A Feasibility Study on Introduction of Clean Development Mechanism for Animal Waste Management Systems in China

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中国における動物性廃棄物管理システムのクリーン開発メカニズム導入可能性に関する研究

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China is expected to be the world's largest host country of Clean Development Mechanism (CDM) projects. Until May 2007, China registered 84 CDM projects, contributing to 43% of the expected average annual global Certified Emission Reductions (CERs). However, although there are lots of large-scale animal feeding farms in China, so far, less attention has been paid to analyzing the potential for Greenhouse Gas (GHG) emission reduction in this sector. This paper examines the CDM potential for Animal Waste Management Systems (AWMS) by analyzing a case study in large-scale swine farms in China. The present situation of animal feeding farms and AWMS in China are investigated. Based on the investigation results, the baseline scenario and project scenario are discussed and the expected CERs are assessed according to the related approved methodology. Finally, the effect of the CERs revenues on the CDM project benefits is analyzed.

Keywords: *Present Situation of Animal Feeding Farms, CDM, CERs, AWMS, Economy*
養殖場の現状、クリーン開発メカニズム、認証排出削減量、動物性廃棄物管理システム、経済性

1. INTRODUCTION

China has become the second largest greenhouse gas (GHG) emitter in the world after the United States. It emitted approximately 4.8 billion tons of CO_2 equivalents (CO_2e) in 2004, accounting for 18% of the total global GHG emitter[1]. Because of a great deal of low-cost abatement opportunities available in the energy sector, China is expected to be the world's number one host country of Clean Development Mechanism (CDM) projects. Many studies indicate about 60% of the total global CDM projects go to China [2]. Since the first CDM project, Huitengxile Windfarm Project, succeeded to be registered by CDM Executive Board (EB) on 26 June 2005, China registered 84 CDM projects until 27 May 2007, accounting for 12% of the total world's registration projects and contributing to 43% of the expected average annual global certified emission reductions (CERs)[3]. Furthermore, until May 2007, 452 CDM projects (including projects registered) were approved by National Development and Reform Commission (NDRC), which is appointed as the Designated National Authorities (DNA) for CDM in China[4]. However, a general lack of awareness by both the Chinese government and business communities may cause China to not fully exploit its potential for CDM projects[2]. Although the Chinese government has put forward the priority areas for CDM projects in Measures for Operation and Management of Clean Development Mechanism Project (The priority areas are energy efficiency improvement, development and utilization of new and renewable energy, and methane recovery and utilization), the projects is concentrating extremely in wind power and small-scale hydropower sectors and non-priority projects like HFC23. Until May 2007, the number of wind power and small-scale projects accounted for 65% of the total projects registered and HFC23 projects contributed to 76% of the expected average annual CERs in China. This causes CDM activity not to take fully disadvantage of the developed countries technologies and the

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investment in wider sector. The Chinese government encourages more CDM projects that would also lead to reductions in local pollutants like energy efficiency improvement projects, methane recovery and utilization projects.

On the other hand, according to the statistical data from Intergovernmental Panel on Climate Change (IPCC)[5], the global emission of CH_4 from the animal feeding farms amounted to 200 ~ 300 million ton, accounting for 5%～8% the total emission of CH_4 in the world. And there are about 50 CDM projects registered for Animal Waste Management Systems (AWMS) in the South America, like Chile, Mexico and Brazil[3]. So far, less attention has been paid to analyzing the potential for GHG emission reduction in animal feeding farms in China. In fact, China has a significant source of animal feeding farms. There are about 6000 large and medium-sized animal feeding farms. And due to lack of the finance, up to now, only 10% is processed through biogas projects mainly on cattle and swine farms. About 80% of all farms discharge directly the refuse and sewage to the rivers or land[6]. It is expected there are a large potential of GHG reduction by introducing environmental friendly AWMS in these animal feeding farms.

This paper aims to examine the CDM potential for AWMS by using a case study in large-scale swine farms in China. We investigated the present situation of animal feeding farms and AWMS in China. On the basis of the above investigation, the baseline scenario and project scenario in CDM project activity are discussed and the expected CERs are assessed by using the related approved methodology. Finally, the effect of the CERs revenues on the CDM project benefits is analyzed.

