Reduced Greenhouse Gases Emission and Improved Governance in China's National Biogas-Household Program

- Case Study of Datong Municipality, Shanxi Province

Jia, Xiaodong

Urban Management Studies
University of Technology, Berlin

Reduced Greenhouse Gas Emission and Improved Governance in China's National Biogas-Household Program

\- A Case Study of Datong Municipality, Shanxi Province -

Jia, Xiaodong
Berlin

12th of February 2009

Submitted in partial fulfilment of the requirements for the ‚Degree of Master of Science' at the University of Technology, Berlin

Statement of authenticity of material

This thesis contains no material which has been accepted for the award of any other degree or diploma in any institution and to the best of my knowledge and belief, the research contains no material previously published or written by another person, except where due reference has been made in the text of the thesis.

Signed

Jia,Xiaodong

Berlin, February 12th 2009

Contents

Preface

In the last five months, my world consisted of my internship and the work on this thesis. It was a busy and fruitful, boring and colourful season. I appreciated to spend my life in this way, which guides me further in future.

Although there is a really long list with names of the people who had helped me, I still try my best to indicate it, because I can't finish the thesis in absence of their help. I would like to thank my supervisor Prof. Dr. Johannes Kuechler. His powerful supervision and careful correction are the guarantee of a high-quality thesis. Mrs. Dr. Vera Susanne Rotter gave me lots of positive suggestions in the field of energy and emissions. Mrs. Dr. Bettina Hamann, our program coordinator, dedicates herself to the program. Thanks for all she did for me and for the master program.

Furthermore, I would like to thank the GreenStream Network for the internship and my job in future. Ms. Laura Lahti, Mr. Christian Saul and Mr. Norbert Heidelmann impressed me deeply by their professional performance in the field of Clean Development Mechanism (CDM) and renewable energy. Their help strongly supported my internship and the thesis, and my whole career.

Last but not least, I am deeply obliged to my parents, whoes strong support made the local interviews possible. Mrs. Wang, Xiuqin and Mr. Huo, Rushan, working in the local government of Datong, provided plentiful information about the Biogas-household program. Ms. Tian Ruimiao and Mr. Li Jun were excellent information transporters between me and my information sources. My warmest thanks to all of them.

"Education is a progressive discovery of our ignorance."

- Will Duran (1885-1981), American historian-

I am just on the way!

Jia, Xiaodong

Abbreviations

AMS	Approved Methodology for Small Scale CDM Project
BHP	Biogas-household Program
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CH_4	Methane
CO_2e	CO_2equivalent
EB	Executive Board
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GWP	Global Warming Potential
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
LPG	Liquid Petroleum Gas
M.A.	Minister of Agriculture of China
NCV	Net Calorie Value
NDRC	National Development and Reform Commission
NGO	Non-governmental Organization
OECD	Organization for Economic Co-operation and Development
PPP	Public-Private Partnership
P.R.C.	People’s Republic of China
pCDM	Programmatic CDM
WHO	World Health Organization
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UNESA	United Nations, Department of Economic and Social Affairs

Glossary

Baseline Emission	基准排放量
Biogas-household Program	新农村沼气工程
Biomass Stove	生物质炉
CDM	清洁发展机制
Climate Change	气候变化
Cun	村
Datong Municipality	大同市
Datong Xian	大同县
GHG Emission Reduction	温室气体减排量
Governance	政府管理
Greenhouse Effect	温室效应
Greenhouse Gas	温室气体
Individual Biogas Digester	户用沼气池
Kyoto Protocol	京都议定书
Large-scale Biogas Plant	大型沼气项目
National Development and Reform Commission	国家发展与改革委员会
National action plan against Climate Change of China	中国应对气候变化国家方案
New Rural in China	新农村建设
Policies and Actions for Addressing Climate Change	中国应对气候变化的政策与行动
Project Emission	项目排放量
Shanxi Province	山西省
Service Station	技术服务站
Xian	县
Xiang	乡

Abstract

Since 2001, the Ministry of Agriculture of China is implementing the national Biogas-household Program (BHP), with the aim to save energy, protect the environment and improve the life quality of farmers. In the first period (2001-2005), the Central Government invested approximately EUR 353,27 mil[1], benefiting 3,57 mil households and 120 biogas plants on large or medium livestock farms. In the second phase (2006-2010), the program is implemented on a wider scale and with national budget of EUR 13,17 billion. The target for 2010 is that there will be 4.700 large-scale biogas installations, attached to almost 40% of China's large livestock farms. Additional to that, there will be 41,18 mil individual bio-digesters, operated by 17,5% of the rural families in China.

The program is expected to have a great positive influence on the reduction of greenhouse gas (GHG) emissions. At the same time, it creates huge ecological and economic benefits which have already been studied in detail. However the GHG emission reduction effect of the program has not yet been estimated and evaluated systematically. This thesis aims determine this positive effect, taking Datong Municipality as a case study.

In accordance with methodologies approved by United Nations Framework Convention on Climate Change (UNFCCC) for different GHG emissions sources and data collected by the author, GHG emission reduction by the BHP in Datong Municipality was determined to be approximately 270,000 tCO_2 equivalent in 2007. The emission reduction consists of three categories: large scale biogas projects, improved-efficiency biomass stoves and individual biogas digesters. The amount of the GHG reduction in 2010 is expected to be 1,041 mil tCO_2e. It equals the GHG emission of 2 fossil fuel power stations working one year with each capacity of 60 MW. It also equals the GHG emission by the combustion of 0,525 mil tones of brown coal briquettes. It is also equivalent to the annual carbon-sink capacity of 236 km^2 of eucalyptus plantation.

Notable is that the decentralized GHG emission control measures could make a great positive influence on the environment in rural area.

[1] Exchange Rate: 10 Renminbi = 1 EURO in 2007

In this thesis, governance is defined as the policy-making and public management performed by governments in China. As a completely publicly initiated program, governments on the various administrative levels play a crucial role in its implementation. More than half of total costs of these biogas digesters and other clean end-use technologies are financed by public subsidies. Also the technical support and services are mainly provided by government institutions. Thus learning about the attitude of biogas users towards the governance of public institutions is a major aim of this study. Altogether 69 households in the rural district of Datong Xian were interviewed. Correlation analysis reveals that the biogas production capacity of biogas digesters is the main factor to decide satisfaction degree. The findings of the survey highlight that, with a public subsidy covering 50% of the total cost of individual biogas digester, governance would be the most cost-efficient. Local government could use the funds saved from this decrease of subsidies for the improvement of the technical and extension service system of the BHP. Besides, an improved and extended private-public partnership is suggested to be introduced into the governance structure, including the involvement of college students, environmental NGOs and self-help team among the farmers. Finally, we call for more endeavours on the cognitive enhancement about the climate change.

Low-carbon society needs a long process to build, but if we do not start now, it would never come.

Key Words: Biogas-household Program (BHP), Greenhouse Gas (GHG) Emission Reduction, Biogas, Governance, Cost-efficiency, Rural Development of China, Datong, Datong Xian

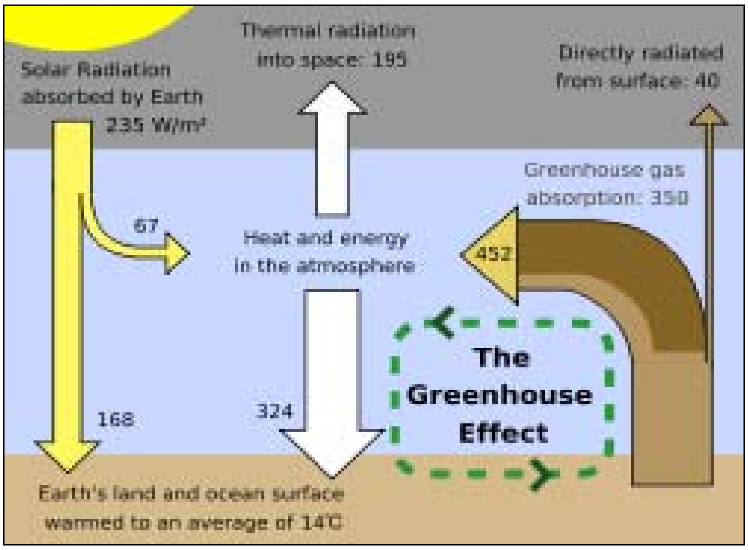
1 Introduction

This chapter will provide some background information about the global climate change, GHG emissions as well as the biogas produce.

1.1 The Greenhouse Effect and Global Climate Change

As the Intergovernmental Panel on Climate Change (IPCC) published the report “Climate Change 2007” (IPCC 2007) the “greenhouse effect” and the “global climate change” became two of the most popular key words in the world. What is the greenhouse effect and what is meant by climate change? How do they happen?
The greenhouse effect was discovered by Joseph Fourier in 1824 and first investigated quantitatively by Svante Arrhenius in 1896 (Held and Soden, 2000, p441). The natural greenhouse effect means the short-wave energy from the sun is absorbed at the earth’s surface and reradiated in the form of infrared Chart (long-wave) radiation. The greenhouse gas (some of low concentrate gases in atmospheric notably CO_2, CH_4, N_xO, CO, etc.) absorb and emit long-wave radiation. The increase in the atmospheric concentration of GHG leads to an incremental absorption and emission of long-wave radiation (see chart 1). All of them would result in a warming of the lower atmosphere and the surface of earth. This effect is referred as “greenhouse effect”. Human beings and most other living creatures can not survive without Natural greenhouse effect. The greenhouse effect keeps the temperature of biosphere stable and filters some harmful radiations and hence protects the ecological system.

Chart 1 Heat flow on the world surface



Source: Rohde, 2003

Due to anthropological influence the greenhouse effect has been enhanced leading to exacerbated climate change. Some of the effects of climate change are clear, others still uncertain. The climate change includes temperature change in global scale, sea level rise, precipitation change and the increase of extreme weather events (IPCC, 2008, p30).

Eleven of the twelve years (1995-2006) rank among the twelve warmest years in the instrumental record keeping of the global surface temperature (since 1850). The 100-year (1906-2005) linear trend of 0.74 °C (varying from 0.56 to 0.92°C) is larger than the corresponding trend of 0.6 °C (from 0.4 to 0.8]°C (1901-2000). The linear warming trend for the 50 years (1956-2005) of 0.13 [0.10 to 0.16]°C per decade is nearly twice that for the 100 years from 1906 to 2005. The temperature increase presented here is an average for the globe and it is greater at higher northern latitudes. Average Arctic temperatures have increased at almost twice the global average rate in the past 100 years. Land regions have warmed faster than the oceans. (IPCC 2008, p30).

Global average sea level rose at an average rate of 1.8 mm (from 1.3 to 2.3 mm) per year over the period from1961 to 2003 and at an average rate of about 3.1 mm per year (from 2.4 to 3.8 mm per year) from 1993 to 2003. Since 1993 thermal expansion of the oceans has contributed about 57% of the sum of the estimated individual contributions to the sea level rise, with decreases in glaciers and ice caps contributing about 28% and losses from the polar ice sheets contributing the remainder. (IPCC, 2008, p30).

Over the last century, also the precipitation trend has changed significantly in North America and Russia (Groisman and Easterling, 1994, p109-113), the Asia and Africa (Petit-Maire, 1994, p3-15) as well as Central Europe (Lapin, 1994, p162-170). These areas are being attacked by drought, flooding, water crisis that are caused by the change of precipitation in the global scale. Some extreme weather events have changed in frequency and/or intensity over the last 50 years. Since 1970, the tropical cyclones have increased obviously in intensity. Furthermore heat waves have affected human beings around the world. El-Nino effect and Tidal Wave have became also more common and in larger scale (IPCC 2008, p30).

China is suffering as heavily as other countries from the global climate change. From 1908 to 2007, the average surface temperature has increased 1.1 °C. The year 2007 was the warmest year in the instrumental record keeping in China (since 1951). In the last 30 years, the sea level of China’s offing rose 90 mm. Furthermore the precipitation has changed significantly in China. Flooding takes place more frequently in south of China, but the middle part of China is always suffered by the heat wave and drought. (NDRC, 2008, p2).

1.2 Greenhouse Gases Emission

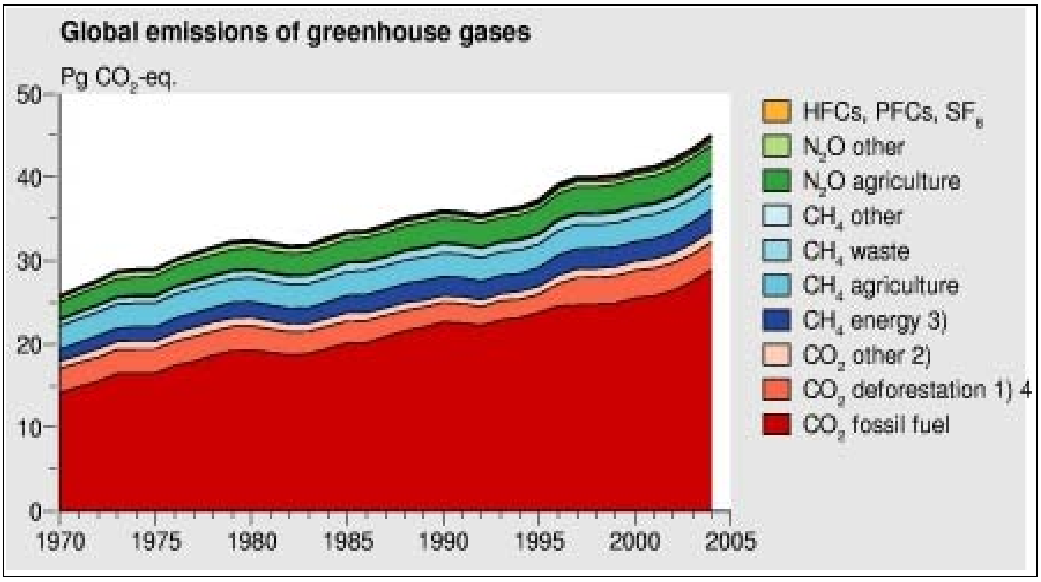
The driver of greenhouse effect and global climate change mainly is the GHG emission. Groups of scientists (IPCC as the leader) are working on the calculation of GHG emission to show us how the GHG discharge is getting stronger and stronger, and what the change is year by year. The sources of GHG are both natural and human related. Since the industrialization, human activities emitted more and more GHG with an increase of 70% between 1970 and 2004 (IPCC, 2008, p36) and an increase of 25% between 1990 and 2004 (Netherlands Environmental Assessment Agency, 2006), all of which destroy the pervious carbon balance heavily (see Chart 2).

The amounts of emission between different kinds of GHG and their sources are obviously different. Carbon dioxide (CO_2) is responsible for about 60% of the greenhouse effect to the increased atmospheric concentrations of GHG, when considered over 100 years of emission. (International Energy Agency, 1991, p15). The annual emission has grown between 1970 and 2004 by about 80% from 21 to 38 GT, and represented 77% of total anthropogenic GHG emissions in 2004 (IPCC, 2008, p36).

Methane (CH_4)'s concentration in the atmosphere has been growing at 1% per year during recent years. Methane could absorb infrared radiation much more strongly (20-30 times) than CO_2. The global atmospheric concentration of CH_4 has increased from a pre-industrial value of about 715ppb to 1732ppb in the early 1990s, and was 1774ppb in 2005. (IEA, 1991, p17).

The other pollutants, NO_x and CO, do not directly influent greenhouse effect, but act indirectly by affecting the concentrations of other greenhouse gases in the atmosphere (International Energy Agency, 1991, p18-20).

Chart 2 Global emissions of GHG



Source: Netherlands Environmental Assessment Agency, 2006

1.3 Current Situation of the GHG Emissions in China

In 2007, China contributed two thirds of the global greenhouse gases emission increase. Resulting from its strong economic growth, China is consuming a growing amount of coal, nature gas and oil. CO_2 emissions from fossil fuel combustion in China increased by 7.6% in 2007, USA by 1.8% and EU-15 by 1.9%, compared to 2006. China topped the list of CO_2 emitting countries in 2007, having about a quarter share in global CO_2 emissions (24%), followed by the USA (21%), the EU-15 (12%), India (8%) and the Russian Federation (6%). (Netherlands Environmental Assessment Agency, 2008).

Considering that population size and levels of economic development differ considerably between countries, the emissions expressed per person show a largely different ranking. CO_2 emissions per person from the USA, Russia, EU-15, China and India are presently about 19.4, 11.8, 8.6, 5.1 and 1.8 metric ton CO_2, respectively in 2007(Netherlands Environmental Assessment Agency, 2008).

One of the reasons for the rapid increase of China’s greenhouse gases emissions results from its role as “the world’s factory”. In 2006, the amount of the embodied greenhouse gases emission from China's export was around 1,846 mil tCO_2e while the amount from import was around 800 mil tons of CO_2e. In total, the net export exceeded 1,000 mil tCO_2e (WWF China, 2007). The transfer of GHG emissions is described as “”Carbon Ship”, what reveals that a large share of China’s rising emissions is due to the dependence of the rest of the world on exports from China (New Economic Foundation, 2007, p10).

Although the per capita GHG emissions are still rather low and a big part of it is used to exports, China does have a huge pressure and responsibility to control her GHG emissions.

In May.30, 2007, "National action plan against climate change(中国应对气候变化国家方案)" was issued by Central government of China. The plan was submitted by National Development and Reform Commission (NDRC), who is China's highest climate policy-making body. In this plan (NDRC, 2007, p27-29)[2], overall targets for 2010 are given:

- "Reduction of the GHG emission (via decrease of the energy consumption per GNP by 20% below the level of 2005, increase of the fraction of renewable energy in the total energy consumption to 10%; reuse of 1 mil m³ coalmine methane, and control of N_2O emissions at the level of 2005, etc.)
- Improvement of the ability to response Climate change
- Enhancement of the research and technology referring Climate change
- Enhancement of public awareness and governance about Climate change and environmental protection"

A notable point is that there is not mandatory request to reduce GHG emission.

The latest national guiding document is the white paper of China's Policies and Actions for Addressing Climate Change(中国应对气候变化的政策与行动), issued by central government in Oct. 29 2008 (NDRC, 2008, p27-29).

1.4 Biogas Production: State of the Art

1.4.1 Biogas Production: Basics

Biogas is a kind of gas produced by the biological breakdown of organic matter in absence of oxygen. Biogas production is the process of anaerobic bacteria transforming manure and other organic material into CH_4, H_2S, NH_3, CO_2, etc. Table 1 indicates the composition of biogas.

$$CcHhOoNnSs + H_2O \rightarrow CH_4 + CO2 + NH_3 + H_2S$$

(Deublein, Steinhauser, 2008, p13)

The process can be divided into three steps (Chart 3).

---

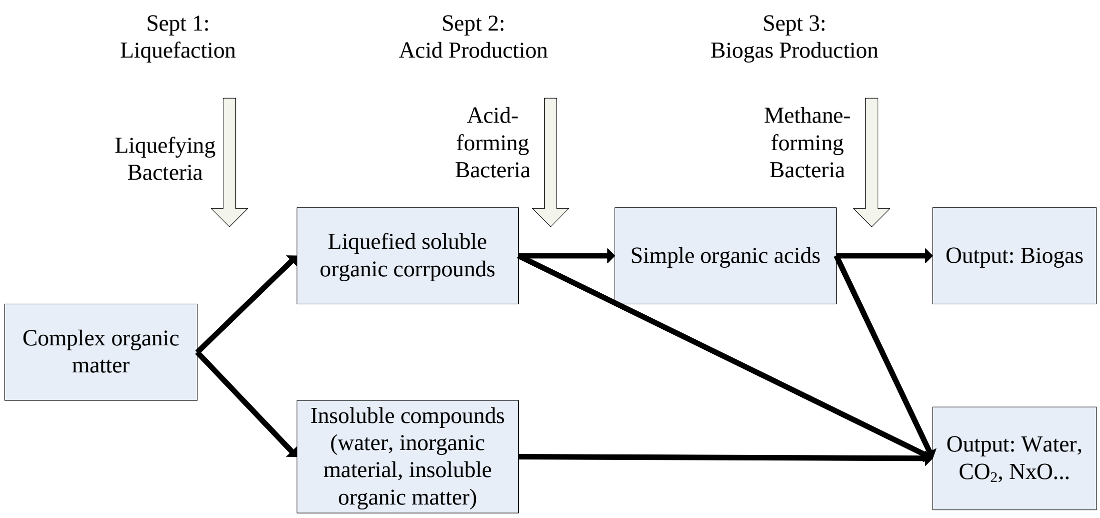
[2] Only a Chinese version of this document is available. The targets are translated by the author.

