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The contribution of the CDM to sustainable development in China

A case study of the emerging biogas sector

December 2009

Abstract

Despite the twofold objectives of the Clean Development Mechanism (CDM), (a) the reduction of greenhouse gas emission and (b) the advancement of sustainable development, research and public discussion has so far been focusing almost exclusively on the first objective.

Contrary or complementary to this, the focus of the following study is on the second objective, specifically on the question of whether or not the the CDM is furthering sustainable development in China's biogas sector.

This was investigated by conducting a survey among experts who are working in the field of CDM and biogas in China. This survey was carried out in form of a questionnaire and several extended interviews.

It is an expectation that projects subsidized by the CDM can contribute to sustainable development. The CDM may attract foreign investors and bring about technology- and know-how transfer. Furthermore the CDM changes incentives for plant owners since it promotes the successful and efficient operation of a plant for the long term.

In practice, this turns out to be aggravated by several factors.

There exists a huge potential for biogas technology in different sectors of China's industry. The majority of the existing CDM biogas projects in China are implemented in the food processing industry. Here, especially in the still rather smaller livestock breeding sector, different obstacles constrain the successful and financially attractive operation of the plants. Low operation skills and inadequate technology prevail due to low foreign technology and know-how transfer. Inadequacies in the international CDM-Framework and problems with national regulations and the legal background are fundamental obstacles. Many of these could be approached in the upcoming reform of the CDM on the international level.

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1. Introduction and objectives of the study

The objective of the Clean Development Mechanism (CDM), as defined under the Kyoto Protocol framework, is twofold. It must offset greenhouse gases (GHG) emissions and it should contribute to a developing country's sustainable development. In the international agreements no definition of sustainable development in the CDM-context was determined and no general standard was settled. It is up to the host countries' Designated National Authority (DNA) to control whether a proposed project complies with the national criteria of sustainable development. Only a short section of the Project Design Documents (PDD) that is written for project evaluation of the UNFCCC Executive Board (EB) contains information about the expected contribution of the projects to sustainable development. It comprises aspects related to environmental, social and economic impacts. This information however will not be evaluated by the Executive Board since the EB is only responsible for the compliance of the GHG reduction targets.

In China there is no common knowledge about a possible set of criteria of the National Development and Reform Commission (NDRC). Reasons why and if a project could be rejected by the NDRC because of its insufficient contribution to sustainable development are not known, the reviewing process is not transparent. Consequently the ideas of consultants and experts in the CDM-Market how a project has to look like to meet the requirements of sustainable development are miscellaneous.

The following survey analyses the contribution of CDM projects to sustainable development in China mainly on the basis of opinions of CDM experts as consultants and members of Designated Operational Entities (DOE). In particular this study will focus on CDM biogas projects since the biogas sector is a new, growing and promising part of the CDM market in China that is up to now poorly considered.

In the course of this survey, ten profound interviews with Chinese and foreign CDM experts were conducted and a questionnaire was sent to 132 experts (with 32 answers; see annex II). Furthermore the PDDs of any Chinese CDM biogas projects (Effective: 09/09) registered and in validation stages were analyzed and interpreted.

At the beginning of this paper the status quo of the CDM biogas market will be characterized. After that overview about number, distribution and classification of CDM biogas projects the main chapter describes the characteristics of the Chinese biogas market and it's currently and prospectively contribution to sustainable development. The institutional background, the current role of the Gold Standard and the investment situation will be analyzed and the current situation and problems during technical implementation and operation will be described.

Particular attention shall be paid on the social impact as well as on the environmental impact of biogas projects. The relevance of household biogas digesters shall be described in a separate brief paragraph, due to the fact that those projects are hardly comparable with other biogas projects types in order of its problems and benefits. In a further chapter the future development potential of the different biogas types in the CDM market shall be demonstrated. At the end of the paper different proposals for a modified CDM in a post-Kyoto system will be discussed whereby the findings of this study will be considered.

2. CDM biogas projects and its contribution to sustainable development

2.1 Overview of existing biogas projects

In order to analyze the impact of CDM biogas projects on sustainable development in China a closer examination of current projects is necessary.
Up to September 2009, 34 projects were either registered or in validation process at the UNFCCC. Projects that are already approved by the DNA, but do not have requested validation up to now will not be considered in the following analysis.

Compared with 1,837 Chinese CDM projects in the pipeline biogas projects represent a relatively small share of roughly 2% of all projects (Fenhann 2009). Although this figure seems to be very small, it doesn't reflect the future potential in the Chinese CDM market. While biogas was relatively unattractive for investors in the past, many highly profitable projects like landfill-, wind- and hydropower plants were realised. But since the potential in these sectors has been diminished, the relative attractiveness for investments in biogas projects has been increased.
In total 30 of 34 biogas projects are small-scale activities[1] representing roughly 88% of all projects. Beside this there are four large scale activities. A household biogas digester program, located in Hubei Province that consists of 33,000 single household digesters, was registered in February 2009.
Until October 2009 four projects were registered, while two projects were requested to be

[1]As biogas projects refer to Type III projects as defined by the UNFCCC, small-scale biogas activities are projects with an annual emission reduction of less than the equivalent of 60,000 t/CO2. (FCCC/KR/CMP/2006/10 Add.1, Decision 1/CMP.2, page 8 number 28)

reviewed. The Henan Muyuan pig farm project is the only one with an existing monitoring report. Between December 2007 and May 2008 the project generated 5,354 CERs. With an estimated annual CER amount of 110,461 the performance is far behind expectations (9.6%).

With a total number of 24 projects and a share of 70%, industrial wastewater is the main source used for biogas recovery. 14 of these projects where developed in alcohol production companies, while the remaining ten projects are situated in other industrial sectors (paper mills, chemical companies, etc.) (see Figure 1) .
Nine projects with a share of 26% are implemented in the livestock husbandry sector (6 swine farms, 2 chicken farms, 1 cattle farm). There is one municipal solid waste management project. A detailed listing of the projects can be found in Table 1 at the end of this chapter.

