated.

Step 5: Aggregation of emission per source into one emission reduction factor per digester per region

The aggregate emission reduction factor consists of the difference baseline emissions minus project emissions

Appendix 4: Example of European Union (EU) directive for landfill, household waste and climate change policy.

Legislation

A. EU Landfill Directive

The EU Landfill Directive includes statutory targets for the reduction of the landfilling of biodegradable waste (kitchen waste, garden waste, paper, card, textiles and wood). The rationale is that the uncontrolled decomposition in a landfill causes: the emission of methane (a very powerful greenhouse gas) and of carbon dioxide; the production of leachate; and the attraction of vermin. Of the fractions of biodegradable waste it is food waste which has by far the greatest environmental impact. A biogas plant uses a similar process to that taking place in a landfill site, the key differences being that the former is contained & controlled, and takes only one month compared with many years in a landfill.

B. EU Animal By-Products Regulation

The EU Animal By-Products Regulation came into force across the European Community on 1st May. This divides animal by-products into 3 categories:

- Category 1 is high risk and must be incinerated;
- Category 2 is material unfit for human consumption, e.g. fallen stock and animals which have failed inspections. Most types of this material must be incinerated or rendered (133°C, 3 bar, 20 minutes);
- Category 3 is material which is fit for but not destined for human consumption, and it is this category which has the widest range of definition and on which the EU-ABPR has the greatest impact in terms of the permissible changes to the disposal route.

Category 3 material includes:

- Abattoir by-products such as soft offal, blood and feathers;
- Food factory waste;
- Food waste from retail outlets, in particular supermarkets;
- Catering waste, including kitchen waste from domestic households and commercial kitchen waste;
- Category 2 material, which has been pressure-cooked.

Category 3 material may be incinerated, rendered or transformed in a composting or biogas plant; only catering waste and retail outlet waste may be landfilled, but the latter only until December 2005. The issue is further complicated in that if a composting or biogas plant transforms only catering waste, then the treatment standard may be set by member states. A biogas plant is likely to treat a combination of materials and is therefore subject to the strict standards set down by the EU, namely:

- The process must be in-vessel; controlled anaerobic digestion is by definition in-vessel;
- The maximum particle size of material is 12 mm;
- All material must be pasteurised at a minimum temperature of 70°C for one hour;
- Procedures must be adopted to prevent recontamination of the final product with raw waste;
- Samples of the final product must be free of salmonella;

The Sunrise Project carried out by Greenfinch in partnership with the University of Southampton reached the following conclusion with respect to pathogen destruction, that:

- Mesophilic or thermophilic anaerobic digestion with the additional process stage of pasteurisation at 70°C for one hour achieves the eradication of salmonella, E.coli and F.streptococci, meeting the standards of the EU-Animal By-Product Regulation.

It is EU policy that food waste and other animal by-products should be recycled as bio-fertiliser to improve the quality of soil, but that it is imperative that this is carried out safely with minimal risk to animal and human health. It is in all our interests to develop a sustainable economy in which resources are reused and recycled. It is has been confirmed that biogas technology is well placed to achieve this, and at the same time to produce renewable energy, contributing to the low carbon economy.

C. Draft EU Biowaste Directive

In its current draft the Bio-waste Directive encourages the recycling of food waste to agricultural land to improve the organic quality of soil and its macro- and micro-nutrients. If this directive is implemented, local authorities will be forced to adopt separate collection schemes for food waste.

D. Climate Change Legislation

It is the policy of the EU and its member states that urgent means are applied to significantly reduce the emission of greenhouse gases. The controlled anaerobic digestion of food waste contributes in two ways: first, it prevents the emission of methane and carbon dioxide to atmosphere from uncontrolled decomposition; and second, by producing renewable energy the carbon dioxide emissions replace those which would otherwise have been emitted from burning fossil fuels.