Table 1 Typical composition of biogas

Matter	***%***
Methane	50-75
Carbon dioxide	25-50
Nitrogen	0-10
Hydrogen	0-1
Hydrogen sulfide	0-3
Oxygen	0-2

Source: kolumbus.fi, 2007, modified by the author

Chart 3 Three steps of biogas production



Design: Jia, Xiaodong

In the **liquefaction step**, liquefying bacteria convert insoluble, complex materials such as carbohydrates, fats and proteins into soluble substances. The rest parts, i.e. water, inorganic matter, are discharged out of the system.

In the **Acid Production step**, most of the liquefied soluble compounds are converted to simple organic acids. Within an anaerobic environment, acid-forming bacteria survive via the energy from the decomposition of the compounds, while acids and other materials are synthesized.

The **Biogas Production step** almost happens in the same time of step 2. These simple organic acids are intermediate products, which would degenerate into CH_4, H_2O and CO_2 soon. Besides, these acids can provide all these bacteria an acidic and anaerobic environment.

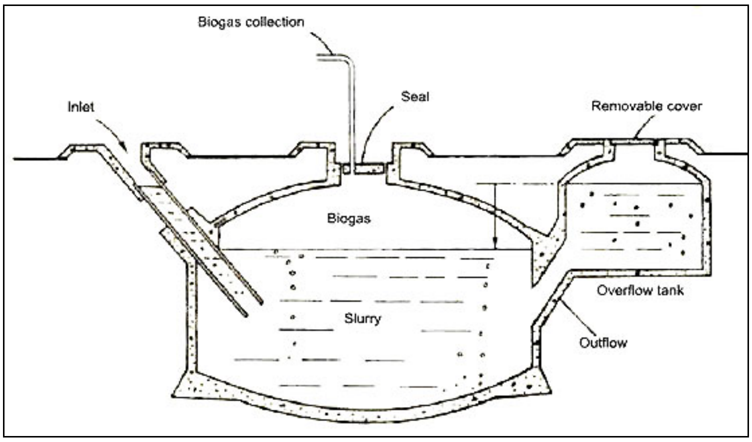
1.4.2 The Structure of a Biogas Digester

There is evidence that biogas was used to heat bath water in Assyria during 10 BC; and the first digestion plant to produce biogas from wastes was built in a leper colony in Bombay, India in 1859. (Li & Ho, 2000, p34).

Nowadays, biogas is a full-fledged technology and could be applied in different situations and scales. In China, serial of construction codes and regulations have been launched by Ministry of Agriculture (M.A.China, 1987, 2002). Some key difficulties are being researched, e.g. performance in cold weather (Gao, et al. 2007, p35-36), high-efficient bacteria that would short the production process (Zhou, et al., 2007, p761-764).

The working principle of a simple biogas digester is described in Chart 4: as more and more biogas is produced, the water level in slurry would decline and in overflow tank would ascend. The slurry is the reaction container of biogas production. Its top space works as the storage tank for biogas. Whilst the biogas is flared, the air pressure in slurry will decrease and the water will be extracted from the overflow tank. The function of the overflow tank is to adjust and moderate the pressure balance.

Chart 4 Basic Form of Biogas Digester



Source: Li & Ho, 2000, p34

1.4.3 Status of the Biogas Use World Wide

In the 1940ies, Germany started to use agricultural products to produce biogas. In 1970s, the demand for biogas increased, driven by the oil crisis. In 1990s, biogas became more and more popular in Europe for two reasons: the profitability of using power derived of biogas and the recycling management based on the principle of waste avoidance. (Deublein and Steinhauser, 2008, p30).

The USA is the biggest electricity generator via biogas with 4.9 TWh in 2001. The United Kingdom is the biggest one in Europe with 2.9 TWh in 2001. Germany produced nearly 2.0 TWh in 2001 (IEA, 2004, p70). As the development of technologies, mechanical-biological treatment, dry-anaerobic digester, central computer control system and the electricity generator with biogas turbine are applied in biogas plants more and more. Nowadays, even, agriculture residues, biomass, organic domestic waste can be applied in developing countries for biogas production, with positive impacts on the environment.

In the developing countries, the biogas production is limited by the lack of suitable technologies and financial ability. So the capacity and efficiency is smaller and lower. Most of biogas plants or digesters consume manure, rather than other organic waste. However, the biogas is still considered as an excellent solution of energy crisis and manure pollution. Since 1970s, Asian countries such as India, The Philippines, Thailand, Indonesia, etc, have solved the technical problems, e.g. carbon/nitrogen ratio, operation in winter[3] (Barnett et al, 1978, p97-109). Nowadays, Asian countries are paying more attention to the biogas issue as an important alternative renewable energy source. Nepal has 145000 biogas plants for a population of about 20 mil financed by the World Bank. In Vietnam, 18,000 biogas digesters were built by the year 2005 and another 150,000 would be constructed by 2010. As the two biggest developing counties, China and India have bigger programs. India is running 2.5 mil biogas digesters. Depending on the substances, the plants generate 3-10 m^3 biogas per day, enough to feed an common family in rural area (Deublein, Steinhauser, 2008, p35).

[3] Till now, the performance of biogas plant in cold weather is still a difficulty in world-wide, especially for individual biogas digesters. In large-scale biogas plants, a heating system is always designed to keep a stable temperature inside the plant via flaring some biogas.

2 Biogas-Household Program in Datong

2.1 National Setting

2.1.1 History of Biogas Use in China

China is one of the pioneering countries for the use of biogas. Three historical stages of biogas application could be distinguished:

Introductory Stage – Early 20th century

By the end of the nineteenth century, simple biogas digesters had appeared in the coastal areas of southern China. In 1920, Luo, Guorui invented and built an 8 m^3 biogas tank and established the Santou Guorui Biogas Co.,Ltd. In 1935, Chinese Guorui Biogas Digester Practical Lecture Notes were published, representing the first monograph on biogas in China and also in the world. (Deublein, Steinhauser, 2008, p13)

First nation-wide introduction Stage – 1970ies

The second stage of biogas use occurred between 1970 and 1990, when the Chinese government considered biogas application as an effective and rational use of natural resources in rural areas. Around 1970ies, about 6 mil biogas plants were set up in China for energy, environmental protection and improvement in hygiene (Deublein, Steinhauser, 2008, p30; Li, 2008, p2). A considerable amount of international researches on the program reflected the world-wide attention given to these Chinese efforts (Van Buren, 1976; McGarry, Stainforth, 1978; GTZ, 1981). The Chinese biogas technology was so successful in that period that the “China dome” bio-reactor became a formal construction standard and a model for the use of biogas in developing countries.

Mass promulgation of improved technologies – 1990ies until present

The third wave started in 1990ies as a part of eighth national five-year plan with the application of the latest research results (Deublein, Steinhauser, 2008, p35; Li, 2008, p3). New concepts have also been developed in this period, e.g. “A pit with three reconstructions", "4 in 1" (livestock-biogas-vegetable-modern greenhouse) and "Livestock-Biogas-Fruits". By the end of 2000, there were 9.8 mil household digesters throughout China and 55% of them conducted integrated utilization (Li, 2008, p3). In the 10^{th} national five-year plan, the BHP was implemented in the national scale.

Table 2 Comparison of the second and third stage of biogas use in China

	1970-1990	*1992-2005*
Background	The pressure of energy-crisis and fast development of economy and society	The pressure of environment, improvement of framer's live quality and energy-crisis
Number of biogas digesters	40 mil (The aim of the 1970s)	9.12 mil
Status	30%-50% had serious problems, due to low standard of maintenance.	Work well
Technology	Too much physical work involved; low efficiency of biogas production	Automatic or semi-automatic Inlet and outlet of the raw material and slurry; higher efficiency
Scale of biogas digester	Small size, for farmer's daily use (kitchen energy supply)	Large size: for electricity and heat generation, operating in livestock farms
Role of Government	Initiator and promulgator of the new technology	One of the stakeholders who provides technology support and parts of finance

Sources: GTZ, 1981; P.R.Ch, Ministry of Agriculture, 2006

2.1.2 The National Biogas-household Program

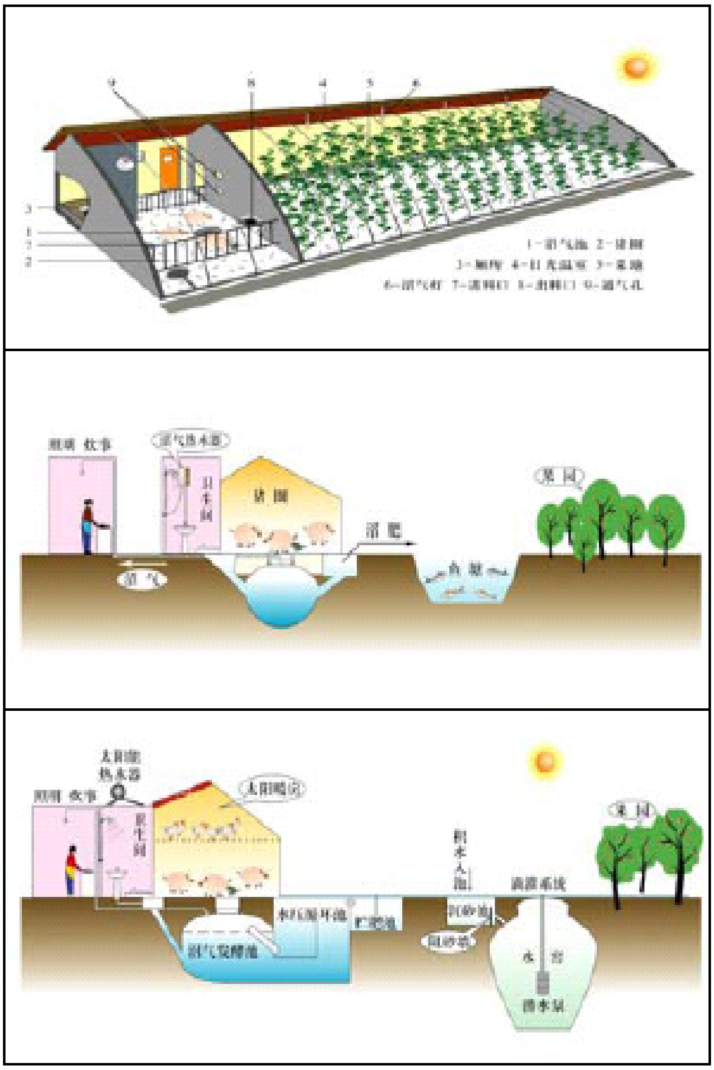
Since 2000, Ministry of Agriculture began to implement the BHP in rural areas. From 2001 to 2005, the central government invested EUR 353.27 mil, benefiting 3.57 mil households and 120 biogas plants on large or medium animal husbandry farms (P.R.C., M.A., 2006, p36).

The BHP integrates the biogas digester, clean kitchen, improved toilet, high-tech livestock farm and modern agriculture. The Ministry recommends concepts, suitable for different climatic conditions (see chart 5). In northern China, the key recommended concept is the "livestock-biogas digester-vegetable-modern greenhouse" model. In southern China, the key concept is the "Livestock-Biogas-Fruits" model.

The construction cost of Biogas digester is 300-350 EUR, 80-120 EUR of which would be subsidized by the Fund of National BHP (P.R.C., M.A., 2006, p30).

In the second phase (2006-2010) of the BHP, the central government invests EUR 13.17 billion for up to 4000 large scale biogas projects and 23.18 mil individual biogas digesters. Until 2010, there will be 4700 large scale biogas projects in operation covering 39% of all large livestock farms. Besides, there will be 41.18 mil individual biogas digesters, supporting approx. 17% of all rural households in China.

Chart 5 Models of Biogas-household program in China



Source: Li, 2007, p3

2.1.3 The Economic, Ecologic and Social Values of BHP

The BHP helps farmers to save energy, i.e. coal and fuel wood. One digester of 8 m^3 could help a three-member family to save ca. 600 kg coal annually (P.R.C., M.A., 2006, p8). Besides, lots of residents cook or heat with fuel wood, the poorer the worse. The survey data suggest that an average household could save 1.5-2 t of fuel wood annually by the use of biogas.

The BHP would also improve the land quality and reduce the costs of agriculture production. Farmers could fertilize with the liquid and rest of biomass instead of 20% of fertilizer and pesticides. At the same time, the agriculture also is stimulated by the organic liquid fertilizer and compost. An investigation in Southern China states, that the production of rice and wheat would increase 10%-12.5% with the use of bio-sludge (Van Buren, 1976, p16).

The program is expected to control the non-point pollution on air and water body in rural area. The low combustion efficiency of the traditional stove causes not only the waste of fuel, but also brings lots of air pollutant, e.g. CO, N_2O, etc. The methane emission from the disposal of manure and domestic waste is a harmful gas whose global warming potential (GWP) is 21 times of CO_2. In rural area of China, the lack of waste disposal and sanitation leads to heavy water pollution. The livestock manure and human excreta so far have not been treated safely. Manure, excreta and leaches from solid waste indiscriminately discharged on land do not only bring pollution to water body and underground water, but may also be the cause for a large variety of infectious diseases. The worse issue is that the rural area is always located in the upstream of the urban area.

The BHP is expected to greatly reduce the occurrence of mosquitoes and flies, and reduce alimentary canal diseases (P.R.C., M.A., 2006, p10). During the anaerobic process, most of pathogens and germs would be killed. The reduction of the parasite eggs in the processed fecal liquid is up to 98% (McGarry, Stainforth, 1978, p71). Besides, the program will enhance better kitchens with clean biogas and a more efficient stove, thus greatly improve the life quality of farmers.

In addition, BHP can improve the women's life quality in rural area, because they are normally in charge of cooking in poor and smoky kitchens with low-efficiency stoves. However, the initiative of BHP is to solve the bottleneck of energy supply in rural areas which is directly relevant to the farmers' life quality. One household-use digester can save some 0.5T coal annually which costs about 30 EUR[4]. Further economic benefits are the output increase of agriculture and the expense saving resulting from the use of bio-sludge as a substitute of synthetic fertilizer. It is estimated that 50 EUR could be saved directly by BHP for each family[5]. Moreover, one medium biogas plant can is expected to produce annually 550,000 m^3 biogas equalling up to 850 tones coals. These two parts could save 28.2 mil tones of coals each year when the 2006-2010 national BHP finishes (P.R.C., M.A., 2006, p8).

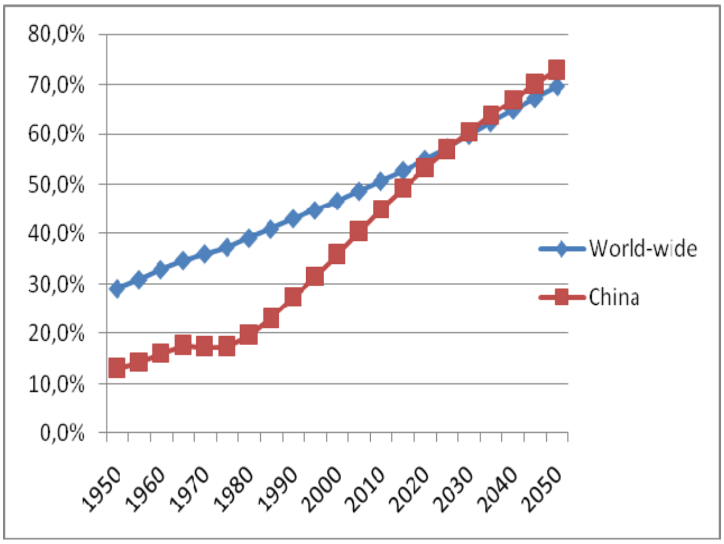
The program plays a crucial role in the development of urban and rural of China. Facing the fast urbanization and immigration of China (see chart 6), a well inner-

[4] The price of coal is changing in a range of 30-80 EUR /T in China.

[5] The use of biogas depends on the lifestyle of the habitants and local geographic conditions. Taking Datong Xian as example, because of its cool weather and abundance of local coal resources, farmers use comparatively more coal per capital than other area. Thus, the introduction of biogas use could also save more coal.

function relationship between urban and rural is expected by government. Mao Zhedong, the first president of P.R.China, had summarised top-10 relationships in China. The relationship between urban and rural is one of them.

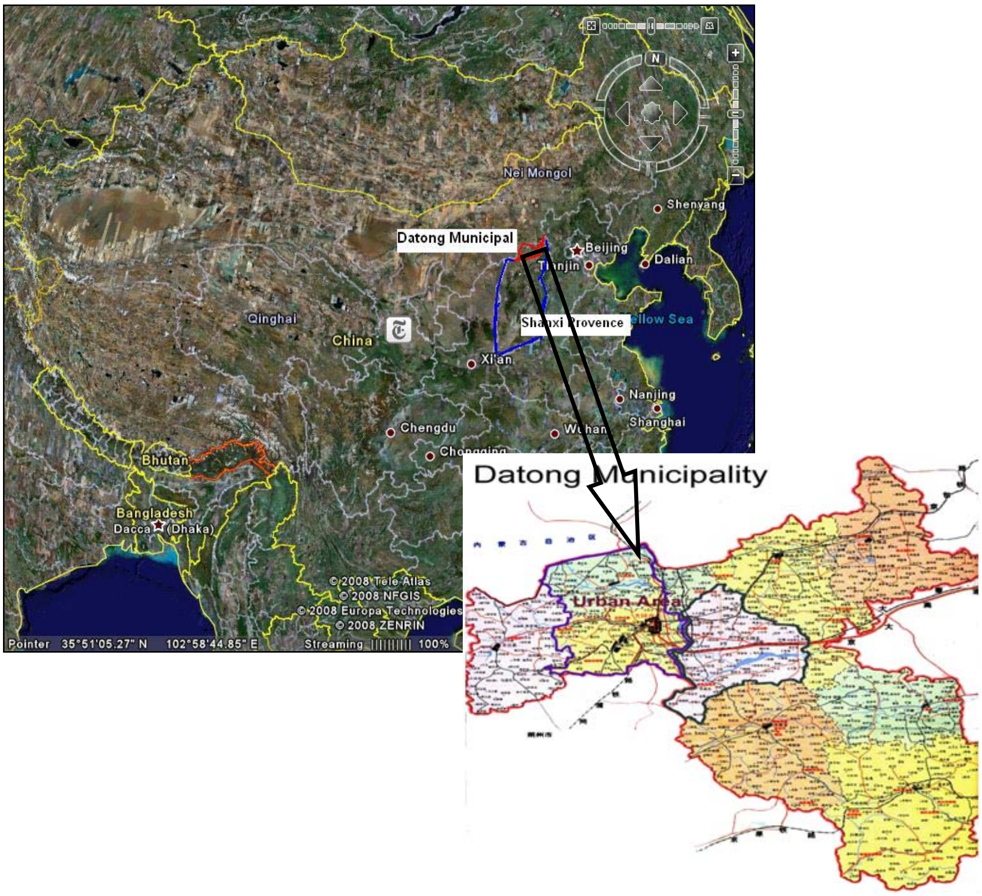
Chart 6 Percentage of urban population in World-wide and China (1950-2050)



Data Source: UNESA, World Urbanization Prospect Database, 2007

2.2 Profile of Datong Municipality[6]

Picture 1 The location of Datong within the Chinese Territory



Source: Google earth, 2008; Sino Maps Press, 2000

Datong is one of the most important industrial centers in northern China and the second biggest Municipality in Shanxi Province, located in 112° 34' -114° 33' W and 39° 03' -40° 44' N with total area of 14,176km^2 and an average elevation of 1090m (Wikipedia, 2008). It's location is presented in picture 1. The mean annual temperature of Datong Municipality is 5.5 °C and its mean annual precipitation totals 400 mm, mainly falling in July, August and September. Datong has four urban sub-districts and seven (rural) counties (see location in picture 1 and details in table 3).

[6] Whenever Datong appears in the paper, it's the abbreviation of Datong Municipality. Datong Xian is one of the administrative subunits of Datong Municipality.