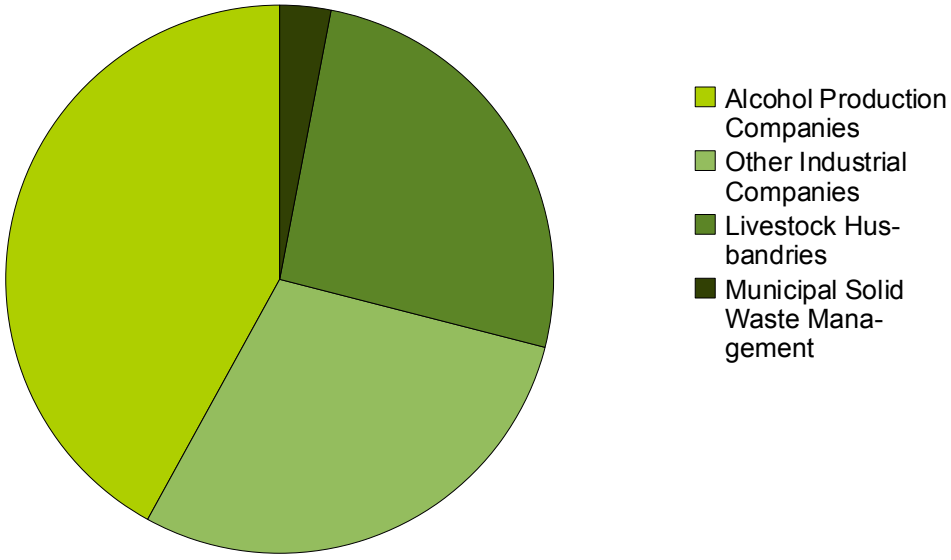

Figure 1: *Share of biogas project types by sector*

Projects are mainly concentrated in the coastal and central provinces of the country. As existing biogas projects are mainly carried out in industries with large amounts of organic wastewater production, the regional potential for biogas projects is closely linked to the economic development of a province. Beside higher project development costs in provinces with lower economic development, this might be an important factor for the concentration of the majority of projects in the eastern part of China.

The analysis of the existing projects showed that the majority of projects are developed in food-processing and other industries. During the interviews with several CDM-experts following

Figure 2: *Regional dissemination of CDM biogas projects in China*

different explanations for the current importance of industrial wastewater as biogas source were given.

The industries which are engaged with a huge amount of wastewater have special characteristics which can not be found in the livestock husbandry sector. On the one hand, the pressure for companies to comply the regulations for wastewater discharge is relatively strong. The anaerobic treatment of wastewater is therefore a common practise and CDM is seen as a co-finance for the wastewater treatment plant. On the other hand there is a lot of experience with the engaged biogas technology and the possibility of income generation seems to be a huge incentive for those companies to implement a CDM biogas project. In contrast to livestock farms, the energy consumption of industrial plants (i.e. breweries) is very high and the possibility to replace existing fuels seems to be attractive.

Another reason for the current situation is the difference of the industrial and agricultural sector in order of commercial business. The livestock sector is much stronger affected by

government regulations, while the industrial sector has a relatively long experience in commercial business. Thus, the managements of the industrial sector tend to be more open-minded for new income opportunities than the managements of livestock farms, who concentrate more on core business. This situation also affects foreign investors, since the management of industrial companies (i.e. breweries) might have more experience in dealing with international investors/ companies.

Table 1: Overview of CDM biogas projects

Name	Location	Project Owner	CER Buyer	annual CERs	UNFCC status
Methane Recovery and Utilization CDM Project at Muyuan Swine Farm in Henan Province	Henan	Muyuan Livestock Feeding Co., Ltd.	Marubeni Corporation, Japan	110,461	Registered on 21.12.2007
Animal Manure Management System (AMMS) GHG Mitigation Project , Shandong Minhe Livestock Co. Ltd., Penglai, Shandong Province, P.R. of China	Shandong	Shandong Minhe Livestock Co. Ltd., China	The International Bank for Reconstruction and Development (IBRD) as trustee of Community Development Carbon Fund (Netherlands)	66,393	Registered on 27.04.2009
Hubei Eco-Farming Biogas Project Phase I	Hubei	Hubei Qingjiang Zhongye Company Ltd., China	The International Bank for Reconstruction and Development (IBRD) as trustee of Community Development Carbon Fund (Netherlands)	58,444 (applied: 58,219)	Registered on 19.02.2009
Biogas Co-generation Project at Shandong Chenming Paper Holdings Ltd.	Shandong	Shandong Chenming Paper Holdings Ltd.	Vitol S.A. , Switzerland	33,096	Validation
Guangxi Wuming Jiaolong Alcohol Production Wastewater Treatment Project	Guangxi	Guangxi Wuming Jiaolong alcohol energy Co., Ltd	voestalpine AG, Austria	88,319	Validation
Power generation by methane from hoggery in Yun'nan Minhong Bio-tech industry Co., Ltd	Yunnan	Yun'nan Minhong Bio-tech industry Co., Ltd.	Climate Corporation Emissions Trading GmbH, UK	32,449	Validation
Greenhouse Gas (GHG) mitigation Project of Waste Management System	Henan	Zhongmu Dongzheng Breeding Industry Science and Technology Co.Ltd.	Advantec C0.,Ltd.	18,895	Validation