2. PRESENT SITUATIONS OF ANIMAL FARMS

2.1 Distribution of concentrated animal farms

With the rapid development of economy and improvement of the feeding level, many large and medium-scale livestock farms and poultry farms have been established in recent years. In 2000, State Environmental Protection Administration (SEPA) investigated the distribution of concentrated animal feeding farms in 23 provinces[7]. The farms investigated included the annual animal populations with more than 200 heads for swine, 40 heads for dairy cows, 80 heads for cattle and 2000 heads for poultry. The results

Table 1: The animal population and its manure for concentrated feeding farms by province in 1999

Region	Swines		Cattles and Dairy Cows		Turkeys and Chickens	
	Annual animal population ($\times 10^4$Head)	Annual animal manure ($\times 10^3$Ton)	Annual animal population ($\times 10^4$Head)	Annual animal manure ($\times 10^3$Ton)	Annual animal population ($\times 10^4$Head)	Annual animal manure ($\times 10^3$Ton)
Shanghai	228.1	1665.2	4.8	349.3	4465.1	1629.8
Guangdong	193.1	1409.6	2.2	158.0	2592.0	946.1
Zhejiang	143.7	1048.9	1.5	109.0	773.8	282.4
Fujian	104.5	762.8	0.8	61.9	658.4	240.3
Hunan	102.2	746.2	1.2	91.0	2635.2	961.9
Beijing	93.4	681.9	5.8	423.7	851.8	310.9
Liaoning	68.5	500.3	4.2	308.2	2083.7	760.5
Guangxi	52.6	383.8	0.5	37.4	413.5	150.9
Shandong	47.7	348.4	3.3	239.6	2979.9	1087.7
Henan	44.5	324.9	3.6	262.6	205.2	74.9
Hebei	39.7	290.1	0.6	44.3	146.9	53.6
Jiangsu	37.1	270.7	1.6	119.3	1033.5	377.2
Heilongjiang	34.5	252.1	1.5	108.1	551.1	201.1
Hebei	31.4	229.4	4.5	327.6	1756.4	641.1
Jiangxi	27.2	198.7	0.4	28.1	58.4	21.3
Anhui	17.1	124.5	3.6	260.0	550.8	201.0
Jilin	16.3	119.0	2.1	152.1	1273.7	464.9
Sichuan	8.6	62.8	0.6	41.6	247.4	90.3
Sanxi	7.3	53.4	0.7	53.2	281.5	102.8
Tianjin	6.8	49.8	1.4	101.0	244.5	89.2
Gansu	4.9	35.4	0.8	55.6	58.3	21.3
Shanxi	4.4	31.8	0.7	54.5	104.2	38.0
Chongqin	4.3	31.6	0.1	3.8	60.4	22.0
Total	1318.0	9621.5	46.4	3389.9	24025.7	8769.4

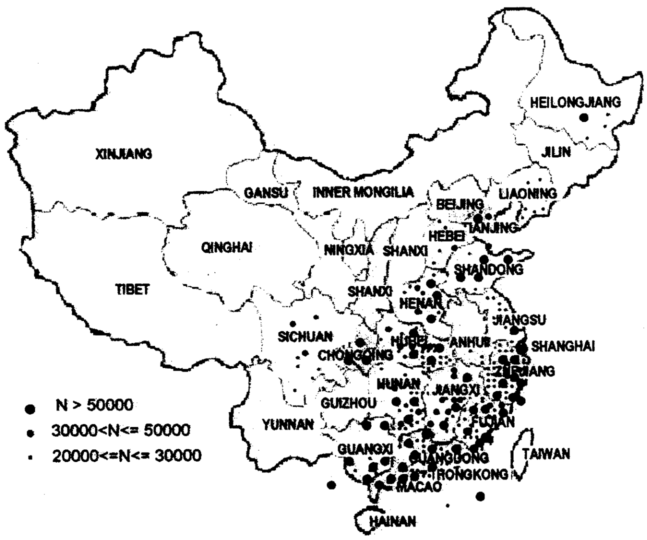

Fig.1: The geographic distribution for large scale swine farms in China

indicated these concentrated animal populations are 13,180,151 for swine, 464,368 for cattle and dairy cow and 240,257,128 for turkey and chicken respectively. According to the data[5], the parameters of animal manure production are assumed as 2 kg/day for swine, 20 kg/day for cattle and dairy cow and 0.1kg/day for chicken. The annual animal manure can be calculated and shows that its total figure accounted to 21,781 thousand ton, among of which swine shared of 44%, about 9,622 thousand ton, followed by chickens with 40% (see Table1). In addition, it can be found that swine farms concentrated in the Middle and Low Yangtze River region and South-East China. Cattle farms concentrated in North-East China. Shanghai, Shandong and Guangdong had overwhelming more chicken farms than others provinces.