Table 3 Datong Municipality: Administrative Sub-Units

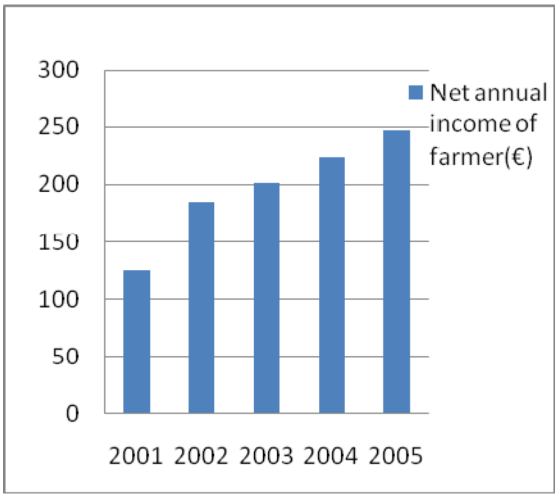
Name	*Area (km²)*	*Approx. Population*
Central Urban District (城区) *The location of local government of Datong	46	580,000
Mining District (矿区)	62	440,000
District Nanjiao (南郊区)	966	280,000
District Xinrong (新荣区)	1,006	110,000
Yanggao Xian (阳高县)	1,678	290,000
Tianzhen Xian (天镇县)	1,635	210,000
Guangling Xian (广灵县)	1,283	180,000
Lingqiu Xian (灵丘县)	2,720	230,000
Hunyan Xian (浑源县)	1,965	350,000
Zuoyun Xian (左云县)	1,314	140,000
Datong Xian (大同县)	1,503	170,000

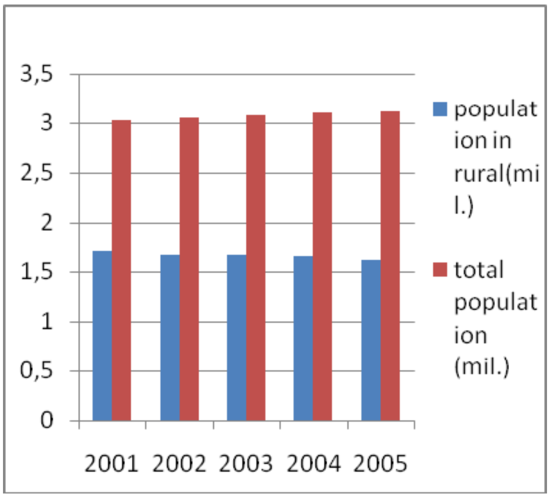
Source: Wikipedia, 2008; Datong Municipality's Bureau of Statistics, 2001-2005

Although Datong is highly industrialized due to its rich coal resources, more than half of its population is rural. The rather unfavourable land conditions (climate, fertility, water shortage) make the farmers' life poor. (See chart 7).

Chart 7 Datong Municipality

Rural per-Capita Income (l); Proportion of Rural-Urban Population (r)





Data source: Datong Municipality's Bureau of Statistics, 2001-2005

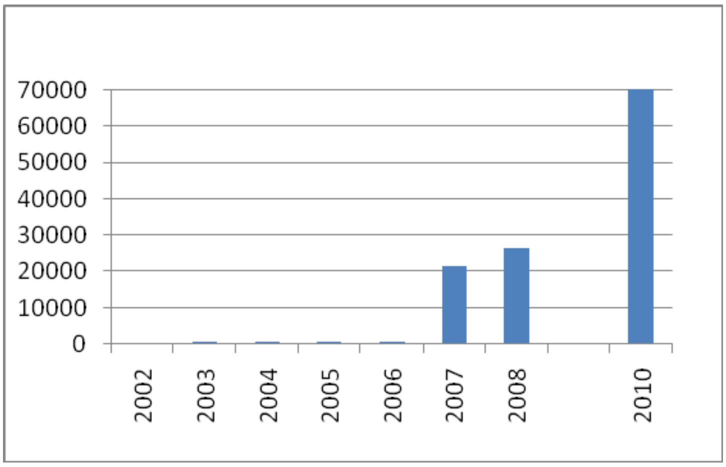
2.3 Biogas-Household Program in Datong

Since 2002, BHP is implemented in Datong. 250 household-use biogas digesters were built in Guangling Xian, as a demonstration project. The number did not change too much from 2002-2006. Since 2007, the municipal government decided to implement individual biogas use on a larger scale. In 2008, the program extends to three categories:

- 20,000 new household-use biogas digesters,
- 200 biomass efficiency-improved stoves,
- 2 large-scale biogas plants for animal farms.

The last two categories were the first to be applied in Datong. In the long-term action plan (2006-2010), there would be 70,000 household-use biogas digesters and 10 large-scale biogas digesters for animal farms till 2010 (Datong municipality's Bureau of Agriculture, 2007, p1). The change of biogas use in rural area is described in chart 8.

Chart 8 Datong: Rural households using Biogas Digesters



Data source: Datong Bureau of Agriculture, 2007

2.3.1 Forms of the Applications

As stated above, there are three categories of application in the BHP till 2008, i.e. Biogas plants, Biomass efficiency-improved stoves, and Individual biogas digesters. All of them will be described below:

Large-scale biogas plant

Till the end of 2007, two large-scale biogas plants were supported by BHP. One is located in Jiye Swine Farm Co., Ltd, and another one in Yubao Dairy Co., Ltd. Jiye Swine Farm raises 120,000 swine annually with a life time of 4.5 month. The biogas project will install a biogas turbine generator (see picture 2) with capacity of 950 kWh. Yubao Dairy Co., Ltd is one of the biggest local milk suppliers, with 2000 dairy cows. The electricity-supply capacity of this biogas project is 400 kWh. The Project Design Documents of them have been submitted in 2007. Hopefully, the construction could start at March, 2009. The biogas projects in these two companies will consume the animal manure and provide clean electricity generation as a substitute of the traditional coal-fire electricity generation. In absence of the program, these manures are disposed in open lagoons and release methane into atmosphere directly.

Picture 2 Datong: large biogas project

(left: biogas plant / right: biogas turbine generator)

Photos: Wang, Xiuqin[7]

Biomass efficiency-improved stoves

The biomass stoves (see picture 3) project is the latest demonstration project in 2007 under the framework of BHP. 200 households in Xietun, Beijingzao, of Datong

[7] Mrs. Wang, Xiuqin is the chef of Agriculture Monitoring Station of Datong and one of the members of Joint Team to supervise and enhance the BHP in Datong. These photos are taken when she inspected and visited the biogas-technology provider.

Xian(大同县倍加皂乡谢屯村) have been selected. Half of them are provided with improved biomass stoves for heating and cooking. The other half are provided with improved biomass stoves for cooking. Traditionally the crop residues are burnt untreated, which wastes biomass energy and releases polluted air into the rooms and into the atmosphere. The aim of this project is to reuse the biomass resources in a higher efficiency in order to save costs for fuel and reduce the burning of coal.

Picture 3 Improved efficiency biomass stoves

(left: Improved biomass stoves for heating and cooking/right: Improved biomass stoves for cooking)

Photos: Jia, Xiaodong

Household-use biogas digesters

Till the end of 2007, 21,362 household-use biogas digesters had been installed in Datong. 20,562 had been built in 2007 with a uniform standard (see picture 4). All are constructed underground with brick concrete having a daily capacity of 8 m^3 biogas. The raw materials for these biogas digesters mainly are animal manure.

Picture 4 Household-use biogas digesters

(left: buried biogas-digester / right: biogas stove)

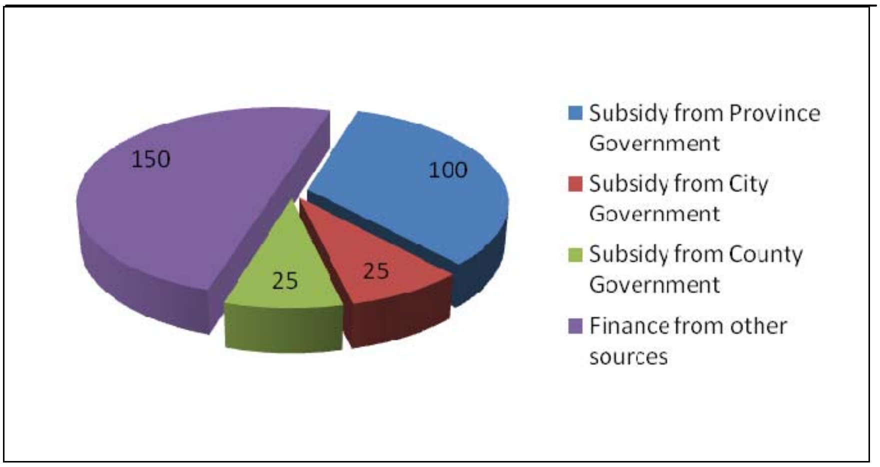
Photos: Jia, Xiaodong

2.3.2 Financing

All three categories of this program, 2 large biogas plants in livestock farms, 200 improved biomass stoves, and 21362 individual use biogas digesters, are implemented with financial subsidies and technical support. The biogas plant in Jiye Swine Farm receives subsidy of EUR100,000 (35% of overall costs). The biogas plant in Yubao Dairy Co., Ltd is financed with EUR40,000 (22% of total costs). 200 new biomass stoves are provided to farmers free of charge. The household-use digesters are the most important constituent of the BHP and get finance of EUR 6.051 mil totally from different levels of government.

Chart 9 describes the basic financial sources of a digester with costs of EUR 300: 33.3% come from the Shanxi provincial budget, 8.3% from the municipal budget of Datong. The financial support granted by the Xian level depends on the individual revenue situation and the attention given to biogas production. However, none gives less than 8,3% (EUR 25). Four of the 11 districts provide EUR 100 for each bio-digester owner, which means that in this case the farmer receives renewable energy free of charge. In the particular case of Datong Xian each household was only given a support of EUR25 (Datong municipality's Bureau of Agriculture, 2007, p6). Within Datong Xian further financial support was also granted from the Xiang budget. Also at this level, the support varies considerably, depending on the local economic situation. Some rich Xiangs and Cuns provide the other half of the cost, by supplying cement, bricks, or/and biogas stoves. Some poor Xiangs can't afford any extra expense.

Chart 9 Datong: Financial Sources for Digester (Unit: EUR)*



** Total cost of individual biogas digester is 300 EURO.

Data source: Datong Municipality's Bureau of Agriculture, 2007; Personal investigation

2.3.3 Technical Support Measures

Governments play a very crucial role in the implementation of the BHP It is not only the biggest financial supporter, but also provides all the technical services.

For technical support, a service network is just being installed in Datong. 2 independent service companies have registered successfully. 10 technical support stations located in every Xian and sub-district (except the Central Urban District)[8]. 54 service stations are scattered in different Villages. Till the end of 2007, 784 technicians obtained career licenses which are awarded by the national administration of agriculture.

Because of the limit of revenue, these technical support stations and service boxes are always lack of cars, computers and some necessary tools.

2.3.4 Monitoring and Evaluation

At the beginning of the program design, governments have considered about the monitoring and evaluation.

In the level of central government, monitoring and evaluation mainly focus on accountability and efficiency of the national fund. 10% of Xians applying the fund will be inspected on site randomly. A service hot-line is set, 0086-10-59191706. The relevant regulations about the award and punishment are also set. (P.R.C., Ministry of Agriculture, 1999, p8)

The local governments pay more attention on effectiveness and quality. “Shanxi Provence’s regulations about the acceptance of BHP activities” indicates that, the acceptance by Xiang’s governments should include the design material, subsidy expense, operation, biogas generation, and environmental impact assessment. 30% of the biogas users should be inspected on site randomly. the inspection will comply with a evaluation system, in which all the aspects of the BHP will be given a mark in the range of 1-5. (Shanxi’s Department of Agriculture, 2004, p1-4)

2.4 The Survey Sample: Datong Xian

As the survey sample, Datong Xian plays an important role in this thesis. The confirmation of all parameters used for the calculation of GHG emission reduction by individual biogas digesters was carried out and finished in Datong Xian by the author

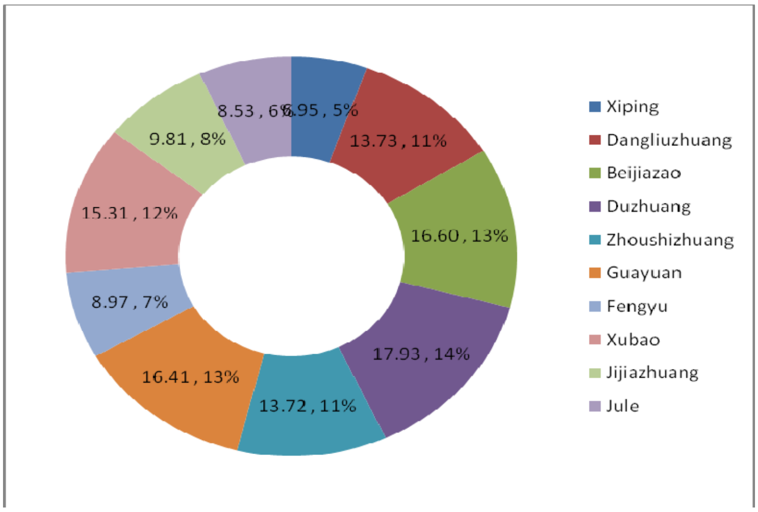
---

[8] District Cheng has been urbanized completely. There are no agriculture or farm activities.

and his team[9]. Beside, the survey about the user attitude towards the Biogas-household program is carried out in here too.

From the economic and social point of view, Datong Xian is eligible to represent the middle level among the 11 Xians and districts of Datong. It is a typical Xian in the northern China located in 130° 20' -113° 35' W and 39° 43' -40° 16' N with an area of 1,503 km^2. The mean annual temperature of Datong Xian is 6.4 °C and its mean annual precipitation totals 300-450 mm, mainly in July, August and September. The total population of Datong Xian is circa 170,000, 130,000 of which work in agriculture activities. Agriculture is the economic backbone of Datong Xian. However, because of the poor land qualities and difficult climatic situation, the net income per capita of farmer is only 313.5 EUR in 2007 (Local government of Datong Xian, 2008).

Chart 10 Datong Xian: 11 Xiang's GDP, 2007(Mil EUR)

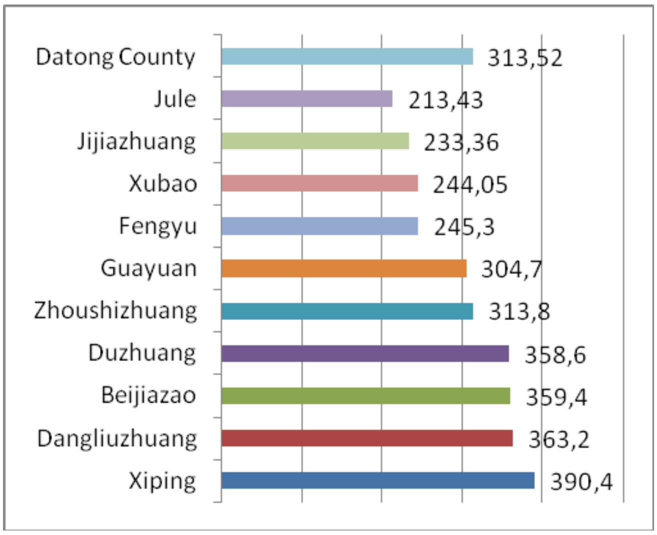


Data source: Local government of Datong Xian, 2008

Datong Xian has ten Xiangs which vary largely in terms of GDP and net income of farmers (see chart 10 and chart 11). The net income of farmers is the main indicator of the degree of wealth, which depends mainly on the given topographic and natural situation in each specific locality. The Xiang which are located closer to High-speed way/national motorway or closer to a river/reservoir normally have a better economic situation (see chart 12).

[9] The team members: Jia, Shiyuan, Liang, Shuzhen. The investigation got lots of help from Bureau of Agriculture of Datong Xian and local xiang governments..

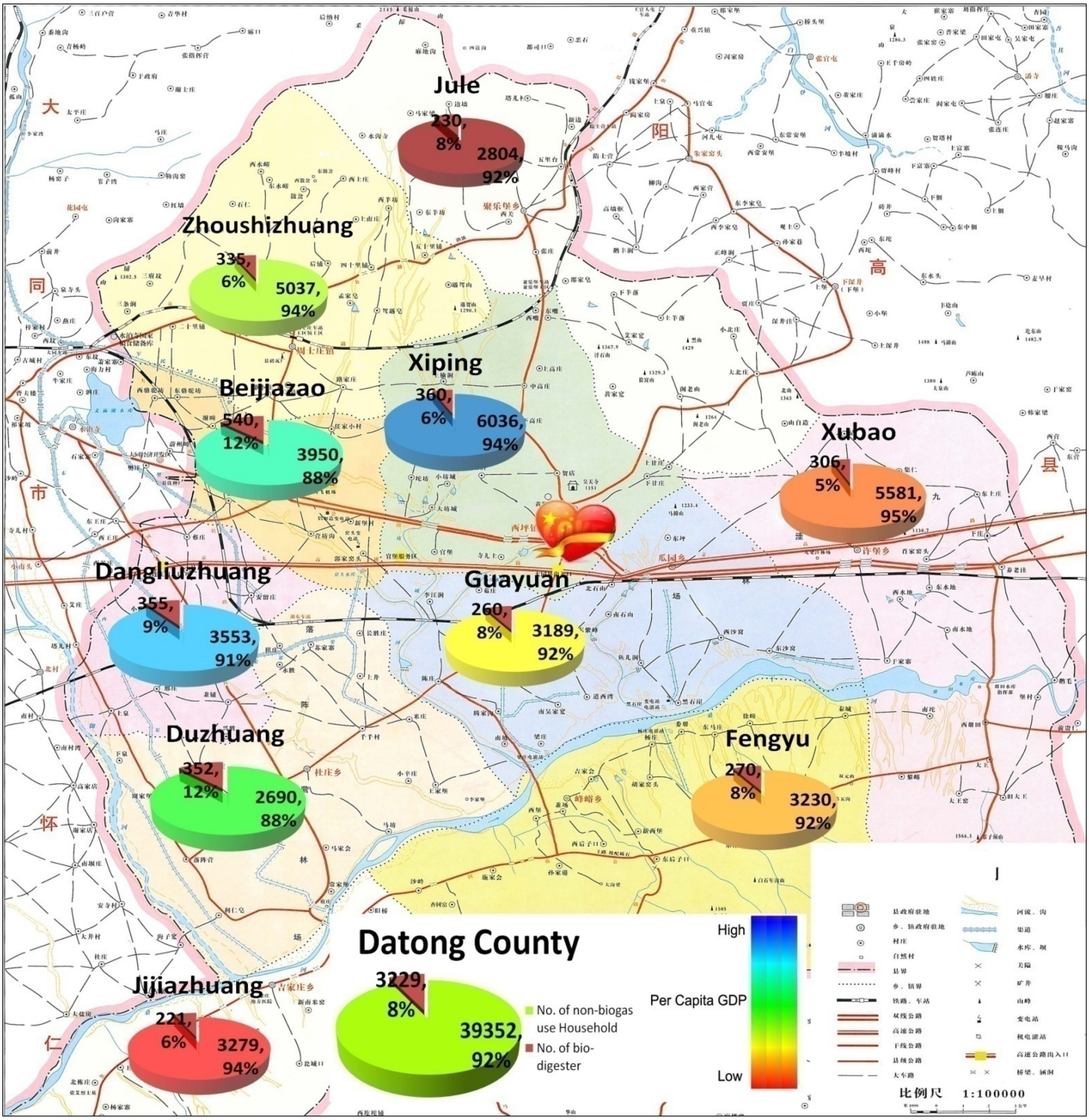
Chart 11 Datong Xian: Net income of Farmers in 2007, by Xiang (EUR)



Data source: Local government of Datong Xian, 2008

Since 2007, Datong Xian started to implement the BHP. 3229 households in 189 Villages, 8% of the total households in Datong Xian, constructed biogas digesters. These biogas digesters were built with concrete or brick concrete under a same construction. They were designed to produce biogas 8m^3/day. The local official in charge of the program claims that 90.4% of these biogas digesters work regularly (Datong Xian's Bureau of Agriculture, 2007).

Chart 12 Datong Xian: Distribution of biogas users in Xiangs in 2007



Design by Jia,Xiaodong

3 State of Research

All the biogas programs in different countries and different period started for the same reason of the lack of the energy. But there is a meaningful value neglected in most situations, which is that Biogas-household program would reduce the non-point greenhouse gas emission and mitigate greenhouse effect.

In Dce.11, 1997, “Kyoto Protocol to the United National Framework Convention on Climate Change” was launched. 156 countries have signed the agreement and promise to reduce their GHG emission till 2005. To stimulate and help the ecological-friendly projects, “Kyoto Protocol” arranges two mechanisms: CDM (Clean Development Mechanism) and JI (Joint Implementation). CDM allows appendix I countries to meet their emission reduction target by paying for the GHG emission reduction from non-appendix I countries (mainly OEDC and some eastern European countries). JI allows appendix I countries to meet their emission reduction target inter the appendix I countries.

With compliance of “Kyoto Protocol” and IPCC (Intergovernmental Panel on Climate Change) Guidelines for National GHG Inventories, series of methodologies are developed to measure the amount of GHG emission reduction by one kind of project. Some of them are relative with the different aspects of the biogas generation and use. However, there are not available and systematic methodologies for the BHP or similar program in a large scale.

“One of the most promising areas for future CDM activities is programmatic CDM (pCDM), wherein the normal project-by-project approval process is aggregated into a broader program including many individual activities” (UNEP Riso Centre, 2007, p1). But the fact is that 2037 projects exist in the CDM project pipeline till June 11, 2007, and only 21 projects with pCDM characteristics.

The reason is lack of systematic methods to calculate the GHG emission reduction by. The most recently relative methodologies are Gold Standard Methodology for Improved Cook-Stoves and Kitchen Regimes and Gold Standard Methodology for small Scale Bio-digester (Gold Standard foundation, 2008). Unfortunately, there is not application for these two methodologies.