Methane Recovery and Power Generation Project in High-concentrated Organic Wastewater Treatment in Hubei, China	Hubei	Huangshi Xinghua Biochemical Ltd	Climate Bridge Ltd. , UK	49,150	Validation
Methane Recovery Project of Chifeng Ruiyang Chemical Co., Ltd.	Inner Mongolia	Chifeng Ruiyang Chemical Co., Ltd.	Energy Initiative Japan Inc.	39,552	Validation
Methane Recovery Project of Jiangsu Fenjinting Qilong Brewing Co., Ltd.	Jiangsu	Jiangsu Fenjinting Qilong Brewing Co., Ltd	Energy Initiative Japan Inc.	63,203	Validation
Methane Recovery Project of Jiangsu Lianhai Bioengineering Co., Ltd.	Jiangsu	Jiangsu Lianhai Bioengineering Co., Ltd.	Energy Initiative Japan Inc.	95,009	Validation
Methane Recovery Project of Huguan Yufeng Brewing Co., Ltd.	Shanxi	Huguan Yufeng Brewing Co., Ltd.	Energy Initiative Japan Inc.	72,483	Registered on 04.09.2009
Methane Recovery Project of Linqu Qinchi Biological Co., Ltd.	Shandong	Linqu Qinchi Biological Co. Ltd.	Energy Initiative Japan Inc.	76,650	Validation
Beixu Group Methane to Energy Project	Henan	Beixu Group Co., Ltd, China	South Pole Carbon Asset Management Ltd. Switzerland	64,147	Validation
Methane Recovery Project of Fuyu Huihai Alcohol Co., Ltd.	Jilin	Fuyu Huihai Alcohol Co., Ltd.	Energy Initiative Japan Inc.	68,233	Review requested
Guangzhou Zhujiang Beer Methane Recovery Project	Guangdong	Guangzhou Zhujiang Brewery Co., Ltd, China	South Pole Carbon Asset Management Ltd., Switzerland	44,662	Validation
Methane Recovery Project of Donghai Taihe Agricultural Products Co., Ltd	Jiangsu	Donghai Taihe Agricultural Products Co., Ltd	Energy Initiative Japan Inc.	59,490	Validation
Methane Recovery Project of Lianyungang Jinchanglin Alcohol Co., Ltd.	Jiangsu	Lianyungang Jinchanglin Alcohol Co. Ltd.	Energy Initiative Japan Inc.	77,169	Validation

Ju County Biogas Utilization Project	Shandong	Shandong Yuantong Bio-energy Co., Ltd. Ju County Branch	EcoSecurities Group Plc, UK	53,562	Validation
Mashan Wastewater Treatment Project, Guangxi	Guangxi	Guangxi Mashan County Yuanyang Industrial and Business Co., Ltd	Equity + Environmental Assets Ireland Ltd.	54,949	Validation
Anning Wastewater Treatment Project, Guangxi	Guangxi	Guangxi Wuming County Anning Starch Mixture Co., Ltd	Trading Emissions PLC	49,068	Validation
Tianjin TEDA Sewage Methane Recovery Project	Tianjin	Tianjin TEDA Alcohol Co.,Ltd	EcoSecurities International Limited, UK	52,858	Review requested
Methane Recovery from Wastewater Treatment Reactor at Linqing Galaxy Paper Mill	Shandong	Linqing Xinneng Natural Gas Co., Ltd.	n.a.	73,230	Validation
Shaanxi Methane Recovery and Electricity Generation Project in Xi'an Guowei Starch Co., Ltd	Shaanxi	Xi'an Guowei Starch Co., Ltd.	n.a.	46,437	Validation
Henan Yinge Industrial Investment Corporation Wastewater Treatment and Methane Recovery Project	Henan	Henan Yinge Industrial Investment Corporation	voestalpine Rohstoffbeschaffungs GmbH. Austria	75,277	Validation
Shaanxi Hancheng Waste Gas Recovery for Electricity Generation Project	Shaanxi	Hanchengcheng Blackcat Carbon Black Co., Ltd.	RWE Power AG	37,553	Validation
Methane capture and nitrous oxide destruction from swine manure treatment for Meng Miao	Henan	Shineway - IBET Bio-Environmental (Luohe) Co. Ltd.	IIBET - Italian Bio-Environmental Technologies S.r.l., Asja Ambiente Italia S.p.A. , Euregio Finance S.p.A.	20,342	Validation
Inner-Mongolian Mengniu Aoya Biogas Power Project (1.36MW)	Inner-Mongolia	Inner-Mongolia Mengniu Biogas Power Co. Ltd,	China Carbon N.V., Netherlands	22,968	Validation
Shandong Methane Recovery and Electricity Generation Project in Jingzhi Liquor Co., Ltd	Shandong	Shandong Jingzhi Liquor Co., Ltd	n.a.	41,230	Validation

Beijing Deqingyuan Chicken Farm 2.4MW Biogas Power Project	Beijing City	Beijing Deqingyuan Agricultural Scientific Co. Ltd,	IFC-Netherlands Carbon Facility, Netherlands	94,833	Validation
Methane Recovery Project of Yuanshi Liyuan Protein Processing Plant	Heibei	Yuanshi Liyuan Protein Processing	Japan Energy Initiative Japan Inc.	68,300	Validation
Recovery and Utilization of biogas from wastewater treatment in Luohe	Henan	Shineway-IBET Bio-Environmental (Luohe) Co. Ltd.	n.a.	72,815	Validation
Hebei Wuan Lancun biogas digester Project	Hebei	Hebei Jinpeng Animal Husbandry Co. Ltd	J-TEC Co., Ltd. Japan	16,623	Validation
Yudong Municipal Solid Waste (“MSW”) Treatment Plant Project	Henan	Yongcheng Jincai Investment Development Co., Ltd.	Climate Bridge Ltd., UK	17,350	Validation

2.2 Characteristics and impact of current CDM biogas projects

Impact of International Institutional CDM-Framework

The international framework of CDM has a significant influence on the CDM market in China. Since the public access and commenting of the PDD is part of the validation process and the monitoring report is published as well, the general framework has immensely increased transparency in the Chinese biogas market. Even though this argument sounds very theoretical a positive impact of these measures should be observed in the long run. Inefficient technology for example can be identified by developers of new projects although they didn't directly deal with the failed project itself. However, the impact is also limited due to the information given in the PDDs. Especially financial information tend to be faked, since these figures are often used for proving additionality.