Considering the emission of CH_4 from animal waste, it comes mainly from the swine farms in China. This can be explained from the following two reasons. Firstly, although the total manure from chicken farms is also considerable large, it emits relative small CH_4 because it is favorite organic fertilizer utilized timely. Another important reason is that annual methane conversion factor (MCF) depends on annual average temperature according to 2006 IPCC Guidelines for National Greenhouse Gas Inventories. For instance, MCF for lagoon treatment system in swine farms at annual average temperature of 28℃ is 80%. This value is 66% at 10℃. As above described, swine farms concentrated mainly in the Middle and Low Yangtze River region and South-East China, where the climate is warm with higher annual average temperature. According to the statistical data[8], the emission from animal waste in 2000 amounted to $2{,}031\times10^9$kg, among of which 72.6 % is responsible for the swine farms. In order to grasp further the distribution of swine farms, large scale swine farms in China with above 20,000 head animals were investigated. Fig.1 is the geographic distribution for these farms investigated and shows that large scale swine farms concentrated also in the Middle and Low Yangtze River region and South-East China. Swine farms with the population being more than 20,000 heads are 304 units; among of which 34 one is more than 30,000 heads and 54 one is above 50,000 heads. In these farms being more than 50,000 head populations, Guangdong province shares of 15 farms overwhelmingly, followed by Zhejiang, Fujian and Guangxi with 7 farms equally, Shandong and Hubei with 4 farms equally, Jiangxi and Hunan with 3 farms equally.

2.2 Animal Waste Management System

As above described, there are many large and medium scale animal farms in China. According to the statistical data [5], the excrement for these farms has amounted to 1.9 billion ton in 1999, which is 2.4 times of the industrial pollutant. In most feeding regions excluding several metropolises like Beijing and Shanghai, the excrement exceeded far the national or regional discharge standard of water pollutant. COD (Chemical Oxygen Demand) of discharged soil water from these farms amounted to 712 million ton, which is more than 10 times of the one from industrial waste water. Although Chinese government has attached high importance and made some effort to control animal waste pollution in recent year, there is no doubt that pollution control is still a key factor restricting to the development of feed industry.

Table 2: Financial analysis of some biogas projects

Items		Biogas Project on Shanghai Xinghuo Husbandry Farm	Biogas Project on Hangzhou Dengta Husbandry Farm	Hangzhou Hen Farm
Scale of husbandry farms (Head)		2000 cattles	120000 swines	200000 chickens
Scale of biogas project (m^3)		2700.0	6000.0	750.0
Total investment of project (10,000Yuan)		912.0	1503.0	95.0
including:	Government Subsidy or other aid (10,000Yuan)	374.0	300 (UNDP/GEF)	-
	Self-financing (10,000Yuan)	538.0	603.0	95.0
	Debt (10,000Yuan)	-	600.0	-
Total operation cost of project (10,000 Yuan)		73.0	174.0	6.0
Total benefit of project (10,000 Yuan)		164.2	460.5	12.8
including:	Biogas selling (10,000 Yuan)	144.1	21.9	6.8
	Biogas price (Yuan/m^3)	1.2	0.6	0.3
	Biogas power generation (10,000 Yuan)	-	231.3	-
	Electricity price(Yuan/kWh)	-	0.7	-
	Grain fertilizer (10,000 Yuan)	4.7	207.3	6.0
	Fertilizer's price (Yuan/Ton)	100.0	40.0	-
	Avoided environmental protection fines(10,000 Yuan)	15.4	-	-
Basic discount rate (%)		10.0	10.0	10.0
Life cycle of the project (Year)		21.0	21.0	21.0
Financial Internal Rate of Return (IRR) (%)		12.0	19.1	2.7

NOTE: UNDP and GEF refer to the United Nations Development Program and the Global Environment Facility, a green wing of the World Bank respectively.

There are lots of AWMS in the world, such as Daily Spread, Uncovered Anaerobic Lagoon, Anaerobic Digester, Composting, and Aerobic Treatment. At present, the anaerobic digester biogas power generation is a modern treatment measures for its accomplishing three goals simultaneously: pollution elimination, electrical and thermal energy generation and the integrated disposal of animal excrement and waster water. However, like other renewable energy technologies, this technology is facing with many barriers and constrains to its commercial development, such as technology, policy and investment in China.

In this paper, the investment barrier will be discussed detailed by several cases. It is noted that the data used in this part refers to the paper [7] and shows in Table 2. From the data, it can be concluded that Biogas Projects on Shanghai Xinghuo Husbandry Farms (BPSXHF) and Biogas Project on Hangzhou Dengta Husbandry (BPHDHR) achieved the IRR of 12% and 19.1% respectively, which implied the projects had better economic benefits. Hangzhou Hen Farm (HHF) only had a considerable low IRR of 2.67%. This can be explained from the following aspects. Firstly, considering the project's scale, the biogas production from BPSXHF and BPHDHR are 3.6 and 8 time of one from HHF. Another further important reason is both BPSXHF and BPHDHR achieved government subsidy or other aid as the initial investment and it accounted for 41% and 20% of the total investment, respectively. On the other hand, comparing with BPSXHF and BPHDHR, it can be found that although BPSXHF achieved more percentage subsidy or aid than BPHDHR, it had lower IRR. This is because the economic benefits mainly come from the following aspects: biogas selling, organic fertilizer selling, electricity selling, and avoided environmental protection fines. The benefits from electricity and organic fertilizer selling in BPHDHR amounted to 4.4 million Yuan, a dramatic higher than one in BPSXHF. From the above results, it can be found financing and prices are two key factors influencing the economic benefits in biogas projects. Fund shortage is an important factor restricting the development of large-scale biogas projects. Thus, CDM should be an effective financing method in the biogas project for animal farms.

3. CDM POTENTIAL FOR AWMS

China is facing double pressures of economic development and environment protection. Developing biogas and establishing sustainable rural energy systems are important considerations for rural energy development, and the protection of the global environment. However, as described in the section 2.2, the shortage of financial resource is a key barrier restricting the development of biogas power generation on animal feeding farms. This paper aims to examine the viability of CDM project biogas power generation in livestock farms by analysis of a case study in Guangxi Province, China.

Table 3: Outline of the swine farm

Item	Parameter
Location	East longitude: 109°15′～110°15′ North latitude: 22°42′～23°42′
Animal population (Head)	53000
Annual average temperature (℃)	21.6
Annual average weight (kg)	28
Coal consumption (Ton/Year)	5700
Electricity consumption (kWh/Day)	2500
Power price (Yuan/kWh)	0.47

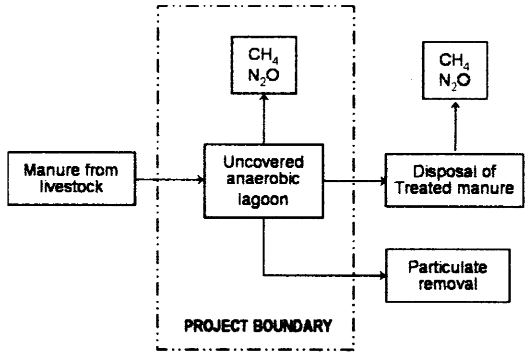

Fig.2: Baseline activity boundary

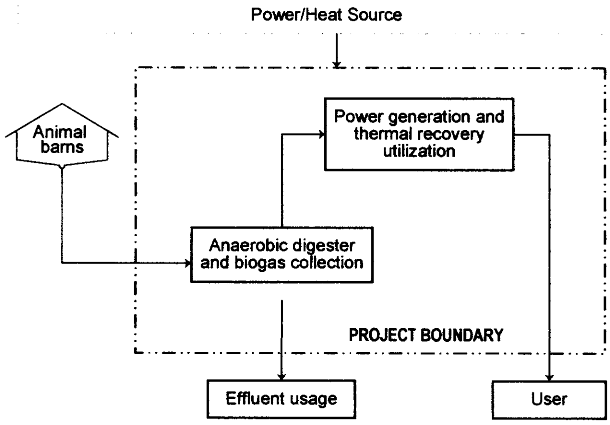

Fig.3: Project activity boundary

3.1 Outline of the swine farm

The proposed project is a swine farm with 53,000 head populations, located in Guangxi Province, where the annual average temperature is 21.6℃. The outline of the swine farm is described in Table 3.

3.2 Baseline scenario and project scenario

As described in the section 2.2, there are lots of AWMS in the world and they are also the possible baseline scenarios in CDM project activity. However, in this project, an uncovered anaerobic lagoon is considered as the baseline scenario. This is because this system represents the most common practice in China presently and it is also considered to be the most economical, efficient, and reliable manure management system. In China, discharge standard of pollutants for livestock and poultry breeding regulates the animal farms to meet wastewater discharge standards before discharging the wastewater into the natural water resources. In order to meet this regulation, the common practice in swine farms is to build uncovered anaerobic lagoon for wastewater treatment. The baseline activity boundary is described in Fig.2.

Anaerobic digester biogas power generation system is considered to be one of the most advanced manure management systems in the world. Unfortunately, only a few projects have introduced because of its poor economical benefits as described in Table 2. However, it is capable of dealing completely with the animal waste and can capture the methane generated during the treatment process and use biogas to generate electricity which can provide clean energy to substitute some traditional energy resource, thus it can reduce CH_4 emission more effectively and contribute to the mitigation of global climate change. Therefore, it is selected as the project activity scenario and project activity boundary is described in Fig.3.

3.3 Assessment of GHG emission reductions

In this paper, the approved methodology is referenced as ACM0010[9]. According to this methodology, the emission reduction by the project activity during a given year y is the difference between the baseline emission and the sum of project emission and leakage, as follows:

$$ER_y = BE_y - PE_y - LE_y \quad (1)$$

$$BE_y = BE_{CH4,y} + BE_{N2O,y} + BE_{elec/heat,y} \quad (2)$$

$$PE_y = PE_{AD,y} + FE_{Aer,y} + PE_{N2O,y} + PE_{PL,y} + PE_{flare,y} + PE_{Elec/heat} \quad (3)$$

$$LE_y = (LE_{p,N2O} - LE_{B,N2O}) + (LE_{P,CH4} - LE_{B,CH4}) \quad (4)$$

Where:

ER_y	:Project emission reduction (tCO_2e/Y);
BE_y	:Baseline emissions (tCO_2e/Y);
PE_y	:Project emissions (tCO_2e/Y);
LE_y	:Project Leakage (tCO_2e/Y);
$BE_{CH4,y}$	:Baseline methane emissions (tCO_2e/Y);
$BE_{N2O,y}$	:Baseline N_2O emissions (tCO_2e/Y);
$BE_{Elec/heat,y}$	:Baseline CO_2 emissions from electricity and/or heat used (tCO_2e/Y);
$PE_{AD,y}$	:Leakage from AWMS systems that capture's methane (tCO_2e/Y);
$PE_{Aer,y}$	:Methane emissions from AWMS that aerobically treats the manure (tCO_2e/Y);
$PE_{N2O,y}$	:Nitrous oxide emission from project manure waste management system (tCO_2e/Y);
$PE_{PL,y}$	:Physical leakage of emissions from biogas network to flare the captured methane supply to the facility where it is used for heat and/or electricity generation (tCO_2e/Y);
$PE_{flare,y}$	:Project emissions from flaring of the residual gas stream (tCO_2e/Y);
$PE_{elec/heat,y}$	:Project emissions from use of heat and/or electricity in the project case (tCO_2e/Y);
$LE_{P,N2O}$	:N_2O emissions released during project activity from land application of the treated manure (tCO_2e/Y);
$LE_{B,N2O}$	:N_2O emissions released during baseline scenario from land application of the treated manure (tCO_2e/Y);
$LE_{P,CH4}$	:CH_4 emissions released during project activity from land application of the treated manure (tCO_2e/Y);
$LE_{B,CH4}$	:CH_4 emissions released during baseline scenario from land application of the treated manure (tCO_2e/Y);

Table 4: Calculation result of CERs

Items	Calculation results (tCO_2e/Y)
Baseline emissions BE_y	86,823
Project emissions PE_y	3,563
Project Leakage LE_y	0
Project emission reduction ER_y	83,260

Table 5: Investments and revenues list

Items	Fees or benefits ($\times 10^4$ Yuan)
Project initial investment	4565.1
including: Land use	1529.9
Equipment fee	2730.8
Others(design, installation,etc.)	304.3
Project running and maintenance fees	200.3
including: Electricity charge	16.5
labour fee	57.8
Generator running fee	74.9
Pre-heat for anaerobic fermentation pot	34.1
Desulfurization of biogas	7.0
Equipment's guarantee and maintenance	9.9
Project total benefit	547.6
including: Electricity selling	352.0
Grain fertilizer selling	104.0
liquid fertiliser selling	91.5

According the above explanations and referencing as ACM0010, the baseline emission, the project emission and the leakage are calculated respectively and listed in the Table 4. The reduction emission from the CDM project activity amounted to 83,260 tCO_2e every year.

3.4 Economic analysis

So far, there are no uniform standards for the design and construction of large scale biogas projects, as well as operation standards, in China. Also, there is scare design and operation data being capable of gaining. In this paper, we take advantage of the data provided by some scientific and technological experts being rich in design and operation experience for biogas project from China Agricultural University. According to the biogas amount produced, 1000 kW biogas engine power generator is introduced. And the corresponding investment and revenues are listed in Table 5. To analyze the economic benefits, we create four scenarios by different subsidy percentage and three scenarios for different CERs prices. In each scenario, three cases are assumed according to different CERs period, namely the period of CDM project actability. And the other economical assumptions include basic discount rate being 10%, governmental and local tax being 33% and the exchange rate of the Yuan (Chinese currency) against the US dollar being 8:1. The Net Present Valve (NPV) and IRR for various cases are calculated and indicated in Table 6. From the results, it can be concluded as follows:

1) Biogas project without both CDM project activity and any subsidies achieves no or little economic benefits.

2) Considering no CDM project activity (CERs price equals to 0 in table), even the government or local contributed to the total initial investment of 50%, the IRR only reached to 8.51%. In actual, although some amount of interest discount has been given to large scale biogas projects by concerned departments, the percentage of discount reached scarce to 50%. Thus, it is almost impossible to rely completely on the governmental or local financial support to develop the biogas technologies.

3) Both CERs price and period influence sensibly the economic benefits. When CERs price being 8$/t-$CO_2$e, it is necessary to achieve to 10 year CERs period,

Table 6: Results of financial evaluation

Financial source	CER's price	CER's period (Year)	NPV (10000 Yuan)	IRR
No-subsidy	0	-	-3239.0	-
	8$/t-$CO_2$e	5	-1219.0	-
		10	852.5	14.20%
	10$/t-$CO_2$e	5	-714.0	3.65%
		10	1671.0	17.99%
Subsidy-25%	0	-	-1283.0	0.29%
	8$/t-$CO_2$e	5	-80.2	9.08%
		10	1991.3	22.33%
	10$/t-$CO_2$e	5	424.8	14.76%
		10	2809.8	26.93%
Subsidy-50%	0	-	-144.2	8.51%
	8$/t-$CO_2$e	5	1058.6	26.90%
		10	3130.0	36.98%
	10$/t-$CO_2$e	5	1563.6	34.31%
		10	3948.6	43.27%
Subsidy-75%	0	-	177.4	15.93%
	8$/t-$CO_2$e	5	2197.3	72.17%
		10	4268.8	77.03%
	10$/t-$CO_2$e	5	2702.3	84.86%
		10	5087.4	50.92%

Note: No-subsidy means that this project activity is not capable of getting any subsidies from government, local or other commission. Subsidy-XX% means that this project activity achieves the subsidy or aid finance, accounting for XX% of the total initial investment. NPV refers to Net Present Value.

otherwise to achieve more than 50% subsidy. With CERs price increasing to 10$/t-$CO_2$e and gaining 25% subsidy simultaneously, only 5-year CERs period can achieve considerable profits. However, in cases without any subsidy, even CERs price increase to 10$/t-$CO_2$e, 10-year CER period is necessary simultaneously, which is a severe condition in CDM market currently. That is to say, it is indispensable to achieve some degree subsidy in implementing CDM project activity of biogas power generation in animal feeding farms in China.

4. CONCLUSIONS

This paper examined the CDM potential for AWMS in China by a case study of large-scale swine farms. The results indicated although the market in China for CDM projects in animal farms is underdeveloped, there are large potential of GHG emission reduction. Both CERs price and period influence sensibly the economic benefits in CDM project activity and it is indispensable to achieve some degree subsidy in implementing CDM project activity of biogas power generation in animal feeding farms.

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