One of similar project under CDM pipeline is the Biogas Support Program – Nepal. This project aims to install a total of 200,000 small biogas digesters all over Nepal. The finance support comes from international subsidy, Nepal government fund and finance from CDM mechanism. Because of lack of relative methodologies, the project developer only chooses these methodologies which are most easy to monitor and comply. Finally, only the GHG emission reduction by the replacement of thermal energy is calculated and monitored, in according with the small scale CDM methodology I: Thermal Energy for the User with or without electricity generation. (Ecosecurities, 2006)

The improved cooperate governance is a new concept in China. Effectiveness, accountability, participation, etc, are introduced to Chinese mind, accompanying with the open and reform of China. One example is that, the open bidding regulations in all public relevant section are learned from the UN and Worldbank regulations, when China apply their loads and subsidies.

There are various methods to evaluate the governance. Vertical comparison is used to evaluate governance with data in a long period of time. The change and tendency of these data can show the evolvement of governance. Almus (2003) set a database on public start-up assistance activities (1990-1999) under the Deutsche Ausgleichs Bank to evaluate its effect on these companies. Esposti (2002) evaluate the Italy’s national agricultural research systems by the similar way with data from 1972 to 1991. Ballesteros and Rico (2001) applied this method to evaluate the Spanish financing of precompetitive research projects which was developed by firms in collaboration with universities and public research organisms. Horizontal comparison is applied to measure the governance inner-countries. One example is Mandl (2008) evaluate the effectiveness of public spending in EU members. Similar case is Herrera and Pang (2005) measured the effect of public spending in developing countries.

We could find out all these methods have two common characteristics: defined indicators and statistic analysis.

4 Methodology

This chapter will introduce the methodology of the thesis, involving the carbon flows in Biogas-household program, the estimation of the GHG emission reduction and survey of the attitudes of the program holders.

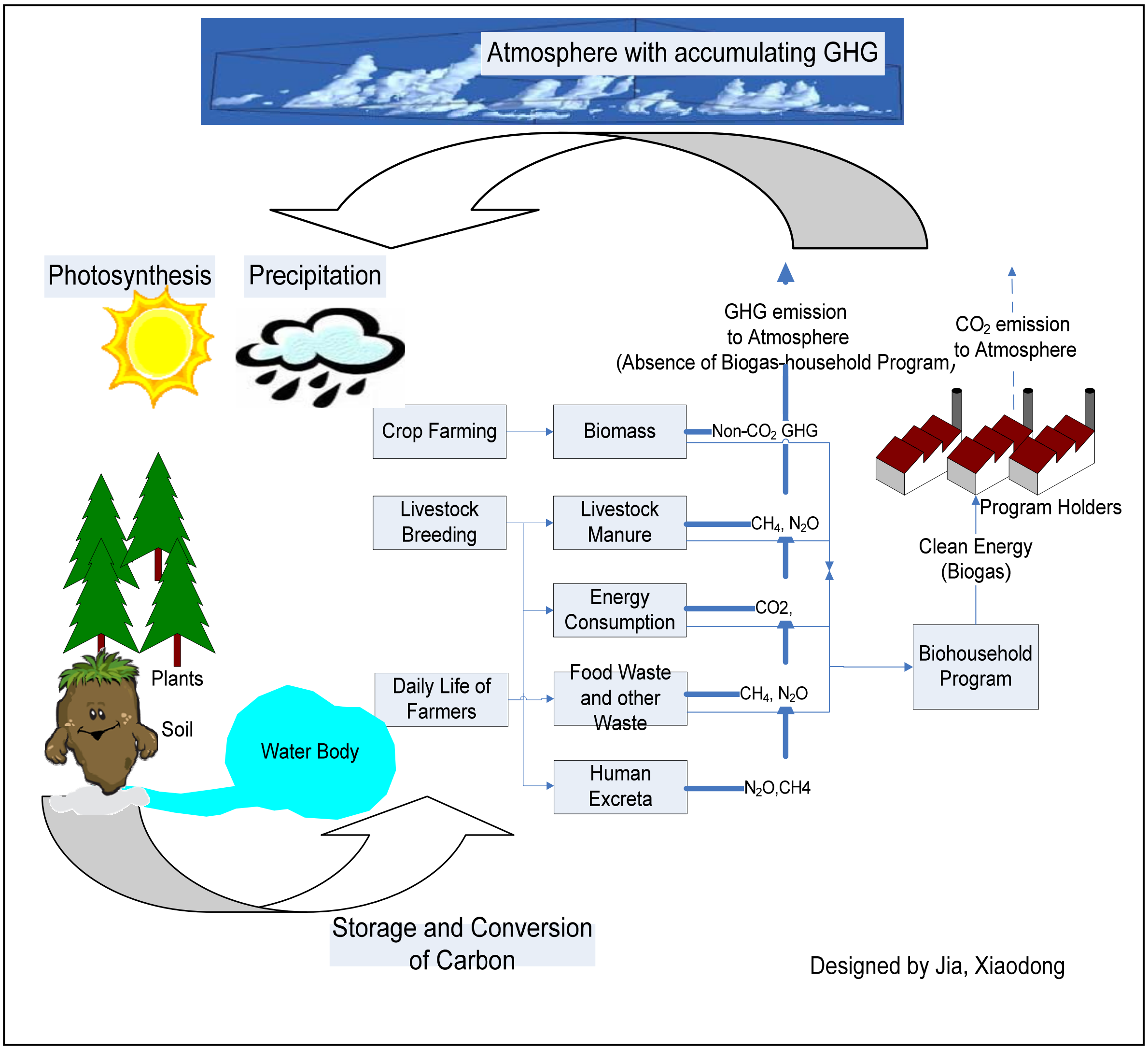
4.1 Carbon Flow Map of BHP

The essence of Biogas-household program is a project of methane and other GHG recovery. It changes the previous carbon flow into a low-carbon emission flow (see chart 13).

In absence of BHP, there would several sources of GHG emissions in rural area in China, above:

- GHG emissions in animal manure management system
- GHG emissions in human excreta management system
- GHG emissions emitted from the Landfill of food waste and other waste
- GHG emissions from fuel consume for the daily life
- Non-CO_2 GHG emissions from biomass burning

Chart 13 The position of BHP within the general Carbon flow



All of these GHG would be released into the atmosphere and become a part of the global carbon circle. The carbon involved in the GHG would come back to the ground through precipitation, or conversed through the photosynthesis and stored in biomasses or fossil fuels. And then, human activity would emit the GHG through the consumption of fuels or other ways. Part of the GHG would accumulate in the atmosphere and form the greenhouse effect.

BHP is able to recover the GHG emissions through the biogas digesters. The biogas produced by the BHP would be used for the cooking and lighting, in which process only the CO_2 would be emitted, rather than CH_4 with a heavy negative impact on climate.

4.2 Estimation of GHG Emission Reduction

IPCC (Intergovernmental Panel on Climate Change) has developed a systemic way to estimate the GHG emissions from all sections (anthropogenic and natural). To make the Clean Development Mechanism (CDM) accurate and comparable, United Nations Framework Convention on Climate Change (UNFCCC) provides series of approved methodologies fit for different project activities that could reduce the GHG emissions.

In 2007, Datong municipality decided to implement BHP in three forms: household-use biogas digesters, large-scale biogas digesters for animal farms, and biomass efficiency-improved stoves. Based on IPCC 2006 [10] and CDM approved methodologies[11], the thesis classifies the sources of GHG emission reduction into three categories. In addition, under each category, every possible source of GHG emission reduction is indicated following the relevant IPCC guidelines or CDM methodologies (see table 4).

Basically, the GHG emission reduction is the difference between baseline emission and the combination of project emission and leakage emission. Baseline for a project activity which is potential to reduce the GHG emissions is the scenario that reasonably represents the anthropogenic GHG emissions that would occur in the absence of the proposed project activity (UNFCCC, 2008, p10). In some case, the proposed project would also cause GHG emissions, i.e. directly from fuel consumption, indirectly from the use of electricity or vehicle. In addition, there would probably be more than one source of baseline emission and/or project emission in one project. Under the CDM framework, different approved methodologies are proposed to calculate the GHG emission reduction for different kind of project. The number of approved methodologies is increasing year by year, as people realize that lots of projects have the potential to reduce their GHG emissions.

Annex 2 is a calculation model linked to an EXCEL calculation sheet. Formulas are introduced in the back-ground of the EXCEL, following the chosen methodologies and references in table 4. The missing data in Annex 2 (marked as 0 in red in the row of “Value”) will be obtained in the process of data collection. Some of them are from

---

[10] IPCC 2006 includes: volume 1 General guidance and reporting, volume 2 Energy, volume 3 Industrial processes and product use, volume 4 Agriculture, forestry and other land, volume 5 Waste. http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

[11] All CDM approved methodologies are listed in the website of UNFCCC: http://cdm.unfccc.int/methodologies/SSCmethodologies/index.html

government, and some come from the survey. The other values are defaulted respectively with the relevant IPCC guidelines.

Table 4 Sources of GHG emission reduction

Sources of GHG emission reduction	*Methodologies and references*
Category 1 For individual household	
GHG recovery in agricultural activities ties at household/small farm level	IPCC 2006, volume 4 chapter 10 p10.37 Equation10.22
Landfill GHG recovery	Methodological Tools[12] for SSC: Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site
GHG recovery in human excreta management system	IPCC 2006, volume 5 chapter 6 Equation 6.1
Thermal energy for the user with or without electricity	CDM AMS[13]-I.C.
Non-CO2 GHG emission from biomass burning	IPCC 2006, Volume 4, p5.2.4 & Equation 2.27
Category 2 For large biogas plant	
Methane recovery in animal manure management system	CDM AMS-III.D.
Grid connected renewable electricity generation	CDM AMS-I.D.
Thermal energy for the user with or without electricity	CDM AMS-I.C.
Category 3 For Improved biomass stove	
Switch from Non-renewable fuel for thermal application by the user	IPCC 2006, volume 2, table 1.2

[12] In some case, a common Tool could be applied in different methodology. http://cdm.unfccc.int/EB/035/eb35_repan10.pdf

[13] CDM AMS are simplified methodologies for small scale CDM project. One of the mainly benchmark between small scale and large scale is 60,000 tCO2e emissions reduction annual. http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html

4.3 Evaluation of Governance

The governments at different level have allocated large funds to develop the BHP, but the most important factor in the implementation of this program should be the farmers, the individual program holders. Hence the thesis try find out the attitudes of the program holders before evaluating them.

First, we need to define the indictors of this program which are related with the attitudes of program holders. Based on a research in the field of promoting renewable energy (Brouns, et al. 2007, p6-7), a sample survey should be designed to collect attitudes about four main dimensions/barriers, including awareness & information, finance & economic, technological, institutional & political.

In the sector of awareness & information, the questions about the degree of known and understanding on the BHP and greenhouse effect are asked towards framers. In the sector of financial & economic, the amount and forms of governmental subsidy, the importance of these subsidies, and the way farmer access the rest part of the cost are asked by the investigators. In the sector of technological, interviews investigate the methods by which the farmers get the knowledge about the biogas digester. In the sector of institutional & political, the farmers are required to evaluate the BHP and the performance of governments and speak out their perspective.

Then, a descriptive statistics analysis would be introduced to summarize the answers and evaluate the governance of BHP.

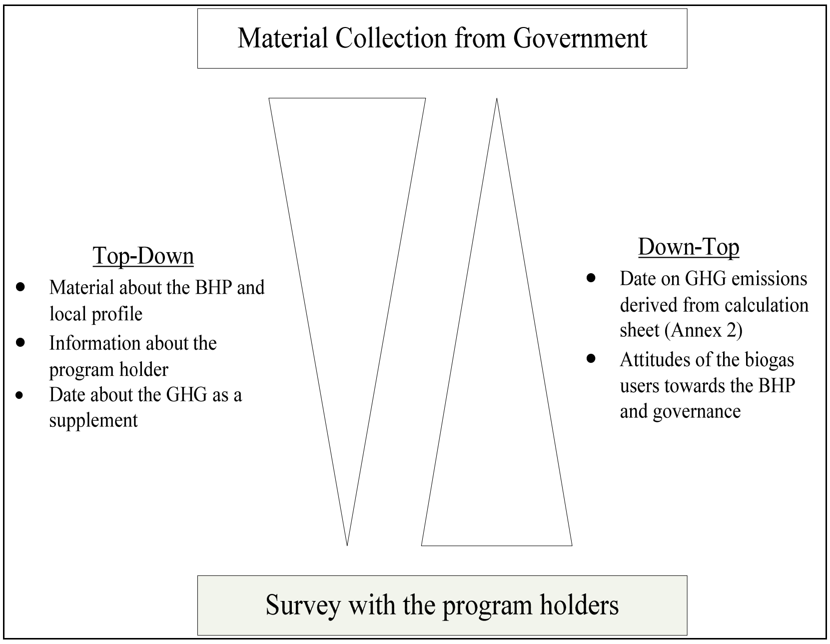
Finally, from the result of the evaluation and perspectives of program holders, the thesis will bring forward proposals improving the governance and management system for BHP.

4.4 Data Collection

The target of data collection is to obtain the missing data in the calculation model and access the attitudes of program holders. It includes two sources, material from government about the implication of the BHP and survey with the farmers who are the program holders.

The data from the survey play a crucial role in the estimation of GHG emission reduction by individual biogas digesters and the attitudes of program holders, and the data from government are used for the estimation of GHG emission reduction by large-scale biogas plants and biomass stoves. It is also is a useful supplement for all relevant information. The framework of data collection would make sure the data are authentic and representative.

Chart 14 Data collection procedure



Design by Jia,Xiaodong

From the Bureau of Agriculture of Datong, which is in charge of the implication of the BHP, and other government departments, the basic statement of the BHP in Datong and the information of the program holders could be obtained.

For the individual use of biogas digester and the attitudes towards the governance, the survey is conducted.

4.5 Survey Design

Survey is chosen as the tool to collect the data and information, rather than census. Because the sample survey is generally cheaper, faster and easier to control, despite that there would be sampling error depending on sample size and the variability of the characteristic of interest. The details describes blew:

- **Survey objective**: the survey is designed to collect the values of the relevant parameter for the estimation of GHG emission reduction, and the attitude of these farmers towards the program
- **Target population**: 3.229 bio-digester holders in Datong Xian (information about interviewees in Annex 4)
- **Survey population**: a sample interval 3% of the target population, 97 householders scattered in different villages considering the economic state and geographic situation.

- **Timeframe**: the survey is implemented from August 2008 to October 2008
- **Resources available**: with the help from the agriculture bureau of Datong Xian
- **Finance**: personally
- **Questionnaire**: see Annex 3, includes three parts: basic information of the farmer, data collection about BHP and the attitude to the program. Data would be used to estimate the GHG emission reduction. The attitude to the program would be used to learn about the governance in the process of implementation of this program.
- **Survey tool**: face-to-face interview
- **Output**: quantifiable value for all question
- **End-use of data**: calculation of the GHG emission reduction by household bio-digester and the analysis of the attitude of biogas users

After the basic statement of the survey, it's important to keep eyes on the accuracy of the survey. Taking into account with some survey design principles [14] [15], the furthermore details are issued below:

- **Sampling frame**: a name list of the all the bio-digester holders in Datong Xian
- **Sample selection**: the principle is summed up in "everyone has to have a measurable chance of being selected". However, depending on the finance and timeframe, it's hard to access every village in which there are biogas users.
- **Sampling strategic**: probability sampling. The interviewee is chosen from the name list randomly, since the investigators have no time and finance to be at every village.
- **Accuracy of result**: acceptable margin of error is less than 0,01; the level of confidence required: 95%.
- **Sources of error**: sampling error depending on sample size and the variability of the characteristic of interest

[14] Statistic New Zealand, 1995: A guide to good survey design
[15] Kott, Phillip S: Sample survey theory and methods, http://www.nass.usda.gov/research/reports/course%20notes%200906.pdf

5 Results and Analysis

5.1 GHG Emission Reduction

In accordance with the calculation model and collected data, the GHG emission reduction by the BHP in Datong are achieved by its three components: 2 large biogas plants in livestock farms, 200 efficiency-improved biomass stoves, and 21.362 individual use biogas digesters.

During the process of data collection, it is found that some sources in table 3 do not exist in currency, e.g. no thermal use in large biogas plants, no crop residues and food waste consumed by individual biogas digesters. Consequentially, the GHG emission reduction from these sources is excluded in the calculation, responding to the real situation.

5.1.1 Emission Reduction by Large Biogas Plants

As indicated in table 4, GHG emission reduction by large biogas plants has three sources: methane recovery in animal manure management system (biogas plants), generation of clean electricity and thermal which could replace the use of traditional fuel and energy. In the real situation, the biogas plants do not generate any thermal energy. The total GHG reduction from this category is 19.518,55 tCO_2e annually (see table 5).

Table 5 Emission reduction by large biogas plants

Sources	*Baseline Emission*	*Project Emission*	*Emission reduction*	*References*
Methane recovery in animal manure management system	12.705,51	2.047,95	10.657.56	CDM AMS-III.D.
Grid connected renewable electricity generation	8.861,00	0	8.861,0	CDM AMS-I.D.
Total	21.566,51	2.047,95	19.518,56 (tCO_2e)	

5.1.2 Emission Reduction by Efficiency-improved Biomass Stoves

The new biomass stoves project is applied in 200 households as a demonstration project. The fact is farmers consume 4 kg renewable biomass (crop residues or corn pellets) per day. They used to consume 4 kg coal for daily use without the new stove. In absence of the project, parts of the crop residues are burnt in wild which waste biomass energy and release polluted air into the atmosphere. Since these crop residues or corn pellets are renewable biomass, the use of them as fuel would not increase the GHG emission.

The GHG emission reduction under this category is 2,94 tCO_2e averagely, consequently, 589,33 tCO_2e in total (see table 6).

Table 6 Emission reduction by efficiency-improved biomass stoves

Sources	*Baseline Emission*	*Project Emission*	*Emission reduction*	*References*
Switch from Non-renewable fuel for thermal application by each user	2,94	0	2,94	IPCC 2006, volume 2, table 1.2
Total (200 stoves)	589,33	0	589,33 (tCO_2e)	

5.1.3 Emission Reduction by Individual Biogas Use

As indicated in table 3, GHG emission reduction by individual biogas use comes from five sources. Since there is no similar study in China, the author designed and carried out a survey to get the details and relevant data for the estimation of GHG emission reduction.

5.1.3.1 The Process of the Survey

The investigators selected 97 (3% of the target population) biogas users in the name list of 3.229 families using biogas (name list in Annex 3). Then, the investigators conducted the survey with the prepared questionnaire due to the name list. Because the name list is randomly created, only 69 out of the 97 questionnaires were received finally. The failure mainly comes from the absence of householders. 17 interviewees were not at home. In the other 9 cases, only a kid or an elder was at home, who was not familiar with the situation.

5.1.3.2 Emission Reduction by Individual Biogas Use

The survey states that there are three real GHG emission reduction sources:

- GHG recovery in agricultural activities ties at household/small farm level,
- GHG recovery from human excreta,
- Thermal energy for the user with or without electricity.

The other two sources listed in table 4 do not occur in the interviewed households. The daily organic waste (kitchen/food waste, garden waste) is not consumed by the biogas digester, so there is no GHG emission reduction from the CH_4 recovery from landfill. The crop residues are sold partly and the other part are burnt directly. No crop residues are used in the biogas digester, so there is no the GHG emission reduction from the avoidance of biomass burning.

The interviewees were selected randomly and scattered in all the 10 Xiangs of Datong Xian. Their economic and geographic situation varies greatly. To control the uncertainty, a correct factor is set as 0,9 for the estimation. Therefore, it's acceptable that the level of GHG emission reduction via biogas use in Datong Xian is eligible to represent the situation of Datong.

The GHG emission reduction is 900,60 tCO_2e by the 69 household, and the GHG emission reduction per household is 13,05 tCO_2e. Hence, the total annual GHG emission reduction by individual biogas use in Datong is expected to be 250.937,91 tCO_2e (see table 7).

Table 7 Emission reduction by individual biogas use

Sources	*Baseline Emission*	*Project Emission*	*Emission reduction*	*References*
GHG recovery in agricultural activities ties at household/small farm level	14,25	0	14,25	IPCC 2006, volume 4 chapter 10 p10.37 Equation10.22
GHG recovery in human excreta	0,01[16]	0	0,01	IPCC 2006, volume 5 chapter 6 Equation 6.1
Thermal energy for the user with or without electricity	886,34	0	886,34	CDM AMS-I.C.
Survey sample (69 households)	900,60	0	900,60	
Mean	13,05		13,05	
Total (21362 households[17])	250.937,91	0	250.937,91 (tCO_2e)	

[16] Only one interviewee uses human excreta in his biogas digester. Author includes this part, because "A pit with three reconstructions" and "4 in 1" are getting more and more popular, in which the human excreta would be used in biogas digester. Nowadays, few farmers apply this, as the construction of these two biogas digester are expensive.