Beside the benefits as a result of the increased transparency, another positive impact is given by changed incentives promoting successful operation of biogas plants. At the moment the construction of biogas plants are - as already mentioned above - very often understood as a way of wastewater treatment. National policies that aim to promote renewable energy very often subsidise the initial investment instead of the successful operation. The CDM as a mechanism that only rewards efficient operation of a plant changes incentives for plant owner. Therefore, biogas plants that have applied for CDM are more likely to be well operated than biogas projects without CDM application. The CDM methodologies even oblige projects to implement measures like monitoring and training of employees to ensure a successful operation.

Institutional and legal background for CDM-Projects in China

Like the international framework plays an important role for CDM market in China, national regulations and legal background determines the effects of CDM projects on sustainable development as well. In fact, according to the Marrakesh accords “it is the host Party’s prerogative to confirm whether a clean development mechanism project activity assists it in achieving sustainable development” (UNFCCC 2002).

On the one hand sustainable development criteria are defined on national level and can be adapted to special national needs, while on the other hand no country has a considerable influence on the market price of CERs. According to Sutter and Parreno this will create the incentive for non-annex 1 countries to set very low sustainable development criteria in order to attract foreign investments. Finally, these incentives could lead to a „race to the bottom“, while the sustainable development objective is most likely to be not fulfilled. (Sutter & Parreno 2007)

With this theoretical thought on mind, a closer look at the Chinese DNA is necessary.

- There are no public available criteria for sustainable development of the DNA.
- Neither one of the experts who were interviewed for this study has ever heard of a project that was rejected due to limited impact on sustainable development.
- The number of projects approved by the DNA tends to be several times higher than the number of projects registered by the UNFCCC (an 8:1 ratio was mentioned by one interviewee).
- 31,2% of the people who participated in the questionnaire haven't ever heard of any projects rejected by the DNA.

The picture drawn by these facts indeed seems to confirm the above mentioned thesis of the „race to the bottom". While Chinese CERs dominate the international market, the DNA is most likely neither interested in setting any criteria for sustainable development nor to check applying projects.

In 2007 the Chinese government launched a fund which is fed from a levy on CERs (65% of the revenue from HFC and PFC projects, 30% from N2O, and 2% from all other projects). (WWF 2008) With a theoretical amount of 3 billion RMB the fund is said to finance capacity building, research activities and financial support for unilateral CDM projects. (GTZ 2008) Although there are some basic information about future activities, there is no common knowledge among CDM stakeholder about detailed activities as transparency of the fund is low. 25% of the persons participating in the questionnaire have never heard of the fund.
Despite the current situation concerning the fund, it could play a major role in improving contribution of the CDM to sustainable development. Since HFC and other large industrial projects with questionable impact are taxed higher than renewable energy projects, it could promote sustainable development through financial support of small-scale projects, projects with strong community participation, etc..

Beside national criteria, renewable energy policies have a similar important influence on the contribution of the CDM to sustainable development.
According to the Renewable Energy Law of the People's Republic of China (PRC), the grid company is responsible for grid connection and maintenance. But due to the small size of biogas plants and the long distance from livestock farms to the grid, especially the first projects struggled with grid connection and transactions costs rose (since the grid companies

transferred the costs for connection to the project). Up to now there is no legal solution for grid connection from the Chinese government. The livestock sector is most affected by the situation since farms are mostly located in remote areas and their electricity demand is much lower than the possible electricity production with biogas. (AHK 2008) A feed-in of waste heat to the regional heating grid has not been realised yet, because of failing agreements with the municipal grid operators.

Furthermore, the current electricity feed-in tariff is too low for a financial feasible operation of biogas plants. CDM as additional income is a strong incentive to implement biogas projects, but since electricity is not a main source of income, the plant owners' attention for an efficient power generation is very low. The situation that CDM is providing the additional income to realize a feasible project might be positive in order of additionality, but it also decreases the government's incentive to realize a uniform feed-in tariff for biogas plants that already exists for sectors like wind-power.

Gold Standard

Beside international and domestic governmental regulations, the Gold Standard (GS) derived from civil society to improve the contribution to sustainable development.

As many problems in CDM projects concerning its benefits on sustainable development derive from low incentives for CER buyer to keep an eye on this topic, the GS established widely acknowledged criteria for sustainable development. At the moment there is only one biogas project (Guangzhou Zhujiang Beer Methane Recovery Project) applying for GS, though the potential for biogas CDM projects is much higher. There are several criteria (at least 65% of biogas should be used for energy, strict monitoring, environmental and social integrity etc.) that have to be fulfilled for successful GS application, while the costs are around 10,000 to 15,000 €. Furthermore a second stakeholder consultation has to be conducted. In most cases the additional income of GS certificates that tend to receive 1 to 2 € more than market price for common CERs doesn't justify the additional financial expenditures. According to an interviewed expert the Gold Standard is not well known in the Chinese CDM market, due to the fact that most CER buyers do not care whether any objectives for sustainable development are archived or not.

Investment

After the macro level was analyzed in the previous chapters in the following part of chapter 2.2 the micro level will be examined. In this part the question "what criteria have to be fulfilled by a project to contribute to sustainable development" will be focused. As before, it is hard to quantify the impact on SD. The authors therefore try to emphasize the most significant criteria that were named by CDM experts with experiences in Chinese CDM and biogas market.

The investment of a project determines in several ways the possible project's impact on SD.
The available amount for investment is most crucial for the decision whether advanced technology will be used or not. As already mentioned in previous chapters, the industrial wastewater plants are common practise for treatment of organic wastewater in industries. The digester technology and experience for successful operation is therefore domestically available. In most cases foreign investment is not needed.
In contrast to this, the domestic digester technology for livestock industry is less developed. To assure high efficiency and less technical failures the implementation of foreign and comparable expensive technology is necessary. Since commercial farms often lack capital for investments, a foreign investor can help to implement a proper developed project with advanced technology. The examples of two biogas plants in livestock sector (Beijing Deqingyuan Chicken Farm, Animal Manure Management System GHG Mitigation Project in Shandong) exemplify the ability of CDM to realize biogas projects that were not financial feasible without additional income through CERs.

Nevertheless the crucial problem of high initial investments for biogas plants in agricultural sector is not solved with the future outlook of CER revenues. Both above mentioned projects were pre-financed with World Bank loans.
Without additional financial institutions providing pre-financing for CDM biogas projects the number of projects with advanced foreign technology will be very limited. Because of the common practise of limited operation period of local biogas technology, banks are often reluctant to grant loans when operation period is supposed to be longer than 10 years (though plants with foreign technology and proper maintenance could run 20 years). With an involvement of a foreign investor both financial and technical problems can be tackled. As business in agricultural sector is often focusing on the initial investment and less on a successful operation, a foreign partner can take care that all needed steps for a successful operation and CERs issuance take place.

The rising number of unilateral projects will most probably face problems which could have been solved with both foreign investments and technology. A contribution of those projects to sustainable development is most questionable, since those projects won't be able to be operated successfully, which means that no environmental, social or economic benefits will contribute to the countries sustainable development at all.

Technical implementation and operation

The applied technologies in the Chinese biogas market are manifold. Since anaerobic treatment of wastewater is a common practise in the industrial sector, there are several Chinese supplier of suitable technology. In the livestock sector however a different technology able to treat liquid manure and to extract biogas is necessary. Furthermore in both sectors generators are needed to produce electricity from the captured biogas. In the opinion of several interviewed experts in the Chinese biogas market the installation of foreign technology is still required in order to get a reasonable amount of gas and electricity.
According to the PDDs four biogas projects and 12,5% respectively stated that foreign technology will be transferred. In the opinion of the interviewed experts foreign technology is more often used in CDM biogas projects than in non-CDM biogas projects, because of the foreign influence and capital investment.

Several interviewed experts therefore think that biogas plants that have applied for CDM are more likely to be well operated and struggle with fewer problems than biogas projects without CDM application.

Up to now biogas plants in China, especially in the livestock sector, struggle with following problems:

- Micro-organisms in the digester are highly sensitive concerning temperature change. Inconvenient heating systems cause unstable temperatures in the digester, so that the environment for micro-organism is poor. Problems occur mainly in winter.
- The sensitivity of the micro-organisms in the digester concerning pH value change is high. The composition of the content has to be monitored.
- The gas yield of liquid manure as single input material is low. The efficiency could be increased by a mixture of manure, agricultural solid waste like straw, food

residues or algae .The dwell time of different substances however is different.
- Too much water is used for cleaning of the livestock buildings, so that the content of the digester is diluted.
- The digester content should be analyzed professional to get information about the composition otherwise the efficiency can be decreased up to 30 percent. The awareness of that topic is low and suitable labs are missing in China.
- Because of the massive use of antibiotics in the Chinese livestock sector the activity of the micro-organisms in the digester can be restrained.

A lot of the occurring problems in the Chinese biogas market are due to inefficient technology or poor operation due to lacking expertise.
To find solutions for the technical problems more foreign technology has to be applied and the technological development in China has to be strengthened. A lot of foreign investors however hesitate to transfer advanced technology to China since they are afraid that it will be copied by Chinese companies.
Chinese suppliers improve their technology by copying foreign plants but only limited by own research & development since the incentives in the market are too low. Customers very often don't trust that technology can outlast more than 10 up to 20 or 30 years. A stronger engagement of foreign investors however stimulates the Chinese market and promotes the Chinese suppliers to develop technology with higher life times. Some generators built in joint ventures already improved and are able to work up to 8000 hours per year.

Technical problems caused by bad performance and insufficient monitoring by the local workers can only be solved through increased training and education. According to an expert the requirements for local workers are so high that they should be trained for a couple of weeks by foreign experts. Through technology- and know-how transfer a strengthened development can be accelerated by CDM.

Local environmental impact/integrity

Beside social and economic dimensions of sustainable development, the environmental integrity of a biogas projects has most significant impact on the living conditions of the local communities. Beside reduction of GHG, manure and wastewater treatment various small impacts on local environment are mostly named in the environmental impact assessment in the PDD (increased noise, risk of explosions, lower air pollution, odour, etc.). The most

significant of these issues might be the decreasing air pollution (SOx, fine dust and soot), since biogas either replaces grid electricity that is commonly generated by burning fossil fuels and/or coal-fired boilers.

For analysing impact on local water quality it has to be distinguished between agricultural and industrial sector.
The industrial sector – as already mentioned above – is relatively strongly constrained to comply wastewater discharge standards. Those biogas plants substitute in most cases existing wastewater treatment plants (open lagoons, etc.). But since those plants replaces existing coal fired boilers or produces electricity as well, a positive impact on local air quality is testified.
With ongoing concentration of livestock farms and the transition of the whole sector, more and more areas face fast amounts of untreated manure and wastewater from livestock farms. In areas where farm concentration is low, no serious problems occur as animal manure and wastewater can be used on the surrounding farms as fertilizer. National standards for the agricultural sector have been implemented by the government, though many farms lack adequate capital to implement facilities. (AHK 2009) More than 90% of the existing commercial livestock farms have no or inadequate wastewater treatment facilities to comply with standards. (GTZ 2009a) Since the CDM methodologies for biogas plants consider an existing wastewater treatment facility as baseline scenario, some farms are forced to build and operate open lagoons for a short period before constructing biogas plants and applying for CDM. In many cases biogas is still seen as a process of wastewater treatment. But to comply with national regulations a further treatment process of the digesters output is necessary. If there is no possibility to use the digester output as fertilizer on fields, post-treatment facilities have to be installed which would lead to financial unattractive additional investments. Thus, it seems unlikely that CDM is able to strengthen local environmental integrity of livestock farms through improving manure and wastewater treatment significantly.