5.1.4 The Total Emission Reduction in 2007

The BHP in rural area has developed over the narrow concept of household biogas use. Lots of new technologies are involved into the program to save energy and improve the life quality of farmers now.

The three types of new technologies under the framework of the BHP have achieved their goals in the perspective of economic and ecological development. It's measured that farmer have saved EUR 5,346 mil by the use of biogas digester annually (Datong Municipality's Bureau of Agriculture, 2007).

As the most important by-product of the BHP, the GHG emission reduction is totally 271.045,79 tCO_2e in 2007 (see table 8).

Table 8 Total emission reduction in 2007

Category	*Baseline Emission*	*Project Emission*	*Emission reduction*
Large biogas plants	21.566,51	2.047,95	19.518,56
Efficiency-improvement biomass stoves	589,33	0	589,33
Individual biogas use	250.937,91	0	250.937,9
Total	273.093,75	2.047,95	271.045,79 (tCO_2e)

5.2 Energy Flow of BHP in Datong in 2007

In last section is the GHG emission reduction clarified. In this section, the energy flow provides us with an overview of the program in the perspective of energy.

5.2.1 Energy Input

The energy inputs of the program are from animal manure and renewable biomass, consumed by bio-digesters and biomass stoves. Therefore,

$E_{inputs} = E_{input,\ manure} + E_{input,\ biomass}$

[17] Till the end of 2007, 21362 households have biogas digester and use biogas in Datong.

Where,

E_{inputs} = Energy inputs of the program (MJ/a)

$E_{input,\ manure}$ = Energy inputs from animal manure (MJ/a)

$E_{input,\ biomass}$ = Energy inputs from renewable biomass use in stoves (MJ/a)

<u>Energy inputs from animal manure and human excreta</u>

Two of the applications in the BHP are relevant with animal manure management. The biogas projects in livestock farms utilize the manure of swine and dairy cow. The raw material for individual bio-digesters is diversified with swine, sheep, horse, cow, poultry and even little human excreta. To simplify the calculation, an average heating value, which equals to NCV, is chosen here. Therefore,

$E_{input,\ manure} = 365 * \sum Ai * VSi * NCV_{manure}$

Where,

NCV_{manure} = Net caloric value of animal manure (4200 Kcal/kg, 1 cal=4.18 J) [18,19]

A = Amount of livestock involved in the program in Datong municipality

VS = Volatile solid matter for animal manure of kind i (kg/dm/animal/day)

i = Animal kind

Table 9 Data relevant with animal manure and human excreta

Animal kind	*Amount**	*VS(kg/dm/animal/day)*[20]
Dairy cow	2000	2.8
Cattle	21390	2.3
Swine	6510+120000 (life time of 0.25 year)	0.3
Sheep	23870	0.32
Horse	1240	1.72
poultry	59520 (life time of 0.75 year)	0.01
Humans*	1240	0.2

*Animal amount involved in the BHP in Datong is estimated with a proportion to animal amount in the survey sample.

*In some cases, human excreta are also used in the biogas digester.

<u>Energy inputs from renewable biomass use in stoves</u>

[18] Niu, Ruofen, Liu, Tianfu: 1984, Handbook of technological and economic agriculture, Agriculture Publishing, Beijing; 牛若峰, 刘天福,《农业技术经济手册》,农业出版社, 1984

[19] Luo, Shiming: 2000, Agriculture Ecology, Agriculture Publishing, Beijing; 骆世明,《农业生态学》, 农业出版社, 2000

[20] IPCC 2006, Volume 4, Chapter 10, Table10.A4-10.A9

In the pilot project of improved biomass stoves, renewable biomass (crop residues, wood chips) is consumed. The relevant energy input is,

$E_{input, biomass} = N * W * NCV_{biomass}$

Where,

N = The number of the stove users (200)

W = Weight of biomass consumed by each stove annually (1460 kg/year)

NCV_{manure} = Net calorie value of solid biomass (11.6 MJ/kg)[21]

5.2.2 Energy Output

The energy output mainly goes to the domestic energy consumption with three forms. The biogas produced by individual bio-digesters is used for the daily life of the residence in rural area. The electricity generated by two biogas projects would be fed into the gird. The biomass stoves provides thermal energy for cooking and heating for the rural inhabitants. Therefore,

$E_{outputs} = E_{output, biogas} + E_{output, elec.} + E_{output, thermal}$

Where,

$E_{outputs}$ = Energy outputs of the program (MJ/a)

$E_{output, biogas}$ = Energy outputs from biogas (MJ/a)

$E_{output, elec.}$ = Energy outputs from electricity generated by biogas project (MJ/a)

$E_{output, thermal}$ = Energy outputs from thermal use of biomass stoves (MJ/a)

Energy outputs from biogas

It is the initial object to produce biogas as a substitute of fossil fuel in rural areas. According with the survey results, the average amount of biogas production per biogas digester is 4,268m^3 annual. Therefore,

$E_{output, biogas} = N * P * NCV_{biogas}$

Where,

N = Number of household-use of bio-digesters (21362)

P = Annual biogas produce for one digester (4,268m^3)

NCV_{biogas} = Heating value of biogas (58.500 Kcal/m^3, 1 cal=4.18 J)[22]

Energy outputs from electricity

The biogas project located in the two livestock farms would generate electricity and feed it into grid. Therefore,

---

[21] IPCC 2006, Volume 2, Chapter 1, Table 1.2

[22] IPCC 2006, Volume 2, Chapter 1, Table 1.2

$E_{output, elec.} = P * h * f$

Where,

P = Total capacity of the two biogas projects (1350 kW)

h = Working hours of the project annual (8232 hours, 24 hours*7days*49weeks)

f = factor (1 MWh=3.6 GJ)

Energy outputs from thermal use of biomass stoves

Although the application of biomass stoves is a pilot project, we also consider it into the energy out. Compared with traditional stove, the efficiency of the improved biomass stove increases from 30% to 90%. Therefore,

$E_{output, thermal} = 0.9 * E_{input,biomass}$

Where,

$E_{input, biomass}$ = Energy inputs from renewable biomass use in stoves (MJ/a)

0.9 = Efficiency of the improved biomass stove

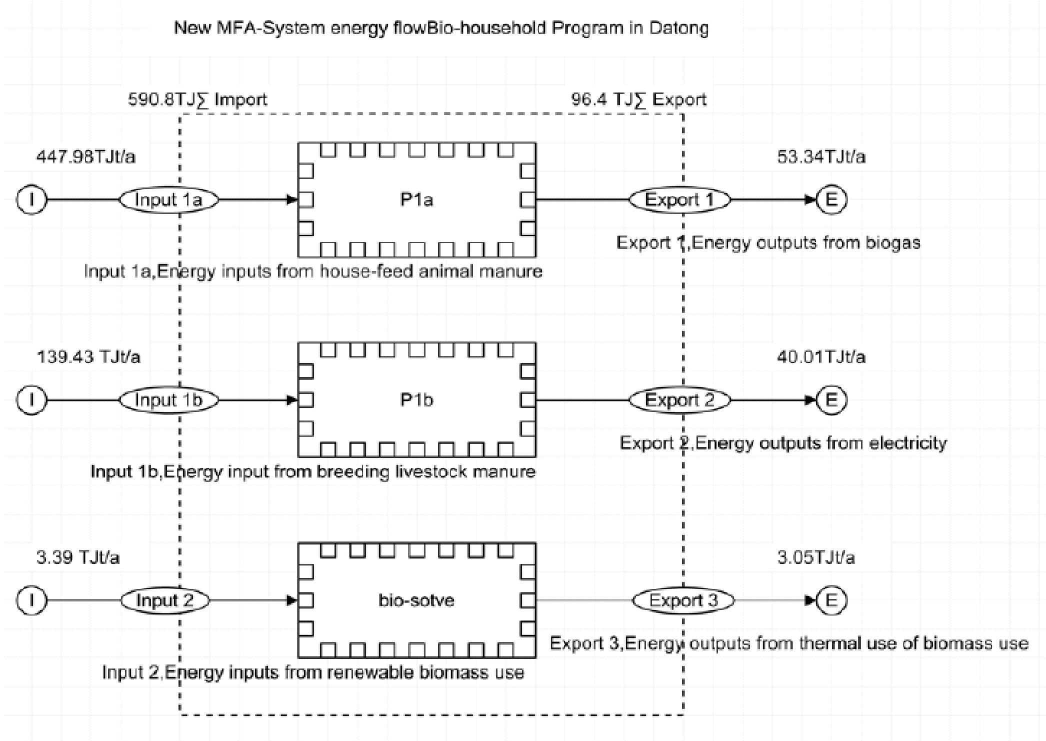
5.2.3 Energy Flow Map

This section complies with STAN tool developed by Institute for water quality, Resources and Waste management of Vienna University of Technology.

Respectively with the calculation of input and output energy, we could draw a clear energy flow map in Chart 15. The total input energy of the program is 590,8 TJ/a and the output is 96,4 TJ/a. The energy exchange rate is 16,32%. Three flow roads are involved in the map, which are the three applications of the program. The energy exchange rate of individual bio-digester is 11,91%. The relevant rate of large scale biogas project is 28,70%. The last, but the highest one is 90% for the biomass stoves. A notable point is that all the input energy comes from renewable energy, which would be wasted in absence of the program. The use of the renewable energy does not only save the energy, but also reduces the GHG emission by the use of fossil fuel and electricity.

However, there should be attention on the energy exchange efficiency, especially in the application of the individual bio-digester. In some samples, the leakage of biogas was obvious. The main reasons are the carelessness of the householder and the lack of technical support.

Chart 15 Energy flow map



Designed by Jia, Xiaodong

5.3 The Attitudes towards Governance

One broad concept of governance is “the entirety of all co-existing modes of collectively regulating social matter” (Mayntz, 2004, p7). Governance refers to all modes of coordinating action in human society in the extended perspective (Risse and Lehmkuhl, 2006, p66). Conceiving governance in this way, one can apply the concept to states, organizations, firms and other social units. The definition of governance is also given according with the different focus of attention. Derwent and Jones (1996, p65) defined the governance as the relationship between shareholders and their companies and the way in which shareholders act to encourage best practice. Parkinson (1994, p59) focused the process of supervision and control intended to ensure that company’s management acts in accordance with the interests of shareholders. The definition is also re-recognized with the development of the economic and the society. The empirical definition of governance focused on the conflicts of interest between manager and owners, and now the owners have been extended to a wide range of stakeholders (Weston, et al, 2004, p583).

Government at the various administrative levels is the initiator of the program. It also is the biggest financial supporter and the technical services provider. One may therefore expect a highly positive reputation of government among those supported by the BHP.

5.3.1 The Meaning of Governance in China

In the context of this research governance is defined by the author as the policy-making and public management by government. Governance and Administration are both used to describe the governments' activities in China[23]. Why is Governance preferred in this thesis? Generally speaking, public management or public administration, no matter in which political system, have the tendency to operate in a top-down manner. The role of government in the BHP is the guider, rather than the administrator. The success of the program relies on the quality of inter-action between the stakeholders, i.e. governments, private companies, individuals. In additions, the management in the BHP is eligible for the characteristics of the notion of accountability, corporate profitability and social responsibility, abstracted by Solomon (2007, p14-15) as governance in future. Maybe, the governance does not work so well now. It is a hope that the governance could be improved to fit these three characteristics.

According the classification of governance by Risse and Lehmkuhl (see table 10), Chinese governance is a classic hierarchical (top-down) structure which is changing gradually. The self-governance at the village (cun) level has already been achieved. The original legal foundation for this can be traced to article 111 of the 1982 Constitution which provided for the establishment of village committees and specified that the residents elect the chairman and members of each committee (Su and Yang, 2005, p125-157). From 1998, self-governance and election in the village level are populated in the overall scale of China. With respect of actors involved, since the reform and open of china in 1978, more and more private actors are introduced into the economic field. Except some key industries, e.g. energy, nature resources, military manufacture, China has marketized completely. Even some of public

[23] In the English-version website of China's central government, "Governance" and "Administration" are used synonymously (guanli) to describe the governments' management and activities.
http://sousuo.gov.cn/search?searchword=SEARCHVALUE%3D%24^~public*administration%24^~&sortfield=-Pubdate&channelid=6001&licensecode=2164260865.1232631035.1&outlinepage=%2Fgw_js%2Fen%2Fjs%2Fzn_outline.jsp&uc=0&detailpage=%2Fgw_js%2Fen%2Fdetail%2Fzn_detail.jsp&sep=%3B&fenlei=0&page=3&prepage=10&searchtype=1
http://sousuo.gov.cn/search?dc1=&dc2=&title=&content=&author=&keywords=governance&sortfield=-Pubdate&sub3=Search&channelid=6001&searchword=KEYWORDS%3D%24^~governance%24^~

services are provided by private sectors, e.g. water supply and waste water treatment, solid waste treatment, public transportation, etc. Market-oriented economy structure and urban governance system have been formed (Wu, 2001, p1071-1093).

Table 10 Modes of Governance

Actors involved / Modes of Coordinating action	State actors	State and non-state actors	Non-state actors
Hierarchical/ Vertical steering	Classic nation-state Supranational institutions/Jurisdiction	Delegation of public tasks to non-state actors or public contractors	Pre-state associations
Non-hierarchical/ Horizontal steering	International cooperation International regimes/organizations International negotiations	Public-private modes of cooperation partnership projects Indigenous collaboration Colonial regimes	Cooperation between non-state actors Private regimes (Religious) networks Colonial agencies

Sources: Risse and Lehmkuhl, 2006, p66

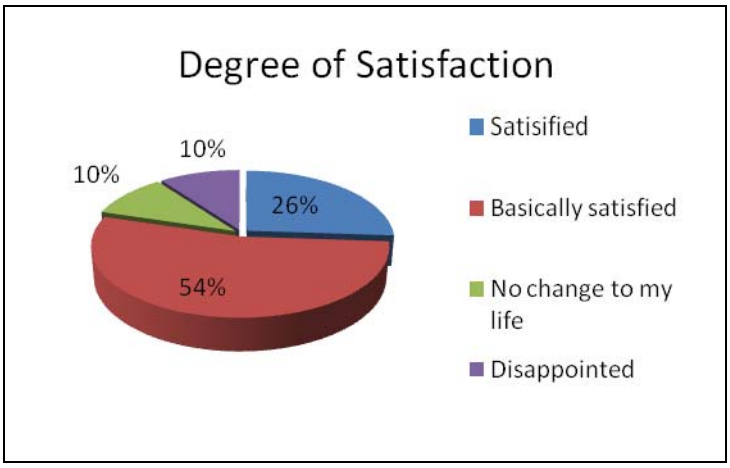
As a hierarchical governance system, the attitude of farmer towards the governance in this program seems important and easy to be neglected. This sector analysis these attitude through the interviews and try to find some valuable issues.

5.3.2 Awareness & Information Sector

Awareness is a very important hypothesis that could motivate and stimulate the biogas user to tap the 100% potential. In the sector of awareness and information, the author tries to find out the awareness about the use of biogas and clean energy. Although the BHP is oriented by government to solve the energy problem, environmental problem and health problem in rural area, farmers should be able to get all the means of the program.

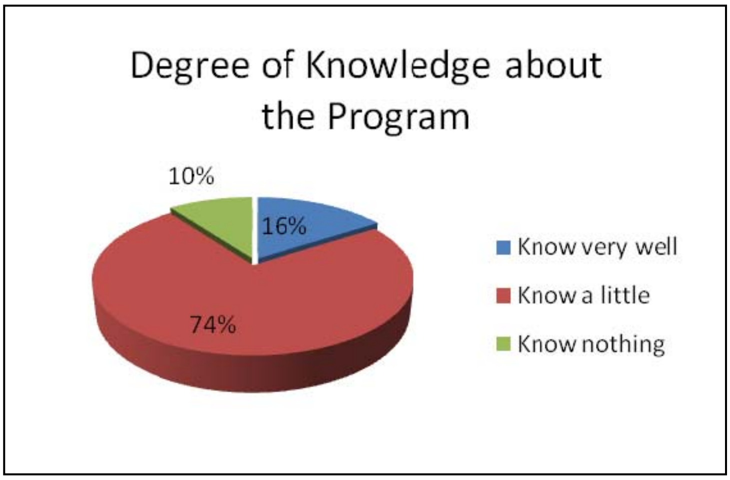
How would you evaluate the Biogas-household program?

About the satisfaction degree towards the BHP, 26% of interviewees feel satisfied about this program. 54% evaluate this program basically satisfied and need some improvement. In contrast, 10% interviewees feel disappointed about this program. The rest part of 10% of respondents told the auditor that the project brings no change for them. In most disappointed case, the reason is that the biogas digester can not generate enough biogas, sometimes, even hard to start fire. A valuable point is that, 3 interviewees among 7 who are frustrated by the project got 100% finance from governments for the digester.



<u>How much do you know the Biogas-household program in China?</u>

The BHP can not only bring economic benefit to farmers, but also great ecological value. This question tries to find out how deep the farmers get known the program. A assumption is that If the interviewees only know the use of biogas can save the use of fuel and decrease the life cost, we supposed they know nothing about the program. If they get known the program can bring the health and environmental value, we believe they know a little about the program. The interviewees who know the program could bring ecological benefit and mitigate the greenhouse effect are considered as “know very well”. Finally, 10% of the interviewees know nothing about the program. 74% know a little. The rest 16% know the program very well.

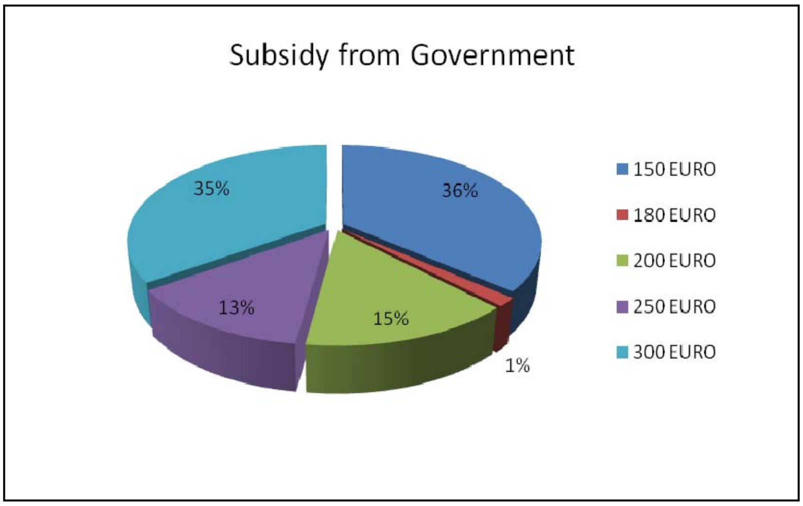


5.3.3 Financial & Economic Sector

In this sector, four questions are asked towards the farmers: the subsidy from government and its form, and the importance of the government subsidy, the form of the portion of self-finance.

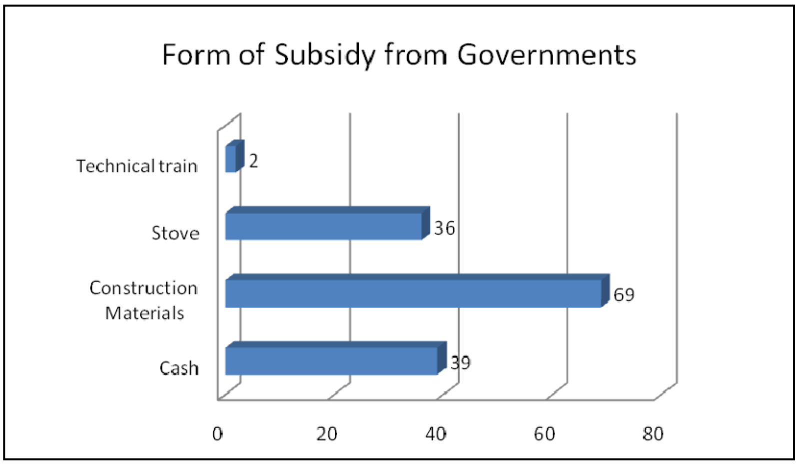
<u>How much did you get from governments as subsidy for the Biogas-household program?</u>

In according with different cuns, 35% of biogas digesters are provided free by governments. 13% get finance of EUR 250 which could cover 83.3% of total cost. 15% get EUR 200 from governments. The smallest amount of finance is EUR150, which can cover the half of the cost.



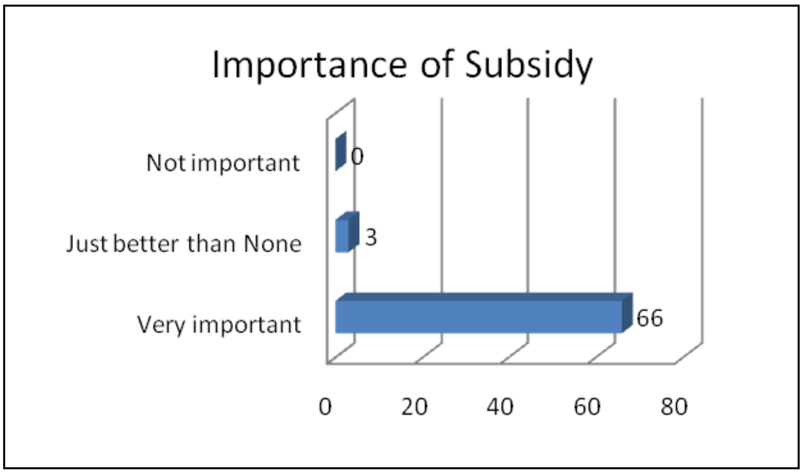
What are the constituent of the subsidy?

The forms of these subsidies are quite diversified. Normally, portfolios of subsidies are provided with cash, construction material, stove and sometimes with technical train. As the main form of subsidies, every respondent do get construction materials, e.g. bricks and cements. In some rich cuns, cash or biogas stove are provided as a supplementation. Only two of the farmers are chosen to take a train workshop. The important issue is the biogas digester belonged to above two farmers can work with a full capacity, which is scarce.



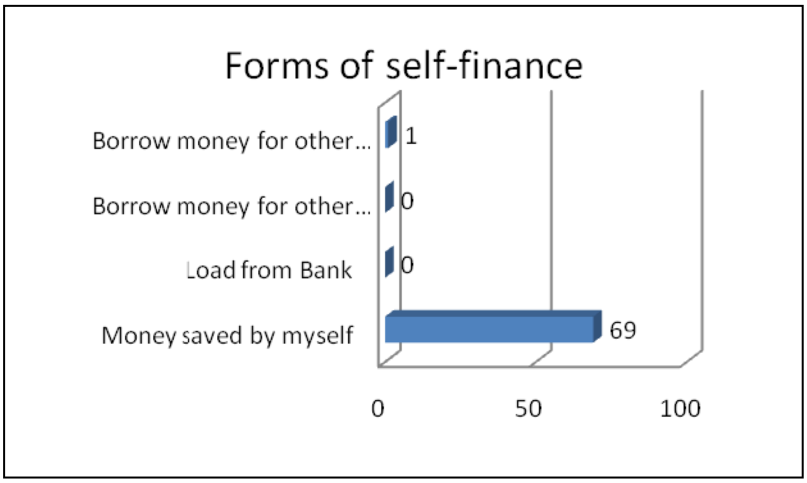
Is the subsidy important?

There are three options provided for this question. 66 of the interviewees think the subsidy is very important, and the rest 3 respondents think the subsidy is “just better than none”. Nobody considers the subsidy is not important. The 3 farmers who think the subsidy is just better than nothing live in the richest Xiang of Datong Xian.



How do you get finance for the rest part of the cost of biogas plant?

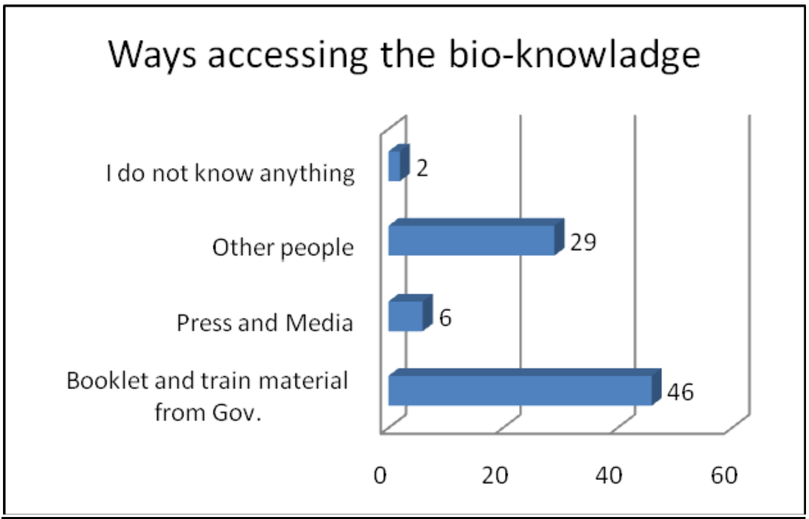
After economist Muhammad Yunus and his Grameen Bank are awarded the Nobel Peace Prize, more and more researchers try to introduce the concept of microfinance into the rural area in developing countries. In this sector, the functions of self-finance are investigated. Except one of the interviewee get part of the expense from his friend, everyone pay from the saved money.



5.3.4 Technological Sector

The technical support is the key factor to deicide the success of the BHP. To guarantee the quality, on the one hand, the government provides uniform construction code and drawing of household-use biogas digester, on the other hand, only the designed entities and technician with licenses could implement the projects. In addition, about 1000 DVDs, 10000 booklets and 10000 posters about the operation and management of digesters are provided to biogas-user free.

During the implementation of Biogas-household program, where did you obtain knowledge and technology referred to biogas and operation?



Booklets and train materials from governments are the main channels through which farmer can access the information and knowledge about the bio-issues. Helps from friends or neighbours in the same village (cun) are the second most important channel. 6 of interviewees get relative knowledge from TV and newspaper, which mainly oriented by governments. 2 of interviewees do not know anything about the biogas issues. They are also 2 among several householders whose biogas digester can not generate any biogas.

<u>An essay question is set to get the open ideas about the perspective of next phase of Biogas-household program</u>

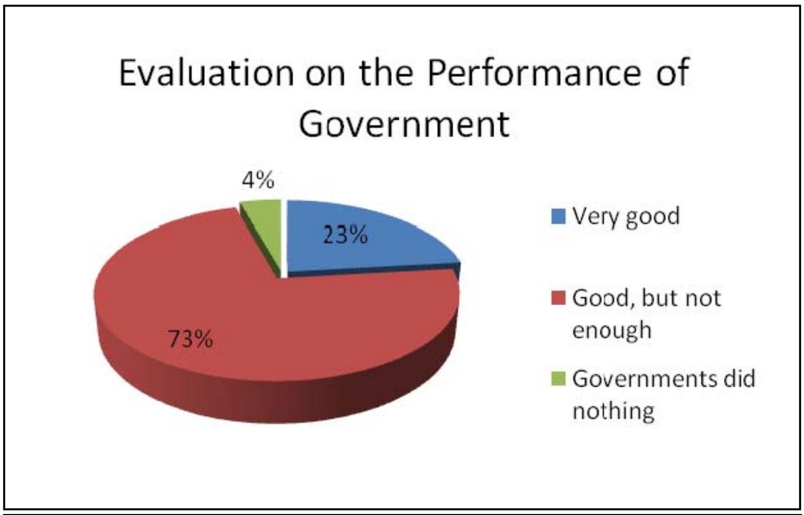
Although most of the interviewees believe the bio-program bring benefit, some of them show us their perspectives about the technical issue. The most frequent problems which farmers face are that, the biogas produce capacity is low and not enough to use, bio-digester in winter works bad. These two problems are common difficulty in the field of household-use biogas digester, rather than the personal behaviours or the construction quality.

5.3.5 Institutional & Political Sector

All governments have responsibilities to provide best public service. Different with the biogas program in other countries cooperating with international and/or internal NGOs and partly financed by foreign governmental subsidy, the BHP in rural China is oriented by governments 100%. This question requires interviewees to evaluate the governments for their performance during the implementation of the program.

<u>What kind of role does the government play in Biogas-household program, in your mind?</u>

As one of four programs which target to sustainable development in rural area, national government of China pays huge revenue and attention on this program. Now, let's give a mark to governments. Results show that 23% of interviewees give a good mark. 73% of interviewees think governments do well, but not enough. 4% of the interviewees think governments did nothing. It is interesting to note that three farmers who evaluate governance poor get half finance for their bio-digester, but the bio-digester can not produce any biogas.



5.4 Cost-efficiency Analysis of Governance

The original modern discussion of efficiency measurement dates back to Farell (1957), who identified two different types of inefficiency: technical inefficiency and allocative inefficiency. The former means people/organization/government could use more input than technically required to obtain a given level of output. The latter means they could use a sub-optimal input combination given the input prices and their marginal productivities (Farrell, 1957, p253-290). In the past decades, numerous techniques and concepts have been developed.

Technical inefficiency measures the pure relation between inputs and outputs taking the production possibility frontier into account. Allocative efficiency reflects the link between the optimal combination of input taking into account cost and benefits and the output achieved (Mandl, et al, 2008, p4). The parametric approach assumes a specific functional form for the relationship between the inputs and the outputs as well as for the inefficiency term incorporated in the deviation of the observed values from the frontier. The non-parametric approach calculates the frontier directly from the data without imposing specific functional restrictions (Herrera and Pang, 2005, p5). The respectively cases in table 11 presents the way in which different approaches are applied.

Table 11 Applications of efficiency measurement

	Technical inefficiency	*Allocative inefficiency*
Parametric (stochastic) approach	WHO's panel data (Greens, 2003)	The effectiveness of public spending in EU members (Mandl, 2008)
Non-parametric (deterministic) approach	The efficiency of public spending in developing countries (Herrera and Pang, 2005)	Efficiency of disaggregate public capital provision in Japan (Ihori, 2000)

Summarized by Jia,Xiaodong

This section arms to find out the most important indicator which relates with the satisfaction degree of farmers. The satisfaction of the bio-digesters holders should be the ultimate target of governance. At the same time, governance should take care about the cost of implementation of the program, including the monetary cost and other cost.

Till now, the government subsidy is spent in two functions, the direct subsidy to farmers and firms who build these biogas facilities, and the indirect expense on the technical support. The first one is the main expense. So we choose the amount of subsidy towards each user, the biogas production and the satisfaction degree as three variables to analysis the cost-efficiency of governance.

The analysis in this section applies the SPSS V11.5.

5.4.1 Group Analysis

As a preview of these three variables, we give a brief description of the data base in table 12. Base on the different satisfy degree, the data base could be divided into 4 groups: satisfied, basically satisfied, no change to my life and disappointed. These four different satisfaction degrees are set as 1, 0.75, 0.5, 0.25. A group analysis shows that the interviewee who feel disappointed with the program have received 235,7 average as subsidy. But their bio-digester could only produce 0,86 m^3 biogas. The ground with the idea of no change has received EUR 232,8 average from government. Their bio-digester production is poor too, 2 m^3 biogas. The group evaluating the program as basic satisfied gets average EUR 214,9 as subsidy. Their bio-digester production is poor too, 4,93 m^3 biogas. The group that feels satisfied with the program can get 5,44 m^3 biogas every day. They get finance of EUR 230,5 from government.

For the total sample, interviewees get subsidy of EUR 222,9 from government and their bio-digesters could produce 4,35 m^3 biogas averagely.

Table 12 Group analysis

Report

SATISFIY		BIOGAS	SUBSIDY
.25	Mean	.8571	2357.143
	N	7	7
	Minimum	.00	1500.00
	Maximum	2.00	3000.00
	% of Total N	10.1%	10.1%
.50	Mean	2.0000	2328.571
	N	7	7
	Minimum	.00	1500.00
	Maximum	4.00	3000.00
	% of Total N	10.1%	10.1%
.75	Mean	4.9324	2148.649
	N	37	37
	Minimum	.00	1500.00
	Maximum	7.00	3000.00
	% of Total N	53.6%	53.6%
1.00	Mean	5.4444	2305.556
	N	18	18
	Minimum	3.00	1500.00
	Maximum	7.00	3000.00
	% of Total N	26.1%	26.1%
Total	Mean	4.3551	2228.986
	N	69	69
	Minimum	.00	1500.00
	Maximum	7.00	3000.00
	% of Total N	100.0%	100.0%

5.4.2 Correlation Analysis

Now, we analysis the correlations between satisfaction degree and the subsidy, and the satisfaction degree and the biogas produce situation. The Bivariate analysis tool is applied here.

5.4.2.1 Correlation between Satisfaction Degree and the Amount of Subsidy

Based on the analysis result in table 13, the 2-tailed pearson correlatiors are both -0,028 and P-value is 0,816. It means there is not any notable correlation between the satisfaction degree and the amount of subsidy. This point could also be proved by some facts, e.g. 3 interviewees among 7 who are frustrated by the project got 100% finance from governments for the digesters.

Table 13 Correlation analysis 1

		Satisfy degree	Amount of subsidy
Satisfy degree	Pearson Correlation Sig. (2-tailed) N	1 . 69	-.028 .816 69
Amount of subsidy	Pearson Correlation Sig. (2-tailed) N	-.028 .816 69	1 . 69

5.4.2.2 Correlation between Satisfaction Degree and the Biogas Production

Based on the analysis result in table 14, the 2-tailed pearson correlatiors between the satisfaction degree and biogas production are both 0.741 and P<0,001 in a confidence level of 99%. It is a believable evidence to show the correlation between them. The result also could be confirmed by the result of group analysis.

The group with an attitude of satisfaction has the biogas produce of 5,44 m^3 /day biogas which is the highest among the four groups. They get subsidy of EUR 230,5 from government without an obvious difference with other group.

Table 14 Correlation analysis 2

		Satisfy degree	Biogas generation
Satisfy degree	Pearson Correlation Sig. (2-tailed) N	1 . 69	.741* .000 69
Amount of subsidy	Pearson Correlation Sig. (2-tailed) N	.741* .000 69	1 . 69

6 Conclusion and Outlook

GHG Emission Reduction by BHP in 2010

According to the ”Action plan for Biogas-household program in rural area of Datong (2006-2010)”,70.000 individual bio-digesters and about 10 large and medium scale biogas projects will be in operation by the end of 2010. Furthermore 10,000 biomass stoves, improved kangs[24] and various types of solar technology applications will also be financed in the rural areas with help of this program. The reason for the enlarged scope of activities is the fact that national subsidies are allocated in combination with provincial and local government subsidies (配套资金). Thus flexibility is guaranteed to adopt the general policy to the specific local conditions.

The three types of new technologies supported by the BHP have achieved their goals in the perspective of economic and ecological development. Following the government estimates farmers in Datong are expected to save EUR 5,346 mil by the use of biogas digesters in 2007 (Datong Municipality’s Bureau of Agriculture, 2007). Following the calculation of this thesis the GHG emission reduction of the BHP lies in the range of 270,000 tCO_2e in 2007. This number will increase to approximately 1,041 mil tCO_2e by 2010. It equals the GHG emission of 2 fossil fuel power stations with a generation of 60 MW[25]. It also equals the GHG emission by the combustion of 0,525 mio t of brown coal briquettes[26]. It is also equivalent to the annual carbon-stock capacity of 236 km^2 of eucalyptus plantation[27].

GHG Emissions Control under a Decentralized Framework

A designed GHG emission control structure should involve point and non-point polluters. Point pollution includes highly localized and large scale GHG emission sources e.g. thermal power stations, factories and big livestock farms. Non-point

---

[24] A kang is a traditional heating facility in the living room of rural farm house which is used as bed in night time and as sofa in day time.

[25] Till Aug. 9th, 2007, China DNA indicates that Electricity Grid Emission factor is 0,97455 tCO2/kWh. www.cdm.ccchina.gov.cn

[26] The net calorie value of brown coal briquettes is 20.7 TJ/Gg; and its CO2 emission factor is 97500 kg CO2/TJ.

[27] The calculation bases on the Equation 2.9, table 4.3 and 4.11 in Volume 4, chapter 2 of IPCC 2006.

GHG emission would include all decentralized emissions caused by human activities, e.g. daily cooking and heating, fugitive emissions during the agricultural production and transfer, emissions from wastewater treatment facilities and waste handling processes, animal and human excreta, etc. Although the amount of non-point emissions is not as high as point GHG emissions, their collection and treatment may be more difficult and possibly (when using centralized treatment facilities) more expensive. Decentralized pollution-control measures proved to be effective and successful. Considerable research has been devoted to the control non-point pollution in the field of wastewater treatment. The decentralized wastewater management based on small units shows excellent environmental benefits (Crites & Tchobanoglous, 1998). In the dimension of GHG emission control, the CDM Executive Board of UNFCCC is promoting the CDM projects especially in developing countries, which are believed to hold the biggest potential for future GHG emissions.

Cost-efficiency of Governance in the Implementation of BHP

Good governance should always seek for the cost-efficiency, which means minimum investment to access maximum satisfaction from its voter. The role of government subsidies should be the stimulus and guide which can lead farmers to the path of clean-energy use. In accordance with the cost-efficiency analysis in chapter 5, the results show that farmers take care about the biogas produce more than the amount of subsidy. The subsidy is important to attract and motivate farmers to set biogas digesters, but once it is over a marginal point, the farmers would not care about the detailed amount of subsidy any more. The marginal point of proportion between subsidy and construction cost of biogas digester should vary in different xiang or cun, depending the economic situation. The richer xiang or cun gets fewer subsidies.

The thesis suggests that part revenue saved from subsidy could be used to develop the service system of the BHP. Lots of interviewees expressed strong wishes to improve the technological service and increase the biogas produce. If this result is viewed with a boarder background it makes more senses. First, since the national government cancelled lots of taxes and charges to release the burden of farmers and agriculture industry, the local governments, especially the governments in the level of xiangs and cuns, have very poor revenue. Second, although a framework of technical support has been built, it seems to work badly. The reason is mainly that the biogas users have not got used to pay for technical service and the revenue towards these service stations is not enough to keep the service run regularly. Since it is difficult to change the behaviours of the farmers and there is not enough revenue for the technical service system in a short time, there is a need to decrease the subsidy to individual biogas digester and use the saved revenue to develop the technical service system.

A long-term evaluation towards the satisfaction and feedback from biogas users should be inducted in the evaluation and monitoring system. Currently, there is only quantity checking and inspection, which care about the “hard” aspects more than the “soft” aspects.

Recommendations for the Improved PPP

Many researchers are encouraged by the tendency from public-private partnership (PPP) to market under the Kyoto Protocol framework in the field of GHG emission reduction, e.g. Benecks, 2008, Esty, 2002. But marketization can not solve all problems in the process of adoption of climate change because of two reasons. First, the Kyoto framework is not able to cover all the projects which could mitigate the climate change and its pipeline is very narrow in global scale and is suffered heavily from bureaucratic burdens. Secondary, lots of programs are not economically attractive even with the finance help from CERs.

The results of the study showed that two private companies have registered to provide bio-technology service in Datong. The local government has also considered the possibility of CDM. However, without a good predicted return, the help from marketization or private sectors will not come. In this situation, improved PPP is recommended.

With the saved finance from subsidy sector, government should pay more attentions on the technical service. First, the technical service system should be completed by the measures of training technicians and allocating basic equipments and tools. Secondary, some NGOs and environmental organizations in local college who are interested in the anti-poverty or adoption of climate change issues should be supported. Take these earth-friendly clubs in college as example, these students have good environmental background and glad to get some working experience for their job seeking in future. Third, a co-ordination team within the biogas users should be set. As the results of the survey show, 29 of the interviewees get their bio-knowledge from their friends or neighbours, which is the second important way to get the knowledge. So the guide towards the self-help is an available option for the improved PPP in the level of communities.

Technology Development

The energy flow analysis shows clearly that the energy exchange efficiency of the BHP is low 16.32 %. The exchange efficiency of individual biogas digesters is 11.91%. Although the size effect of small biogas application is negative, it is indubitable that the technology and quality need to develop. For these householders who feed amount of livestock, the uniform 8 m^3 biogas digester is not sufficient. They can not afford a tailor-made biogas design service from private company, because their feed capacities are not as big as the livestock farms. For these median-size householders, government should provide more options, e.g. the standard 10 m^3 or bigger biogas digester.

Except householders in some demonstration villages, most have no opportunities to get a face-to-face train. The bullet and oral teaching from friends are the main channels to obtain the biogas knowledge, which are not sufficient during the operation. A framework of service system of the BHP has been set in Datong, but it does not work well. The main reasons are the finance limitation and ignorance from governments. The saved money from the proper subsidy could fill the finance gap. The improved evaluation system could force local government to pay more attention on the quality, rather quantity.

Contribution to Urban Area

China is facing fast urbanization and immigration, which brings a heavy burden on the fragile eco-system of China. It is proved that the BHP is able to reduce the life cost and improve the life quality of the farmers. The BHP is one part of a huge portfolio “New Rural in China”. The portfolio includes road and TV signal connection to every cun (village), development of small hydro power stations, biogas-household program, modern agriculture etc. The targets of the portfolio are the sustainable development in rural, better live condition in rural area and decrease of gap between urban and rural.

If the environment and life quality are acceptable, farmers might prefer the living in countryside. All of these ecological and economical benefits are eligible to attract farmers to live in rural area and mitigate the pressure of urbanization. Besides, the saved energy by BHP would release the pressure of energy supply in China. The BHP can also contribute to water quality of urban area, as it consumes manure which would pollute the water body and the urban area is always in the downstream of rural area.

Cognitive Enhancement

“Even small improvements in general cognitive capacities can have important positive effect” (Bostrom, 2007, p3). Respectively with the survey result, most of interviewees (76%) know some basic ideas about the economic and ecological benefit from the biogas use. 10% of the interviewees considered the BHP as a way to save the money from the fuel use. In case that the price of coal or other fuels is low, the use of biogas would not be an attractive solution.

Cognitive enhancement of the biogas-use would be a huge and comprehensive program. Climate change will affect everyone around the world, no matter rich or poor. An over-view perspective of mitigating climate change and reducing GHG emission should be instilled into every social sector with the endeavour of governments and all the social participants. Low-carbon society needs a long process to be built, but if we do not start now, it would never come.

References

1) Almus Matthias, 2003: Evaluating the Impact of Public Start-up Assistance – Results from an Econometric Approach, Centre of European Economic Research, Mannheim, GE

2) Ballesteros, Juan Acosta and Rico, Aurelia Modrego: 2001, Public Financing of Cooperative R&D projects in Spain; the Concerted Projects under the National R&D Plan, Research Policy, Elsevier, UK, Vol. 30(2001), p625-641

3) Barnett, Andrew, et al, 1978: Biogas Technology in the Third World; A Multidisciplinary Review, A Research Publication by International Development Research Centre, Ottawa ,CA, p97-109

4) Benecks, Gudrun, et al, 2008: From Public-Private Partnership to Market: The Clean Development Mechanism (CDM) as a New Form of Governance in Climate Protection, The Research Center 700 in Free University, Berlin

5) Bostrom, Nick, 2007: Smart Policy: Cognitive Enhancement in the Public Interest, Oxford University, p3, [accessed 12/11/2008], Available: http://www.nickbostrom.com/papers/smart-policy.pdf

6) Brouns, Bernd, et al, 2007: Promoting Renewable Energy Technologies in Developing Countries Through the Clean Development Mechanism, The Federal Environmental Agency, Dessau,p6-7

7) Crites, Ron and Tchobanoglous, George, 1998: Small and Decentralized Wastewater Management Systems, WCB/McGraw-Hill, p1-7

8) Datong Xian's Bureau of Agriculture, 2007: Summary of the Experience on the Construction of the Biogas-household Program in 2007, Datong Xian (大同县2007年新农村沼气建设总结), Datong, p2

9) Datong Municipality's Bureau of Agriculture, 2007: Yearly Work Report of 2007; Action Plan of Implementation of Biogas Use (2006-2010); Inner Materials

10) Datong Municipality's Bureau of Statistics, 2001-2005: Yearly Report about Economic and Social Development of Datong Municipality, [accessed 11/09/2008], Available: http://www.dt.gov.cn/dtgov/cn/jjpd/jjgb/

11) Derwent, A. Richard and Jones E. Martyn, 1996: The Corporate Governance Handbook, Gee Publishing, London, p65

12) Deublein, Dieter and Steinhauser, Angelika, 2008: Biogas from Waste and Renewable Resources, WILEY-VCH Verlag GmbH, Weinheim, p13, 30, 35

13) Ecosecurities, 2006: Project Designed Document of Biogas Support Program – Nepal, [accessed 12/12/2008], Available: http://cdm.unfccc.int/Projects/DB/DNV-CUK1132671435.09/view

14) Esposti, Roberto, 2002: Public Agricultural R&D Design and Technological Spill-ins; A dynamic Model, Research Policy, Elsevier, UK, Vol. 31(2002), p693-717

15) Esty, Daniel C, 2002: Global Environmental Governance, Options & Opportunities, New Haven, Ct, US

16) Farrell, M.: 1957, The Measurement of Productive Efficiency, Journal of the Royal Statistical Society, Series A, 120(3): 253-290

17) Gao, Yan, et al, 2007: The Experiment of Function of Biogas Digester with Heat Preservation in Winter at High-latitude Area: Modern Agriculture, 2007(12):35-36; 高艳，等，2007:《高寒地区整体保温沼气池越冬试验》:《现代农业》

18) Gold Standard Foundation, 2008: GS VER Methodologies, Geneva, [accessed 12/12/2008], Available: http://www.cdmgoldstandard.org/materials.php?id=102

19) Google Earth, [accessed 12/09/2008]: Shanxi, Datong

20) Greene, William: 2003, Distinguishing between Heterogeneity and Inefficiency; Stochastic Frontier Analysis of the World Health Organization's Panel Data on National Health Care Systems, [accessed 08/01/2009], Available: http://pages.stern.nyu.edu/~wgreene/

21) Groisman, Pavel Ya. and Easterling, David R., 1994: Precipitation Changes over the Northern Hemispheric Extratropics during Last Hundred Years, Global Precipitation and Climate Change (edit by Debois, Michel and Desalmand, Francoise), Springer-Verlag, Berlin, p119-133

22) GTZ, 1981: Biogas in the People's Republic of China; Project Report, GTZ, Eschborn, Germany, P7

23) Held, Isaac M. and Soden, Brian J., 2000: Water Vapor Feedback and Global Warming, Annual Review of Energy and the Environment, 25, November 2000 p441-475

24) Herrera, Santiago, Pang, Gaobo, 2005: Efficiency of Public Spending in Developing Countries: an Efficiency Frontier Approach, [accessed 09/01/2009],

Available:
http://www1.worldbank.org/publicsector/pe/PEAMMarch2005/EfficiencyofPublicSpendingin.pdf

25) Hinostroza, Miriam, et al, 2007: Potentials and Barriers for End-use Energy Efficiency under Programmatic CDM, UNEP and UNEP Risoe Centre, Roskilde, DK, p1

26) IEA, 2004: Renewable Energy; Market & Policy Trends in IEA Countries, OECD Publishing, p70, [accessed 10/06/2008], Available:http://www.iea.org/textbase/nppdf/free/2004/renewable1.pdf

27) IEA, 1991: Greenhouse Gas Emission; the Energy Dimension, OECD Publishing, p14-20

28) Ihori, Toshihiro, 2000: Efficiency of Disaggregate Public Capital Provision in Japan, [accessed 10/06/2008], Available: http://www.e.u-tokyo.ac.jp/cirje/research/dp/2000/2000cf75.pdf

29) IPCC, 2008: Climate Change 2007: Synthesis Report, Washington, p30-36, [accessed 10/06/2008], Available: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

30) Kolumbus, 2007, [accessed 12/06/2008], Available: http://www.kolumbus.fi/suomen.biokaasukeskus/en/enperus.html

31) Lapin, M., 1994: Possible Impacts of Climate Change upon the Water Balance in Central Europe, Global Precipitation and Climate Change (edit by Debois, Michel and Desalmand, Francoise), Springer-Verlag, Berlin, p162-170

32) Li, Kangmin and Ho, Mae-wan, 2006: Biogas China, Science in Society, 2006 (32): 34,
[accessed 10/06/2008], Available: http://www.i-sis.org.uk/full/pdf/sis32.pdf

33) Li, Jingming, 2006: Rural Biogas Development in China, p2-3, [accessed 10/06/2008], Available:
http://www.methanetomarkets.org/resources/ag/docs/china_profile.pdf

34) Local Government of Datong Xian, 2008: Statistics Year Book of Datong Xian, 2007(大同县年鉴 2007); Datong, p2-14

35) Mandl, Ulrike, et al, 2008: The Effectiveness and Efficiency of Public Spending, EU Publishing, Brussels, p4, [accessed 09/01/2009], Available: http://ec.europa.eu/economy_finance/publications/publication11902_en.pdf

36) Mayntz, Renate, 2004: Governance in Modern State, Governance Regieren in komlexen Regelsystemen (edit by Benz, A.), Wiesbaden, p66

37) Methane to Market, 2008, [accessed 12/06/2008], Available: http://www.methanetomarkets.org/about/methane.htm

38) McGarry, Michael and Stainforth, Jill, 1978: Compost, Fertilizer, and Biogas Production from Human and Farm Waste in the People's Republic of China, International Development Research Centre, P71

39) National Development and Reform Commission,: National Action Plan Against Climate Change of China 中国应对气候变化国家方案, Beijing, p26-28, [accessed 7/01/2009], Available:http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/File189.pdf

40) National Development and Reform Commission: China's Policies and Actions for Addressing Climate Change 中国应对气候变化的政策与行动, Beijing, p26-28, [accessed 21/01/2009], http://bb.china-embassy.org/chn/xwdt/P020081110750388638623.pdf

41) Netherlands Environmental Assessment Agency, 2006: Global Greenhouse Gas Emission Increased 75% since 1970, [accessed 12/06/2008], Available: http://www.mnp.nl/en/dossiers/Climatechange/TrendGHGemissions1990-2004.html

42) Netherlands Environmental Assessment Agency, 2008: Global CO2 Emissions: Increase Continued in 2007, [accessed 12/06/2008], Available: http://www.mnp.nl/en/publications/2008/GlobalCO2emissionsthrough2007.html

43) New Economic Foundation, 2007: Chinadependence – the Second UK Interdependence Report, London, p10, [accessed 7/01/2009], Available: http://www.neweconomics.org/gen/uploads/fmq2gmn5w2dn2qemwoor0m4505102007192709.pdf

44) Petit-Maire, Nicole, 1994: Natural Variability of the Asian, Indian and African Monsoons over the last 130 KA (130,000 years), Global Precipitation and Climate Change (edit by Debois, Michel and Desalmand, Francoise), Springer-Verlag, Berlin, p3-15

45) Rohde, Robert A., 2008, [accessed 01/06/2008], Available: http://www.globalwarmingart.com/wiki/Image:Greenhouse_Effect_png

46) Parkinson, J. E. 1994: Corporate Power and Responsibility, Oxford University Press, Oxford, GB, p59

47) P.R.C., Ministry of Agriculture, 1987, 2002: Architectural Codes of Hydrostatic Biogas Digester in Rural Area《农村水压式沼气池标准图集》(GB/T4750-2002); Operation Regulations of Hydrostatic Biogas Digester in Rural Area 《农村家用水压式沼气池试工操作规范》 (GB/T4752-2002); Design Codes of Pipes of

Biogas Digester in Rural Area《农村家用沼气管路设计规范》(GB/T7636-87); Operation Regulations of Pipes Construction of Biogas Digester in Rural Area《农村家用沼气管路施工安装操作规程》(GB/T7637-87)

48) P.R.C., Ministry of Agriculture, 1999: Framework of the National Fund for the Implementation of Biogas-household Program 《农村沼气建设项目国债管理办法(试行)》,p8, [accessed 04/06/2008], Available: http://www.jincao.com/fa/law25.31.htm#04

49) P.R.C., Ministry of Agriculture, 2006: National Action Plan for Biogas-household Program in Rural Area (2006-2010) 《全国农村沼气工程建设规划》, Beijing, p8,10,30,36, [accessed 04/06/2008], Available: http://www.agri.gov.cn/xztz/P020070418570346665578.doc

50) Risse, Thomas and Lehmkuhl, Ursula, 2006: Governance in Areas of Limited Statehood – New Modes of Governance? The Research Centre 700 in Free University, Berlin, p7

51) Shanxi's Department of Agriculture, 2004: Shanxi Provence's Regulations about the Acceptance of BHP Activities《山西省沼气项目验收办法(试行)》, p1-4, [accessed 30/01/2009], Available:http://ehome.gov.cn/Article/UploadFiles/20046985717188.doc

52) Sino Maps Press(中国地图出版社), 2000: Atlas of China, Beijing

53) Solomon, Jill, 2007: Corporate Governance and Accountability (second edition), John Wiley & Sons, Chichester, Great Britain, p14-15

54) Su, Fubing and Yang, Dali, 2005: Elections, Governance and Accountability in Rural China, Asian Perspective, Seoul, Vol.29, No.4, p125-157

55) UNESA, 2008: World Urbanization Prospects: The 2007 Revision Population Database, [accessed 30/01/2009], Available: http://esa.un.org/unup/index.asp?panel=1

56) UNFCCC, 2008: Glossary of CDM terms, p10, [accessed 21/01/2009], Available: http://cdm.unfccc.int/Reference/Guidclarif/glos_CDM_v04.pdf

57) Van Buren, Ariane, 1976 (reprint in 1998): A Chinese Biogas Manual: Popularizing Technology in the Countryside, Practical Action Publishing, Rugby, GB, p16

58) Weston, J. Fred, et al, 2004: Takeovers, Restructuring, and Corporate Governance (fourth edition), Pearson education, New Jersey, US, p583

59) WWF China, 2007, [accessed 25/06/2008], Available: http://www.wwfchina.org/english/loca.php?loca=496

60) Wikipedia, 2008, [accessed 07/01/2009], Available: http://de.wikipedia.org/wiki/Datong; http://en.wikipedia.org/wiki/Datong
61) Wikipedia, 2008, [accessed 12/07/2008], Available: http://en.wikipedia.org/wiki/Biogas
62) Wu, Fulong, 2002: China's Changing Urban Governance in the Transition towards a more Market-oriented Economy, Urban studies, Routledge, Vol.39, No.7, p1071-1093
63) Zhou, Junhu, et al., 2007: The Impacts on the Methane-forming Process of Biogas Production Caused by Different Sources of Sludge, Journal of Zhejiang University: 41 (5) 761-764
周俊虎， 等 , 2007: 不同污泥来源对稻草发酵产氢影响的研究: 浙江大学学报

Annex 1: Multiples

Value	Symbol	Name
10^3	K	Kilo-
10^6	M	Mega-
10^9	G	Giga-
10^{12}	T	Tera-

Annex 2: Calculation Sheet

National Biogas-household Program in China (Datong)						
Category 1 For individual household						
Source: GHG recovery in agricultural activities ties at household/small farm level						
	Parameter	Unit	Value	Description	Calculation	Reference
Baseline Emission	BE_{CH4}	TCO2e	0	Baseline emission	GWP*∑EFT*NT/103	2006 IPCC volume 4 chapter 10 P10.37 Equation10.22
	GWP_{CH4}		21	Global warming potential for CH4		
	EF_T	kg CO2/head/year	9	emission factor for Cow,		2006 IPCC volume 4 chapter 10 table 10.14, table 10.15
	N_T	head	0	the number of head of Cow		
	EF_T	kg CO2/head/year	1	emission factor for Horse,		
	N_T	head	0	the number of head of Horse		
	EF_T	kg CO2/head/year	2	emission factor for Swine,		
	N_T	head	0	the number of head of Swine		
	EF_T	kg CO2/head/year	0.1	emission factor for Sheep,		

	N_T	head	0	the number of head of Sheep		
	EF_T	kg CO2/head/year	0.01	emission factor for Poultry,		
	N_T	head	0	the number of head of Poultry		The average life time of Poultry is 9 month. Farmer feed poultry in the circle of one year once.
Program emission	PE	TCO2e	0	Project emission	$PE_{leakage}+PE_{power,y}$	
	$PE_{leakage}$	TCO2e	0	Project emission from physical leakages	LF_{AD} * [GWP_{CH4}* D_{CH4} * Bo * $VS_{m,y}$]/1000	ASM III R: Methane recovery in agricultural acitvities at household/small farm level: Project Emission
	GWP_{CH4}		21	Global warming potential for CH4		
	D_{CH4}		0.67	Conversion factor of m3 CH4 to kilogram CH4(CH4 density)		table 10A-8 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, and Chapter 10.
	Bo	m3 CH4 per kg of dm by Cow	0.13	Maximum methane producing potential of the manure type treated in the biogas digesters		table 10A4-9 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, and Chapter 11.
	VS	kg of dm per year	0	Annual amount of volatile solids treated in the biogas digesters on dry matterweight basis		
	Bo	m3 CH4 per kg of dm by Horse	0.1	Maximum methane producing potential of the manure type treated in the biogas digesters		
	VS	kg of dm per year	0	Annual amount of volatile solids treated in the biogas digesters on dry matter weight basis		

	Bo	m3 CH4 per kg of dm by Swine	0.29	Maximum methane producing potential of the manure type treated in the biogas digesters		
	VS	kg of dm per year	0	Annual amount of volatile solids treated in the biogas digesters on dry matter weight basis		
	Bo	m3 CH4 per kg of dm by Sheep	0.13	Maximum methane producing potential of the manure type treated in the biogas digesters		table 10A-9 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, and Chapter 10.
	VS	kg of dm per year	0	Annual amount of volatile solids treated in the biogas digesters on dry matter weight basis		
	Bo	m3 CH4 per kg of dm by Poultry	0.36	Maximum methane producing potential of the manure type treated in the biogas digesters		
	VS	kg of dm per year	0	Annual amount of volatile solids treated in the biogas digesters on dry matter weight basis		
	LF_{AD}		0	fraction of Leakage emission from anarobic digesters		
	$PE_{power,y}$	TCO2e	0	Emission from the use of fossil fuel or electricity for the operation of the installed facilities		
Emission Reduction	ER	TCO2e	0	GHG emission reduction caused by this source	BE-PE	

National Biogas-household Program in China (Datong)						
Category 1 For individual household						
Source: Landfill GHG recovery						
	Parameter	Unit	Value	Description	Calculation	Reference
Baseline Emission	BE	tCO2	0	Baseline emission	$\phi*(1-f)GWP_{CH4}*(1-OX)*16/12*F*DOC_f*MCF*\sum W_{j,x}*DOC_j*e^{-kj*(y-x)}*(1-e^{-kj})$	Methodological Tools for SSC: Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site
	j		0.9	Model correction factor to account for model uncertainties		
	f		0%	Fraction of methane captured at the SWDS and flared, combusted or used in another manner		
	GWP_{CH4}		21	Global warming potential of methane		
	OX		0	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)		unmanaged waste disposal point: 0
	F		0.5	Fraction of methane in the SWDS gas		
	DOC_f		0.5	Fraction of degradable organic carbon that can decompose		
	MCF		0.4	Methane correction factor		Un-management-shallow waste disposal point

	$W_{j,x}$	Tons	0	Amount of organic waste type j prevented from disposal in the SWDS in the year x		
	DOC_j		0.15	Fraction of degradable organic carbon(by weight) in the waste type j		temp<20.C MAP/PET<1
	K_j		0.06	Decay rate for the waste type j		
	x		20	Year during the crediting period: X runs from the first year of the first crediting period(x=1) to the year y for which avoided emissions are calculated (x=y)		
	y		1	year for which methane emissions are calculated		
Program Emission	PE		0	Program emission	$PE_{power,y}$	
	$PE_{power,y}$		0	Emission from the use of fossil fuel or electricity for the operation of the installed facilities		o in rural area
Emission Reduction			0	GHG emission reduction caused by this source	BE-PE	

National Biogas-household Program in China (Datong)
Category 1 For individual household

Source: GHG recovery in human excreta management system						
	Parameter	Unit	Value	Description	Calculation	Reference
Baseline Emission	BE	tCO2	0	Baseline emission	$\sum(U_i*T_{ij}*EF_j)(TOW-S)-R$	2006 IPCC volume 5 chapter 6 Equation 6.1
	TOW	kg/BOD/year	0	total organics in wastewater	P*BOD*0.001*I*365	
	S	kg/BOD/year	0	organic component removed as sludge		
	U_i		1	fraction of population in income group i		
	T_{ij}		0.5	degree of utilization of treatment/discharge system		2006 IPCC volume 5 chapter 6 Table 6.5
	EF	$kgCH_4/kgBOD$	0.3	Emission factor	Bo*MCF	
	R	$kgCH_4/yr$	0	Amount of CH4 recovered		
	Bo	$kgCH_4/kgBOD$	0.6	Maximum CH4 producing capacity		2006 IPCC volume 5 chapter 6 Table 6.2
	MCF		0.5	Methane correction factor		2007 IPCC volume 5 chapter 6 Table 6.3
	P		0	population involved in the boundary		
	BOD	g/peoson/day	40	per capita BOD inside the boundary		2007 IPCC volume 5 chapter 6 Table 6.4
	I		1	Correction factor for additional input		
Program Emission	PE		0	Program emission		

Emission Reduction			0	GHG emission reduction caused by this source	BE-PE	

National Biogas-household Program in China (Datong)						
Category 1 For individual household						
Source: Thermal energy for the user with or without electricity						
	Parameter	Unit	Value	Description	Calculation	Reference
Baseline Emission	BE	tCO2	0	Baseline emission	$BE_{fuel}+BE_{elec.}$	The category comprises Biogas that supplies individual households or users with the renewable energy to replace fossil fuels. (CDM SSC TYPE Ⅰ C)
	$BE_{elec.}$	tCO2	0	Emission from the electricity consume		Q*EF/1000
	Q	KWh	0	Quantity of electricity consume		
	EF	kgCO2/KWh	0.79734	Emission factor of electricity		Chinese DNA's Guideline of Emission Factor of Chinese Electricity Grid
	BE_{fuel}	tCO2	0	Emission from the fuel consume, biomass, coal, LPG(liquefied petroleum gas)…		$\sum Q_{fuel,i}*EF_i/E_i$
	$Q_{fuel,coal}$	kg	0	Quantity of fuel type i consume		
	EF	kg CO2/kJ	94.6	Emission factor of coal		IPCC 2006 Volume 2 P1.23 Table1.4
	F	kJ/kg	0.0282	Energy content of coal		IPCC 2006 Volume 2 P1.18 Table1.2
	$E_{coal\ stove}$		0.3	Efficiency of the plant using fuel coal		

	$Q_{fuel,LPG}$	kg	0	Quantity of fuel type LPG consume		
	EF	kg CO2/kJ	63.1	Emission factor of fuel:LPG		IPCC 2006 Volume 2 P1.23 Table1.4
	F	kJ/kg	0.0473	Energy content of LPG		IPCC 2006 Volume 2 P1.18 Table1.2
	$E_{LPG\ stove}$		0.9	Efficiency of the plant using fuel LPG		
	$Q_{fuel,wood}$	kg	0	Quantity of fuel wood consume		
	EF	kg CO2/kJ	112	Emission factor of fuel: wood		IPCC 2006 Volume 2 P1.23 Table1.4
	F	kJ/kg	0.0156	Energy content of coal		IPCC 2006 Volume 2 P1.18 Table1.2
	$E_{wood\ stove}$		0.3	Efficiency of the plant using fuel: wood		
Program Emission	PE		0	Program emission		
Emission Reduction			0	GHG emission reduction caused by this source	BE-PE	

National Biogas-household Program in China (Datong)						
Category 1 For individual household						
Source: Non-CO2 GHG emission from biomass burning						
	Parameter	Unit	Value	Description	Calculation	Reference
Baseline Emission	BE_{CH4}	tCO2	0	Baseline emission of CH4	GWP_{CO}*A•MB •C_f •Ge_f•10^{-3}	CH4 emission from the biomass burning at the crop-land

						(Volume 4, 5.2.4 & Equation 2.27, IPCC Inventory)
CH_4	MB	T/ha	0	mass of fuel available for combustion		(wheat residues 4.0; Maize residues 10.0; rice residues 5.5; sugarcane 6.5 chapter 2 Table 2.4)
	GWP_{CH4}		21	Global warming potential for N_2O		
	A	ha		area burnt		
	C_f		0.9	combustion factor		
	Ge_f	G/kg dry matter burnt	2.7	emission factor		
Program Emission	PE		0	Program emission		
Emission Reduction			0	GHG emission reduction caused by this source	BE-PE	

National Biogas-household Program in China (Datong)						
Category 2 For large scale biogas digester						
Source: Methane recovery in animal manure management system						
	Parameter	Unit	Value	Description	Calculation	Reference
Baseline Emission	BE_{CH4}	tCO2	0	Baseline emission of CH4	GWP_{CH4} $*D_{CH4}*UF_b*\sum MCF_j$ * $B_{0,LT}*N_{LT,y}*$ $VS_{LT,y}*$ $MS\%_{Bl,j}$	ASM III D: Methane recovery in animal manure management systems

	GWP_{CH4}		21	Global warming potential		
	D_{CH4}	t/m3	0.00067	CH4 density		
	MCFj		0.66	Annual CH4 conversion factor for the baseline animal waste management system		2006 IPCC volume 4 chapter 10 table 10.17
	$B_{0,LT}$		0.13	Maximum CH4 producing potential of VS generated for Cow		
	$N_{LT,y}$		0	Annual average number of animal of Dairy Cow		
	$VS_{LT,y}$	a dry matter weight basis, kg dm/animal/year	102.2	Volatile solid for Dairy Cow entering the animal manure management system		
	$B_{0,LT}$		0.29	Maximum CH4 producing potential of VS generated for Swine		
	$N_{LT,y}$		0	Annual average number of Market Swine		Life time is 4.5 month.
	$VS_{LT,y}$	a dry matter weight basis, kg dm/animal/year	109.5	Volatile solid for Swine entering the animal manure management system in year "y"		
	$MS\%_{Bl,j}$		100%	Fraction of manure handle in baseline animal manure management system		
	UF_b		0.94	model correction factor to account for model uncertainties		

Program Emission	PE	tCO2	0	Program emission	$PE_{PL,y}$ + $PE_{flare,y}$ +$PE_{power,y}$	
	$PE_{PL,y}$	tCO2	0	Program emission due to the physical leakage	LF_{AD}*GWP_{CH4} *D_{CH4}*$\sum B_{0,LT}$*$N_{LT,y}$* $VS_{LT,y}$* $MS\%_{Bl,j}$	
	LF_{AD}		0.1	fraction of Leakage emission from anaerobic digesters		Default value
	GWP_{CH4}		21	Global warming potential		
	D_{CH4}	t/m3	0.00067	CH4 density		
	$B_{0,LT}$		0.13	Maximum CH4 producing potential of VS generated for Cow		
	$N_{LT,y}$		0	Annual average number of animal of Dairy Cow		
	$VS_{LT,y}$	a dry matter weight basis, kg dm/animal/year	102.2	Volatile solid for Dairy Cow entering the animal manure management system		
	$B_{0,LT}$		0.29	Maximum CH4 producing potential of VS generated for Swine		
	$N_{LT,y}$		0	Annual average number of Market Swine		Life time is 4.5 month.
	$VS_{LT,y}$	a dry matter weight basis, kg dm/animal/year	109.5	Volatile solid for Swine entering the animal manure management system in year “y”		
	$MS\%_{Bl,j}$		100%	Fraction of manure handle in baseline animal manure management system		

	PE $_{flare,y}$	tCO2	0	emission from flaring or combustion of the biogas stream		
	PE $_{power,y}$	tCO2	0	emission from the use of fossil fuel or electricity for the operation of the installed facilities		
	Q	KMh				
	CEF_{grid}	kg CO2e/ kWh	2	emission coefficient for electricity consume		
Emission Reduction			0	GHG emission reduction caused by this source	BE-PE	

National Biogas-household Program in China (Datong)						
Category 2 For large scale biogas digester						
Source: Grid connected renewable electricity generation						
	Parameter	Unit	Value	Description	Calculation	Reference
Baseline Emission	$BE_{baseline}$	tCO2	0	GHG emission caused by elec. production that is replaced by Clean elec.	EP_{bio} * CEF_{grid}	This category comprises biogas working as renewable energy generation that supplies electricity to replace the use of fossil fuel fired generation unit.(CDM SSC TYPE Ⅰ D)
	EP_{bio}	MWh	0	Electricity produced by the biogas generator unit for grid electricity replacement		
	CEF_{grid}	kg CO2e/ kWh	0.79734	emission coefficient for electricity grid		
	$KE_{Yanggao}$	kWh	0	Electricity generating capacity of		

				Yanggao		
	KE_{Yubao}	kWh	0	Electricity generating capacity of Yubao		
Program Emission	PE		0	Program emission		
Emission Reduction			0	GHG emission reduction caused by this source	BE-PE	

National Biogas-household Program in China (Datong)						
Category 2 For large scale biogas plant						
Source: Thermal energy for the user with or without electricity						
	Parameter	Unit	Value	Description	Calculation	Reference
Baseline Emission	BE	tCO2	0	Baseline emission	$BE_{fuel}+BE_{elec.}$	The category comprises Biogas that supplies individual households or users with the renewable energy to replace fossil fuels. (CDM SSC TYPE Ⅰ C)
	$BE_{elec.}$	tCO2	0	Emission from the electricity consume	Q*EF/1000	
	Q	KWh	0	Quantity of electricity consume		
	EF	kgCH4/KWh	0.79734	Emission factor of electricity		
	BE_{fuel}	tCO2	0	Emission from the fuel consume, biomass, coal, LPG(liquefied	$\sum Q_{fuel,i}*EF_i/E_i$	

				petroleum gas)…		
	$Q_{fuel,i}$	kg	0	Quantity of fuel type i consume		
	EF	kgCH4/kg	1	Emission factor of fuel type i		
	E_i		0.3	Efficiency of the plant using fuel i		
Program Emission	PE		0	Program emission		
Emission Reduction			0	GHG emission reduction caused by this source		

National Biogas-household Program in China (Datong)						
Category 3 For Improved biomass stove						
Source: Switch from Non-renewable fuel for thermal application by the user						
	Parameter	Unit	Value	Description	Calculation	Reference
	$NCV_{brown\ coal\ riquettes}$	TJ/Gg	20.7	Net calorific value of brown coal briquettes that is substituted		2006 IPCC volume 2 table 1.2
	$EF_{brown\ coal\ briquettes}$	kg CO2/TJ	97500	Effective CO2 emission factor of brown coal briquettes		2006 IPCC volume 2 chapter 2 table 1.4
	N		0	Number of stove		

	B	kg	0	Quantity of coal used in the absence of the project activity annually		about the treatment of biomass, see 2.3.3.4
Emission Reduction	ER	tCO2	0	GHG emission reduction by one stove	N*B*EF*NCV	

Annex 3: Questionnaire

1. Basic information

   Region: Sex:

   Family member: The capacity of his/her biogas digester: m^3/d

   Since when, you start to use biogas:

2. Data collection

   2.1 What are the energy sources in the absence of Biogas-household program? How much would they consume?

   A. Coal B. Wood fuel C. LPG(Liquefied Petroleum Gas)

   D. Electricity E. Others __________________

   The amount of these energy consume: ___________________

   2.2 Livestock types and numbers

   A. Chickens B. Swine C. Cows

   D. Sheep E. Others __________________

   The numbers of these livestock: _____________

   The days that livestock could live: ____________

   2.3 The amount of waste (food waste, garden waste, et al) that would be used in the biogas digester?

   ____

   2.4 The amount of biomass used in the biogas digester, which would be combusted after the harvest in the absence of Biogas-household program.

   ____

3. Attitudes

   3.1 How would you evaluate the Biogas-household program?

   A. satisfied B. basically satisfied C. No change to my life

   D. Very Bad if choose D, the reason is __________________

   3.2 How much do you know the Biogas-household program in China?

   A. I don’t know at all. B. Just a little.

   C. I know a lot. if choose C, how did you get to know it _________

   3.3 In which forms would the subsidy from government arrives your hand?

   A. Cash B. Construction material C. Technological support

D. Others _________

3.4 Is the subsidy important?

A. Yes, very important. B. Just better than none. C. Not important.

If you have something to supplement? ________

3.5 How do you get finance for the rest part of the cost of biogas plant?

A. Money saved by myself B. Loan from bank

C. Borrow money from other people with interest

D. Borrow money from other people without interest E. Others ________

3.7 During the implementation of Biogas-household program, where did you obtain knowledge and technology referred to biogas and operation?

A. From the bullet and train organized by government

B. From books and media C. From other people

D. I have no knowledge about them.

3.8 What kind of role does the government play in Biogas-household program?

A. Very important B. Important, but less than what I expect.

C. I don't think the government makes any sense in this program.

Tell me, in your opinion, where should be improved in the implementation of Biogas-household program?

3.9 Since next 5 years, the national and local government would pay lots of money and energy on Biogas-household program, What is your perspective for this program?

Annex 4: Information of Interviewees

Li, Xiulong	李秀龙	Male	倍加造镇解庄村	Beijiazao Xiang	Xiezhuang Cun	Oct,2007
Lv, Jin	吕进	Male	杜庄乡落镇营村	Duzhuang Xiang	Luozhenying Cun	Oct,2007
Ding, Zhuang	丁壮	Male	巨乐乡塔儿村	Jule Xiang	Ta'er Cun	Oct,2007
Ding, Chun	丁春	Male	巨乐乡塔儿村	Jule Xiang	Ta'er Cun	Oct,2007
Liu, Chengrui	刘成瑞	Male	巨乐乡下羊落村	Jule Xiang	Xiayangluo Cun	Oct,2007
Wang, Shouguan	王守官	Male	西坪镇官堡村	Xipin Xiang	Guanbu Cun	Oct,2007
Yang, Zuo	杨作	Male	西坪镇上高庄村	Xipin Xiang	Shanggaozhuang Cun	Oct,2007
Xu, Hong	徐红	Male	西坪镇水头村	Xipin Xiang	Shuitou Cun	Nov,2007
Ge, Ming	葛明	Male	西坪镇寺上村	Xipin Xiang	Sishang Cun	Oct,2007
Yang, Gen	杨根	Male	西坪镇唐家堡村	Xipin Xiang	Tangjiabu Cun	Nov,2007
Gou, Gang	苟刚	Male	西坪镇坨坊村	Xipin Xiang	Tuofang Cun	Oct,2007
Liu, Yong	刘永	Male	西坪镇西坪村	Xipin Xiang	Xipin Cun	Oct,2007
Wei, Quan	魏全	Male	许堡乡集仁村	Xubao Xiang	Jiren Cun	Nov,2007
Song, Zhiyuan	宋志元	Male	许堡乡肖家窑头村	Xubao Xiang	Xiaojiaoyaotou Cun	Nov, 2007
Du, Tianli	杜天礼	Male	许堡乡许堡村	Xubao Xiang	Xubao Cun	Nov, 2007
Liu, Runchai	刘润才	Male	许堡乡养老洼村	Xubao Xiang	Yanglaowa Cun	Nov,2007
Bai, Fucai	白福才	Male	周士庄镇后铺村	Zhoushizhuang Xiang	Houpu Cun	Oct,2007
Yang, Cuntian	杨存田	Male	周士庄镇后铺村	Zhoushizhuang Xiang	Houpu Cun	Oct,2007
Wang,Yufu	王玉福	Male	周士庄镇后铺村	Zhoushizhuang Xiang	Houpu Cun	Sep,2006
Wu, Cheng	武成	Male	周士庄镇架遇造村	Zhoushizhuang Xiang	Jiayuzao Cun	Oct,2007
Zhou, Shengcai	周生才	Male	周士庄镇驾遇造村	Zhoushizhuang Xiang	Jiayuzao Cun	Sep, 2007
Dang, Wen	党文	Male	周士庄镇孟家宅村	Zhoushizhuang Xiang	Mengjiazhai Cun	Oct,2007
Zhao, Hai	赵海	Male	周士庄镇上庄村	Zhoushizhuang Xiang	Shangzhuang Cun	Nov,2007
Feng, Yong	冯勇	Male	周士庄镇西羊坊村	Zhoushizhuang Xiang	Xiyangfang Cun	Nov,2007
Li, Jiang	李江	Male	巨乐乡吴家洼村	Jule Xiang	Wujiawa Cun	Oct,2007
Guo, Ailian	郭爱莲	Female	倍加造镇郭家窑头村	Beijiazao Xiang	Guojiayaotou Cun	Jun, 2007
Wang, Ji	王继	Male	倍加造镇郭家窑头村	Beijiazao Xiang	Guojiayaotou Cun	Jun, 2007
Yang, Jie	杨杰	Male	倍加造镇郭家窑头村	Beijiazao Xiang	Guojiayaotou Cun	July, 2007

Li, Baolong	李宝龙	Male	倍加造镇郭家窑头村	Beijiazao Xiang	Guojiayaotou Cun	Sep,2006
Li, Haiwu	李海武	Male	党留庄乡新胜村	Dangliuzhuang Xiang	Xinsheng Cun	Oct,2007
Liu, Changbao	刘常保	Male	党留庄乡邢庄	Dangliuzhuang Xiang	Xinzhuang Cun	Oct,2007
Qi, Wanshan	齐万山	Male	瓜园乡吴家洼村	Guayuan Xiang	Wujiawa Cun	Oct,2007
Fan,Wenlin	范文林	Male	巨乐乡五里台村	Jule Xiang	Wulitai Cun	Nev,2007
LI, Fa	李发	Male	巨乐乡小北庄村	Jule Xiang	Xiaobeizhuang Cun	Oct,2007
Wu,Yong	吴勇	Male	巨乐乡下养落	Jule Xiang	Xiayangluo Cun	Oct,2007
Zhang,Sijian	张司建	Male	党留庄乡候大庄	Dangliuzhuang Xiang	Houdazhuang Cun	Sep, 2007
Wang, Yigen	王一根	Male	瓜园乡梁庄村	Guayuan Xiang	Liangzhuang Cun	Nov,2007
Yan, He	闫和	Male	瓜园乡西紫峰村	Guayuan Xiang	Xizifeng Cun	Oct,2007
Zhang,Shilin	张世林	Male	吉家庄乡古定桥村	Jijiazhuang Xiang	Gudingqiao Cun	Nov,2007
Chai, Shenggao	柴圣高	Male	吉家庄乡麻峪口村	Jijiazhuang Xiang	Mayukou Cun	Nov,2007
Xu,Jinwen	许进文	Male	吉家庄乡南栋庄村	Jijiazhuang Xiang	Nandongzhuang Cun	Nov,2007
Chen,Zhibing	陈志兵	Male	吉家庄乡王渐曈村	Jijiazhuang Xiang	Wangjiantong Cun	Nov,2007
Ren, Hao	任好	Male	吉家庄乡西浮头村	Jijiazhuang Xiang	Xifutou Cun	Nov,2007
Gong,Bao	龚保	Male	西坪镇大坊城村	Xipin Xiang	Dafangcheng Cun	Oct,2007
Sun, Ping	孙平	Male	倍加造镇独树村	Beijiazao Xiang	Dushu Cun	Nov, 2007
Liu, Xi	刘喜	Male	倍加造镇独树村	Beijiazao Xiang	Dushu Cun	Aug,2007
Guo,Cheng	郭成	Male	倍加造镇郭家窑头村	Beijiazao Xiang	Guojiayaotou Cun	Sep,2006
Guo,Ai	郭爱	Male	倍加造镇郭家窑头村	Beijiazao Xiang	Guojiayaotou Cun	Aug,2006
Zhang,Yuan	张元	Male	倍加造镇解庄村	Beijiazao Xiang	Xiezhuang Cun	Jun, 2008
Jin,You	靳有	Male	倍加造镇营坊沟村	Beijiazao Xiang	Yingfanggou Cun	Jun, 2007
Du, Ming	杜明	Male	杜庄乡长安村	Duzhuang Xiang	Chang'an Cun	Oct,2007
Liu, Bing	刘兵	Male	杜庄乡杜庄村	Duzhuang Xiang	Duzhuang Cun	Nov, 2007
Tian, Zhong	田忠	Male	杜庄乡千千村	Duzhuang Xiang	Qianqian Cun	Nov, 2007
Li, Fu	李福	Male	杜庄乡苏家宅村	Duzhuang Xiang	Sujiazhai Cun	Oct,2007
Wang, Rilong	王日龙	Male	峰峪乡峰峪村	Fengxu Xiang	Fengyu Cun	Oct,2007
Wang, Yousheng	王有生	Male	峰峪乡小王村	Fengxu Xiang	Xiaowang Cun	Oct,2007
Zhao,Shoubi	赵守毕	Male	峰峪乡西后口村	Fengxu Xiang	Xihoukou Cun	Nov,2007
Xu, Yuanshun	徐元顺	Male	峰峪乡徐家堡村	Fengxu Xiang	Xujiabao Cun	Oct,2007
Zhao, Shengzhu	赵生柱	Male	峰峪乡杨庄村	Fengxu Xiang	Yangzhuang Cun	Oct,2007
Liang, Shuqing	梁树清	Male	瓜园乡北石山村	Guayuan Xiang	Beishishan Cun	Nov,2007
He,Shouwen	贺守文	Male	瓜园乡李汪涧村	Guayuan Xiang	Liwangjian Cun	Nov, 2007
Zhen, Biao	郑彪	Male	巨乐乡张庄村	Jule Xiang	Zhangzhuang Cun	Oct,2007

Du,Wen	杜文	Male	巨乐乡张庄村	Jule Xiang	Zhangzhuang Cun	Oct,2007
Zhang,Pin	张平	Male	西坪镇康店村	Xipin Xiang	Kangdian Cun	Sep,2007
Chen, Shanlin	陈善林	Male	西坪镇康秀村	Xipin Xiang	Kangxiu Cun	Oct,2007
Chai, Shougong	柴守攻	Male	许堡乡清泉村	Xubao Xiang	Qinquan Cun	Nov,2007
Guo,Yucai	郭玉才	Male	周士庄镇三府村	Zhoushizhuang Xiang	Sanfufen Cun	Jun,2007
Zhang,Sheng long	张生龙	Male	周士庄镇周士庄村	Zhoushizhuang Xiang	Zhoushizhuang Cun	Sep,2006

Annex 5: Schedule of the thesis

Time / Steps	Apr. 2008	May 2008	June 2008	July 2008	Aug. 2008	Sep. 2008	Oct. 2008	Nov. 2008	Doc. 2008	Jan. 2009	Fe. 2009
Subject searching											
Background info. collection											
Introduction											
Methodology											
Survey design											
Survey implementation											
Calculation and Analysis											
Conclusion											
Review of first version											
Review of second version											
Review of third version											
Final version											

List of Charts

List of Tables

List of Pictures