Local economic and social impact

In general it is assumed that CDM biogas projects have positive impacts on the local economic and social development. In the PDDs of the 34 Chinese biogas projects it is expected that on average 17.9 new jobs will be created, whereas 11 projects did not mention the number of job opportunities.
Furthermore following economic benefits were mentioned by some projects:

- The project will provide sludge to farmers. Two projects plan to provide the sludge for free.
- As a result of training on the operation of the plant the employee's skills will increase.
- The project will support raising awareness of environmental topics and biogas technology and therefore have impact on the implementation of new biogas plants in other companies.
- During construction the projects help to secure local employment in construction companies.

Several for this study questioned CDM-consultants and DOE-members confirmed that CDM biogas plants have positive impacts on social and economic development. Some of the interviewees assured that the know-how of the local workers will be increased since the technical monitoring of the operation is very demanding, especially in comparison to the operation of other renewable energy projects.
In a questionnaire that was implemented for this study 13 respondents marked on the question: “To what extent do biogas projects increase employment opportunities in comparison to other CDM project types?” the answer “on average”. 15 respondents marked the answer “above average”. 3 participants chose the answer “below average”.
On a further question: “To what extent do biogas projects increase employee's skills in comparison to other CDM project types?” 15 respondents marked the field “on average” and 13 persons the field “above average”. 4 interviewees think that the employee’s skills are increased “below average”. (see tables on next page)

Answers	Frequency	Percent
No answer	1	3,10
Below average	3	9,40
On average	13	40,60
Above average	15	46,90
Total	*32*	*100,00*

Table 2: *Answers to the question to what extent do biogas projects increase employment opportunities in comparison to other CDM project types.*

Answers	Frequency	Percent
Below average	4	12,50
On average	15	46,90
Above average	13	40,60
Total	*32*	*100,00*

Table 3: *Answers to the question to what extent do biogas projects increase employee's skills in comparison to other CDM project types.*

To assure the acceptance of new biogas plants in the local communities the UNFCCC established stricter requirements for the obligatory stakeholder consultation. While stakeholder comments were often faked in the beginning of the market period meanwhile they are usually reliable. The acceptance and support of new plants in the local community is important to ensure a sustainable operation.

As mentioned above biogas plants in the livestock breeding market suffer from low energy efficiency. Successful operating biogas plants with a high energy output in comparison can have positive economic effects on the market since the trust in reliable and efficient technology will be strengthened. Professional implemented plants that will receive revenues of CERs like the Beijing Deqingyuan Chicken Farm can serve as a model for other Chinese plants and its investors.

To get a closer look on the local economic and social impact of biogas plants it is necessary to differentiate between biogas types. Plants that are installed in the industrial sector like in food processing companies usually have low social and economic impact since the technology is part of the production process. Companies of paper production or chemical industry have similar low impact.

When biogas plants are erected in livestock farms surrounding residents may benefit in different manner. Besides additional job opportunities and training sessions for the workers, improved organic fertilizer can be distributed. However, to realize these benefits the current situation at Chinese biogas plants has to change completely. Efficient technology and additional waste water treatment facilities to comply discharge regulations have to be installed, while at the same time the awareness for negative externalities must be increased.

Centralized biogas plants in rural areas might have the highest benefits for social communities.

Those plants support local farmers to manage their waste, to improve sanitation conditions, to reduce additional costs and to substitute dirt inducing and expensive fossil fuels. Up to now however there is no centralized biogas plant with help of CER revenue realized or in validation stage. One interviewed CDM-consultant expressed that his company planed to invest in such a plant, however struggled with the CDM methodology. Following the methodology it is not possible to take the manure by vehicles to the biogas plant since the transport causes incalculable carbon dioxide emissions. A further obstacle for more CDM investments in centralized biogas plants might be the small scale of the plants. Investments in plants that generate less than 30,000 CERs are seldom financial feasible.

Household-based biogas programs

A special project type in the CDM livestock breeding market is the household-based biogas digester program. Up to now there is one registered project in the rural area of Hubei province financed by local farmers, the Chinese government, the International Bank for Reconstruction and Development (IBRD) and the future CER revenue (registration status). According to the PDD the project intended to install biogas digesters for 33,000 households. Pig manure is fermented in small biogas digesters and the gained biogas is used as thermal energy to replace the fossil fuel (mainly charcoal) that is used to meet the households' daily energy needs for cooking and heating. Managed by a local project company the households get technical training. Operation is supervised and monitored.
In the opinion of several experts the social and economic impacts of programs of activities as the household-based biogas program are relative high in comparison with usual biogas plants (however in the eyes of an expert lower than impacts of centralized biogas plants; see above). Employment rate can be increased especially during construction of the digesters; but also afterwards for operation and maintenance workers are needed. Furthermore a great number of farmers benefit of decreased indoor pollution and improved sanitary conditions and thus reduced risk of diseases. In addition the program helps to decrease household expenditures since biogas can be used to substitute fossil fuels. Theoretically farmers save money and get additional money of the CER revenue and therefore can invest residual capital in further equipments.

However, financial problems, question of additionality and doubts about the contribution to environmental sustainability exist. First of all some experts disbelieve that it can be assured that every plant is used. Costs and efforts to train and to monitor the digesters are very high.

Investment costs in the beginning are high as well and for farmers it is still more difficult to raise money than for owners of big farms or for companies. If the revenue of the CERs is not transferred to the farmers, they don't have credit standing and will not get loans by banks. In the Hubei Eco-Farming Biogas Project the carbon trade revenues shall be used to cover the project operation costs and technical service being provided to farmers, however "the large portion" (cf. PDD) of the money shall be channelled to the farmer households "for the purpose of loan repayment, biogas digester maintenance, and livelihood needs". A significant problem for every household-based biogas program is that investors and coordinating entities have to be found. Besides the governmental subsidies, the farmers' investments and the potential CER revenue in the Hubei Eco-Farming Biogas Project the World Bank (IBRD) had to act as an initiator and fourth investor.

In contrast to this several similar projects in China were implemented without investments by the IBRD and without CER revenues (there are 22.6 million household digester in China [UPM 2009]), funded by the subsidies of the Chinese government that has supported household biogas digester since the 1970s. On the resulting question of additionality of the Hubei Eco-Farming Biogas Project the PDD is arguing that those farmers are supported that never could have afforded the plants in spite of the governmental subsidies.

According to the governmental "Plan of Biogas Construction in Rural Areas in China, 2007 – 2010" and the "Plan of developing national biomass energy industry, 2007 – 2015" it is estimated, that by 2010 40 million household biogas plants will be installed in rural areas. It is aimed to increase the number of household biogas digester until 2015 up to 60 million. (GTZ 2009a)

Apart from financial problems and the question of additionality the amount of the contribution to environmental sustainability is discussed. According to experiences from Nepal household biogas plants suffer from leakages of the digester. If plants are constructed badly or if the consumption is irregular, leakage can be up to 20 percent. Since the monitoring of small household digester is difficult, it is also questionable, if the gained gas substitutes charcoal as intended or other fossil fuels.

3. Development potential for biogas in China

After the status quo of biogas CDM projects in China and its contribution to sustainable development was analyzed in the last chapter, the following part will focus on the future potential for biogas plants in general and CDM projects in particular. Therefore, a closer look on the different sectors where biogas is most likely to be implemented is necessary.

Answers	Frequency	Percent
Similar relevance than currently	8	25,00
Higher relevance than currently	18	56,20
Significant higher relevance than currently	6	18,80
Total	*32*	*100*

Table 4: *Given answers on the question of the future relevance of biogas in CDM market*

In the questionnaire that was carried out for the study two questions about the future potential were asked:

Answers	Frequency	Percent
No answer	5	15,60
Livestock Breeding	18	56,20
Food processing industry	5	15,60
Industrial wastewater treatment	3	9,40
Total	*32*	*100,00*

Table 5: *Given answers on the question of the most attractive sectors for biogas in future*

75% of the participants assessed the future relevance of biogas projects on the Chinese CDM market higher than currently. Detailed answers are given in Table 4.

56,2% of the participants think that the livestock breeding sector offers the most attractive opportunities for business. While another 15,6% named the food processing industry and 9,4% the other wastewater producing industries.

The agro-industrial sector

As previous chapters revealed the main focus of current biogas projects is lying on wastewater as source for biogas generation. In 2008 there were in total 17,490 manufactures of companies with large organic wastewater production (for detailed figures see Table 6).

Sector	Number of Enterprises
Food processing industry	5701
Manufacture of foods	3331
Manufacture of beverages	2640
Manufacture of paper and paper products	5818
Total	*17490*

Table 6: Number of companies with large organic wastewater production

Source: China Environmental Yearbook 2008

As technical and financial barriers for those projects are comparable low, many biogas projects in this sector could be realized. Although the number of manufactures seems to be very high, many companies won't be suitable for biogas projects (due to size, investments, etc.). However, eight people and 25% respectively of all participants of the questionnaire also underline the major role of those projects in the Chinese CDM and biogas market in future.

The agricultural sector

In contrast to the industrial sector the development of biogas projects in the agricultural sector still struggles with many problems concerning efficiency, investments and operation.
As the rising living standard and population in China will continuously increase, the demand for agricultural products – especially meat and milk – will rise sharply. The industrial livestock husbandry sector seems to profit most from rising demand as clear tendencies towards middle to large-scale commercial husbandries in concentrated areas can be observed (see Table 7). (AHK 2009)

Year	Number of commercial farms in China (000s)	Number of large[1] farms in China
2002	2,422	8,241
2003	2,999	8,883
2004	3,362	10,532
2005	3,910	11,952
2006	4,262	12,604

Table 7: Number of commercial and large farms in China

Source: ADB 2009 from China Livestock Statistical Yearbook, various issues

[1] Large farms are farms with more than 10,000 annual sold pigs, more than 1,000 annual sold beef cattle, more than 1,000 dairy cattle inventory, more than 100,000 broilers or more than 50,000 chicken layers

As a result of rising concentration of commercial farms huge amounts of manure is produced in areas with not enough capacity to dispose the waste on fields as fertilizer. The potential for biogas (especially the number of projects) seems to be huge. Experts expect that around 7000 projects, each more than 500kW, can be realised in this sector. In 2015 around 200MW of energy could be produced by biogas with a share of 33% produced by agricultural biogas plants. Until 2020 the share of agricultural plants will rise to 50%, while a total capacity of 1500MW can be expected. (GTZ 2009a)

The future potential of biogas could even rise, if agricultural waste (e.g. straw) became a co-substance for biogas digestion. Currently incineration plants dominate energy production of biomass, although biogas digestion could lead to a threefold higher energy yield than incineration projects. At the moment there are some encouraging research plants running that deal with straw as a co-substance.

The municipal solid waste sector

Several interviewed experts named municipal solid waste management projects as promising sector for CDM biogas market. Indeed, the densely populated provinces in China produce enormous amounts of organic household waste. In Shenyang for example the daily amount of organic waste exceeds 2000 tons. Regarding the number of cities with similar size the potential seems to be tremendous. Even though, up to now only one CDM municipal waste biogas project is undergoing validation process at the UNFCCC.

Limitations for CDM-application

The potential for biogas projects in China is going to be huge, while CDM consideration for biogas projects is still connected with some limitations:

- Methodologies are very strict in order of additionality. Newly constructed commercial farms are not suitable for CDM, even though a minimum age is not strictly defined by the EB.
- The uncertainty concerning the post-Kyoto regime will diminish the number of newly developed projects until 2012. Foreign investors already consider this in their calculations and projects with an IRR under 20% are unlikely to be realised. Though, the European Union committed to CDM even after 2012, requirements in order of additionality are still unclear, so that CDM funding could become impossible for many projects.

4. Conclusion and Outlook

As discussed above the goal of the CDM to contribute to sustainable development depends most on the implementation of well-operating and financial attractive technology. Regarding the biogas market in China the majority of projects are poorly designed, struggle with low efficiency and are therefore not expected to be operated in a certain way that contributes to the countries' sustainable development. In the opinion of most interviewed experts technical problems can be solved if advanced technology is installed, while staff should be well trained and a highly sophisticated monitoring system is implemented. The involvement of a foreign investment partner can contribute to a project in order of finance and know-how so that existing barriers of biogas projects can be overcome. According to the opinion of several experts existing biogas CDM projects with strong involvement of foreign partners are apparently better planed and operated than unilateral plants.

In order to assure the contribution of biogas projects to sustainable development the successful operation of the plant is required while the international framework and national regulations play the major role in creating an environment in which both objectives of the CDM can be achieved. At the moment it is the host-Party's prerogative to confirm whether a CDM project assists in achieving sustainable development. As previous chapters pointed out the current situation sets incentives for non-annex-I countries to set very low sustainable development

criteria. Up to now the Chinese DNA NDRC hasn't set up any public criteria and most projects are approved.

Although the Gold Standard has been established, the majority of CER buyers are not interested in purchasing credits of projects that were implemented with stricter standards. The CDM as a demand driven market is most likely to fail in achieving both of its objectives as long there is no self-commitment of Annex-I countries or an international agreement on sustainable development criteria. In the following part different possibilities how the objective of sustainable development contribution can be achieved if an international agreement on criteria is obtained.

1. One of the most obvious possibilities is to consider a projects' contribution to sustainable development during registration and certification as it is already done with greenhouse gas reduction and additionality. Since the Gold Standard procedure is very similar strength and weaknesses of this solution are predictable. While duration and costs for registration and monitoring would rise, it could be assured that every project itself complies certain standards.
2. Through discounting emission reductions from projects that are less important for sustainable development, the incentives to implement CDM projects with significant sustainable development benefits would increase. Currently CER prices only reflect the amount of GHG emission reduction, whereas in a system which also values the projects impact on sustainable development, CER prices would reflect both objectives of the CDM. However, beside international criteria countries have to agree on particular discount rates for every project type. (Schneider 2007) In contrast to the first solution, this system tries to approximate a project's benefits (by distinguishing between project types) rather than assure that every project itself contributes to both objectives of the CDM. The question whether the project type or other factors determine a projects' contribution to sustainable development is therefore crucial for the quality of this proposal.
3. As already practise in China a fund that is fed by a graded levy on CER revenues could be established on an international level. In contrast to the existing international Adaptation Fund and in order to contribute to sustainable development projects with fewer benefits should be heavily taxed whereas projects with significant impact should be low taxed. The international community has to agree on particular rates of taxation and clearly defined criteria for what the money of the fund is used. Whereas the first and the second proposals aim to intervene in market conditions, this suggestion tries to achieve the second objective of the CDM beside market activities.

Beside the above mentioned proposals which are all based on an international agreement on sustainable development criteria, a self-commitment of annex-I countries could change current situation concerning sustainable development as well. Basically there are two possibilities:

a) A minimum quota of projects with high sustainable benefits or long-term benefits in the portfolio of annex-I countries could be established. It could be required that a certain share of the CERs portfolio are projects that support the long-term transition of the energy system, such as renewable energy generation and energy efficiency improvement projects. (Schneider 2007)
b) A self-commitment on obligatory sustainable development criteria (e.g. the Gold Standard) seems possible as no international agreement is needed.

However, this solution with no involvement of non-annex-I countries in the decision-making process would undermine the principles of the international climate regime.

Although a number of different proposals on modified international regulations concerning sustainable development exist, the current development in post-Kyoto negotiations suggest that the second objective of the current CDM will play a minor role in future. The current development in the Chinese CDM and biogas market exemplifies a huge potential of CDM to contribute to a countries' sustainable development while main obstacles could be solved through a modified international framework.

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Annex I: List of interviewed experts

Name	Company/ Organization
Dilger, Martin	UPM Oasis Power Technology Beijing Ltd.
Gu Qing	Deqingyuan Egg, Beijing
Mr. Han	TÜV NORD (Hangzhou) Co. Ltd.
Hünteler, Henning	UPM Oasis Power Technology Beijing Ltd.
Lieberg, Karla	Climatefocus, Beijing
Mang, Heinz-Peter	Centre for Sustainable Environmental Sanitation/ University of Science and Technology Beijing
Schmidt, Claus	Ecolutions GmbH, Hangzhou
Wan Peng	Ecolutions GmbH, Beijing
Wang Haoping	Research Centre for International Environmental Policy/ Tsinghua University, Beijing
Wang, Leon	Gold Standard Foundation, Beijing
Winter, Stefan	Environmental Science Research and Design Institute of Zhejiang Province, Hangzhou

Annex II: Details on the questionnaire

In the course of the study a questionnaire was sent to 132 experts who are working in the field of CDM and biogas in China. 32 persons answered the twelve questions which were partly multiple-choice. Following details about the participants were collected: