Biogas Toilets and Use of Methane in China

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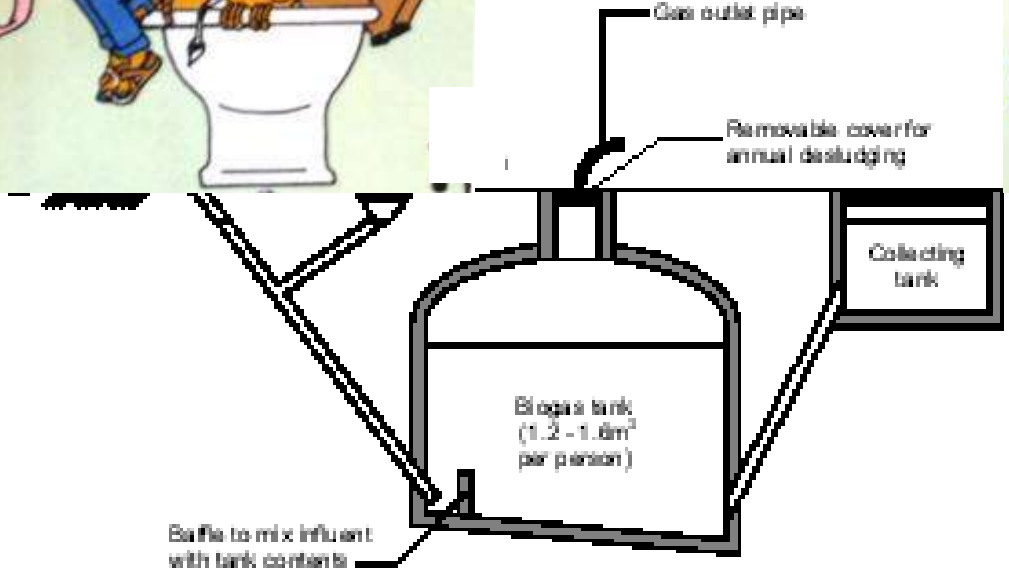
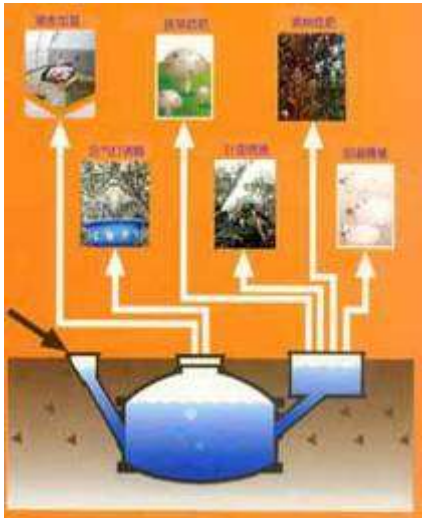
Closed loop on-site sanitation

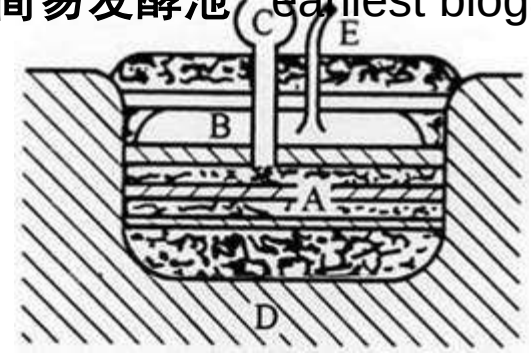


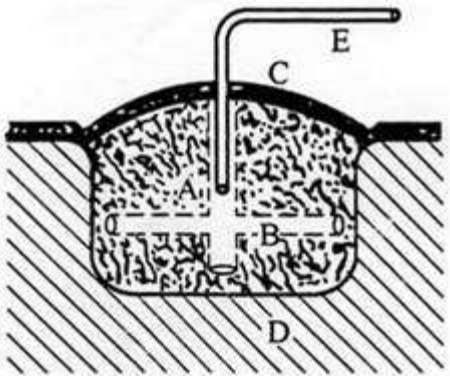


户用沼气的应用
Biogas using household appliances

中国沼气发展回顾
Biogas in China--history

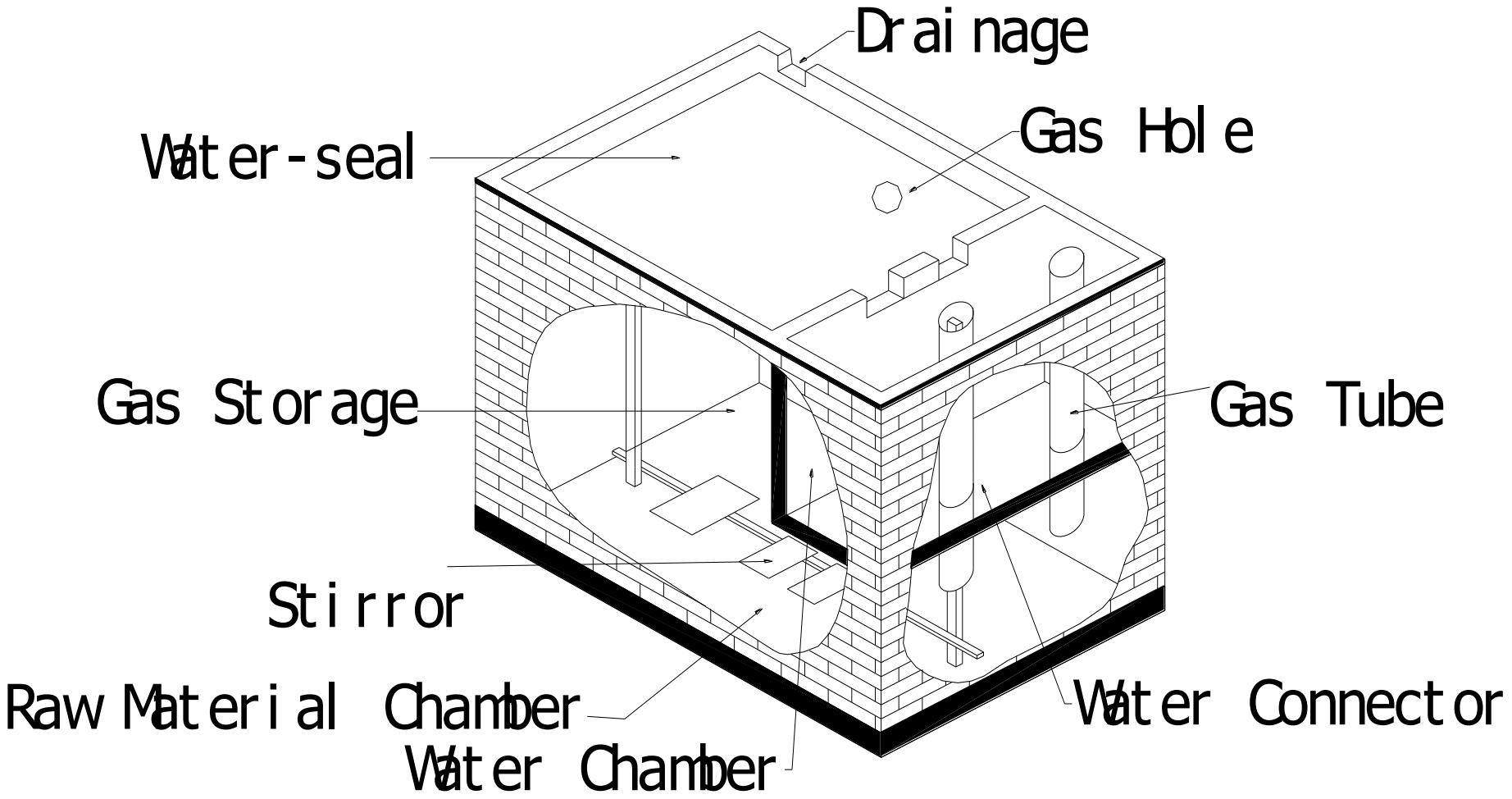
早期的简易发酵池 earliest biogas fermentation pool

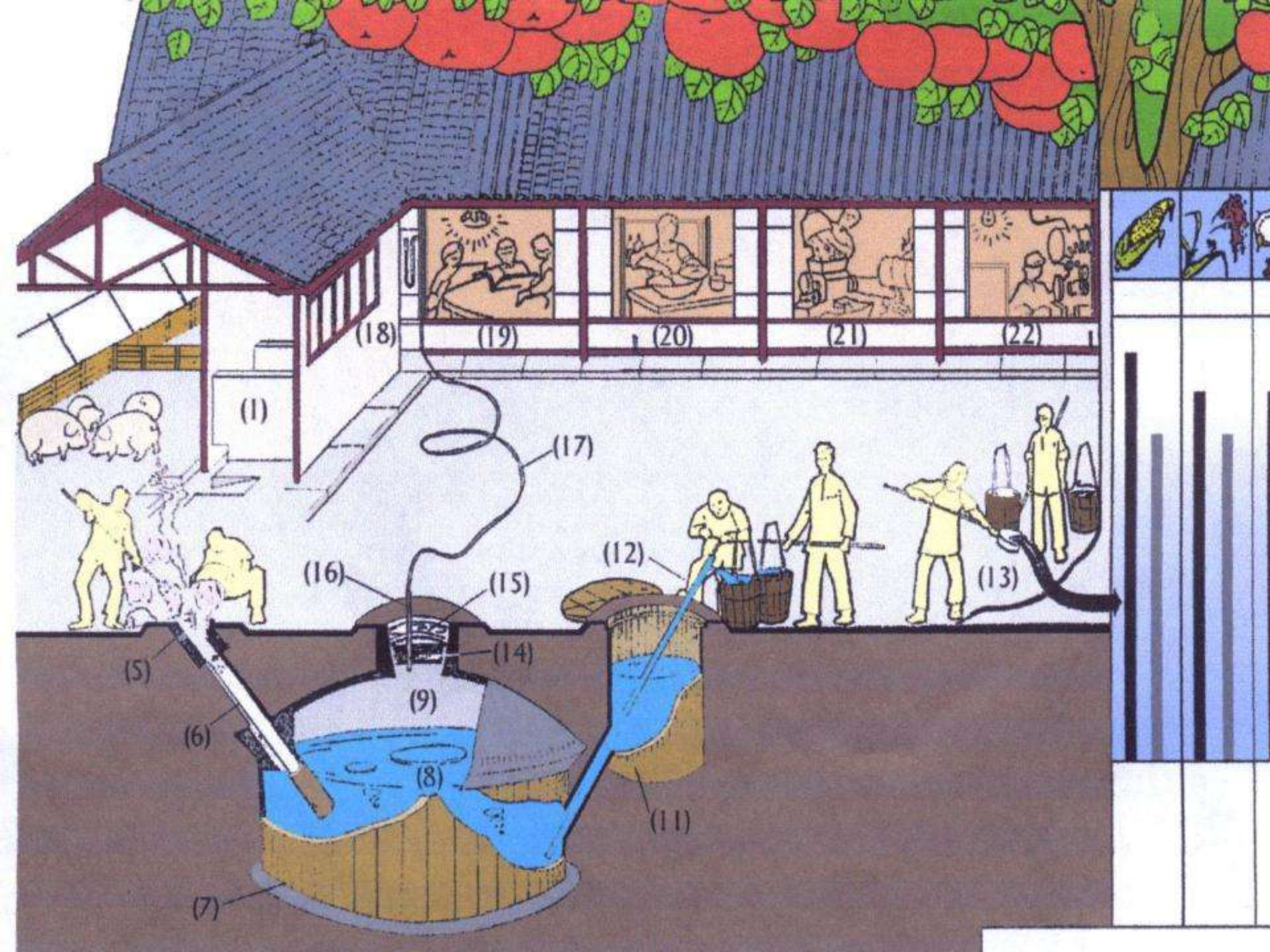




A. 发酵池　pool for fermentation;
B. 储气室　biogas storage;
C. 池盖　cover;
D. 地基　groundwork;
E. 输气管　biogas tube.

In the 1920's Luo Guori's digester

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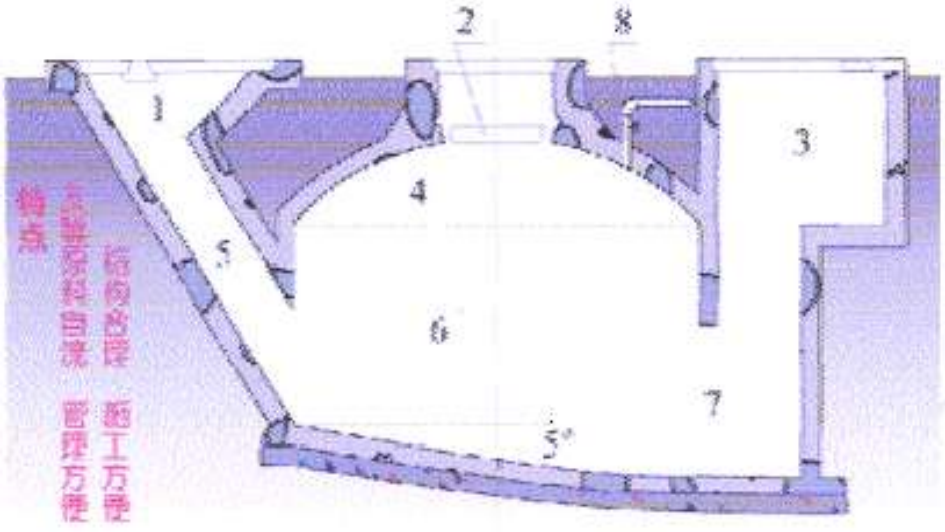
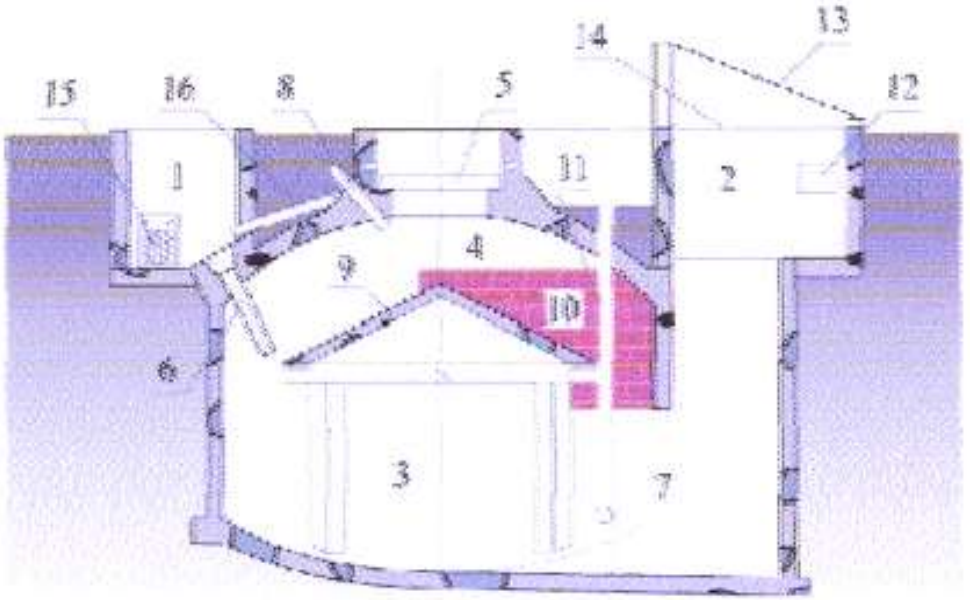
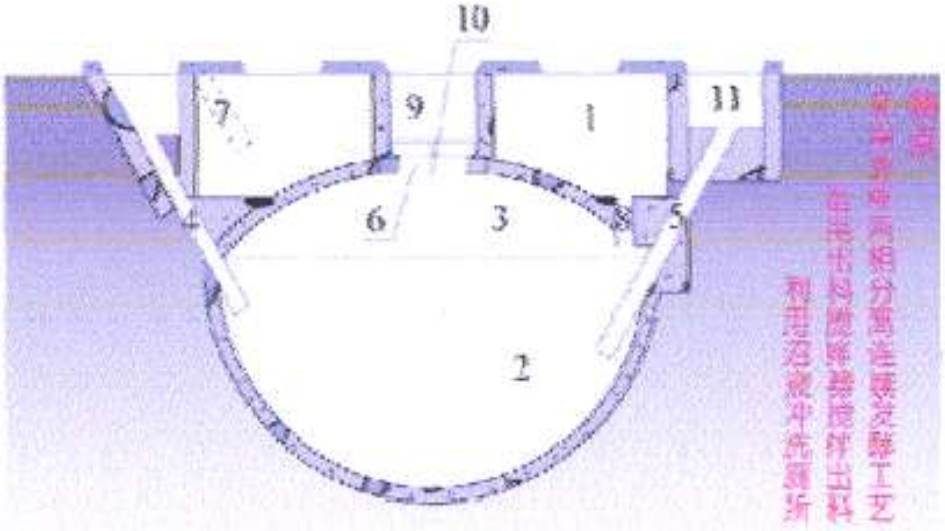
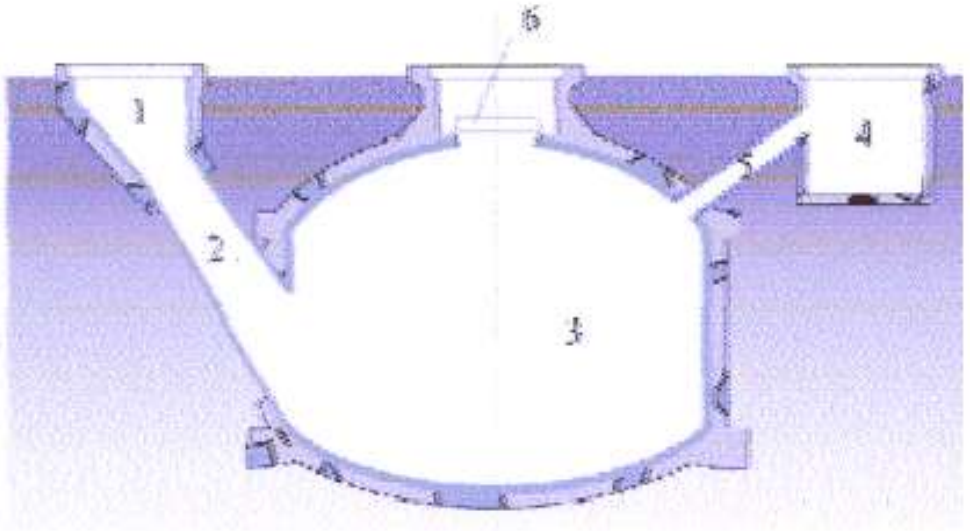
典型户用沼气池









Since 2000, also biogas digesters of glass fiber reinforced plastic are commercialized


新家园
HZB-6 旋流布料玻璃钢沼气池
西北农林科技大学设计研制
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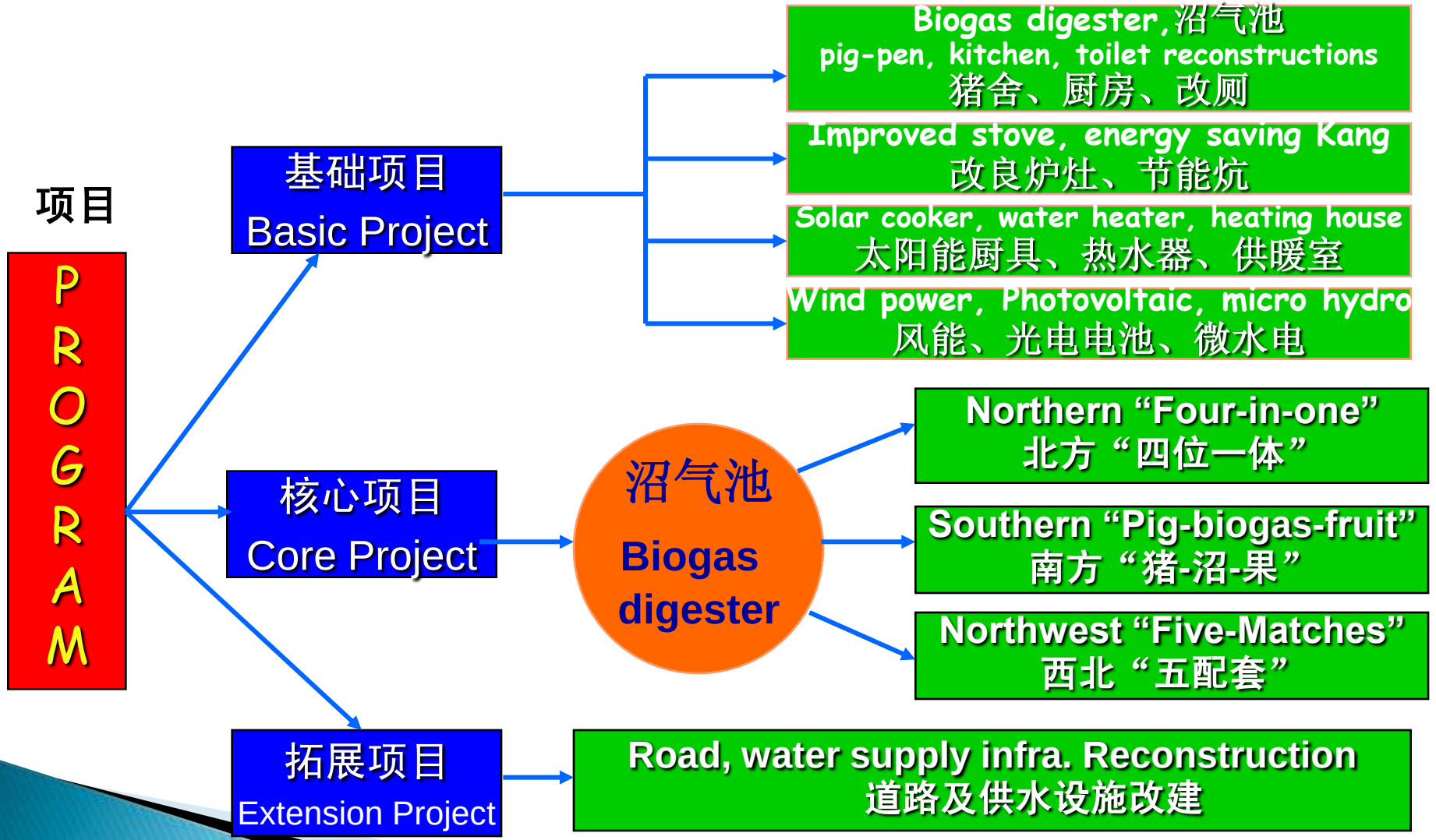
National program for domestic biogas digesters development

Year	Quantity	Increased	Popularized rate(%)
2006	18 Mio		15.0
2010	39 Mio	21 Mio	32.5
2015	61 Mio	22 Mio	50.8
2020	84 Mio	23 Mio	70.0

Basic ideas of Ecological Home & Prosperity Program

生态家园基本构想及促进项目



Crops, trees, shrubs
作物、树木、灌木

Irrigation灌溉

Feed饲养

Pond
鱼塘

Family家庭

Livestock
家禽

Excreta
排泄物

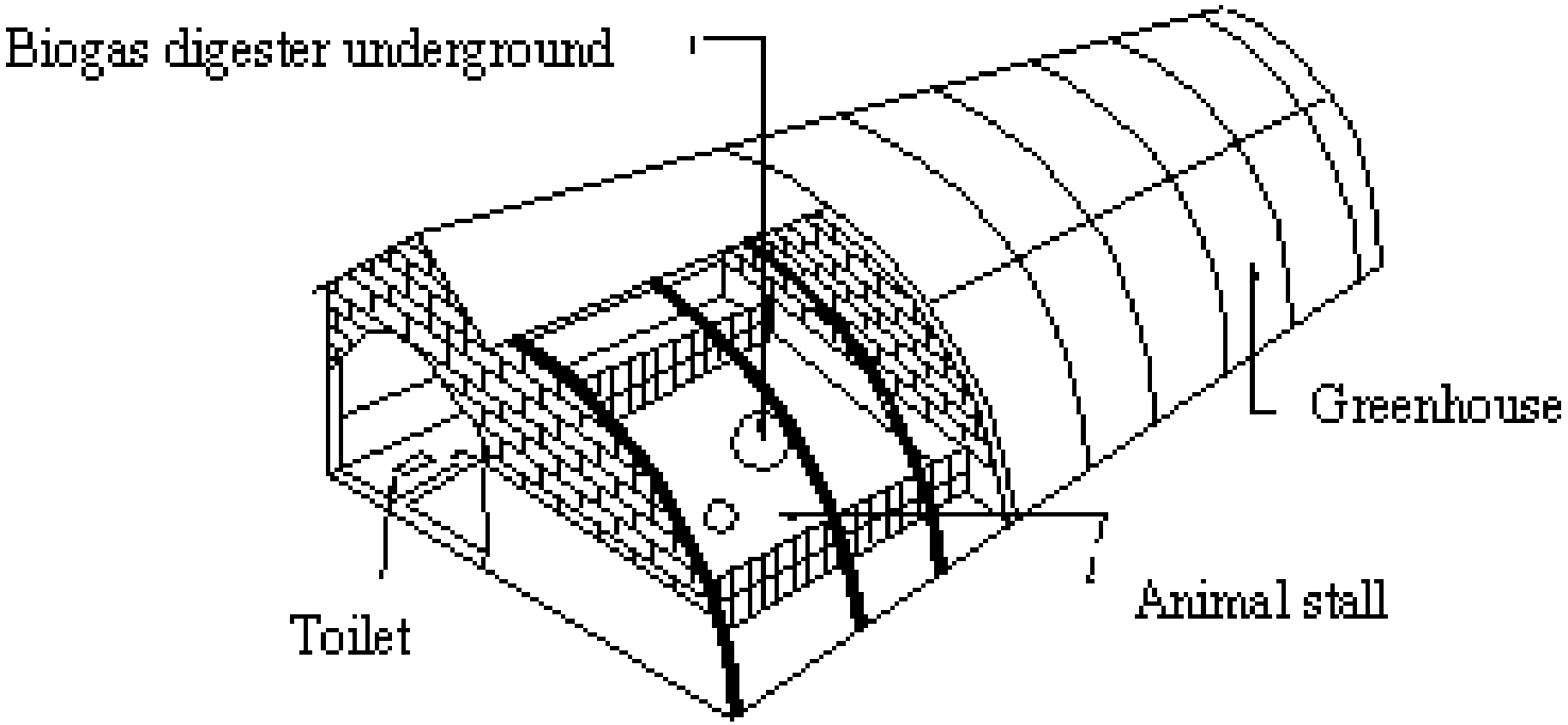
Biogas
沼气

Effluent沼液

Manure粪便

The ecological farm生态农场

Bio digester 消化器



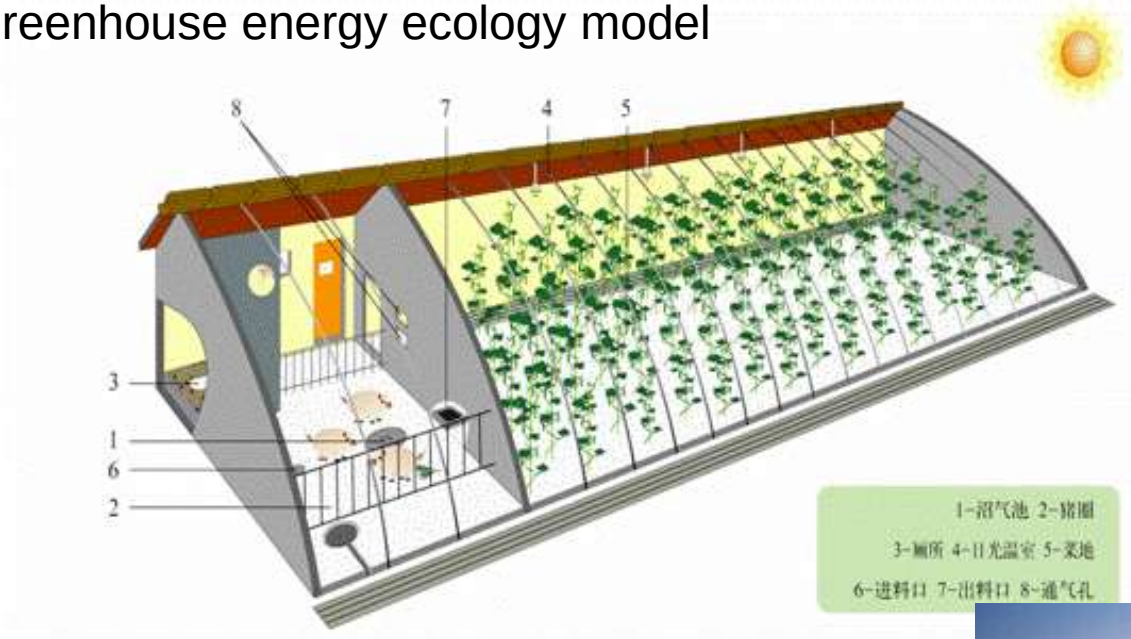
“Four-in-One” biogas model

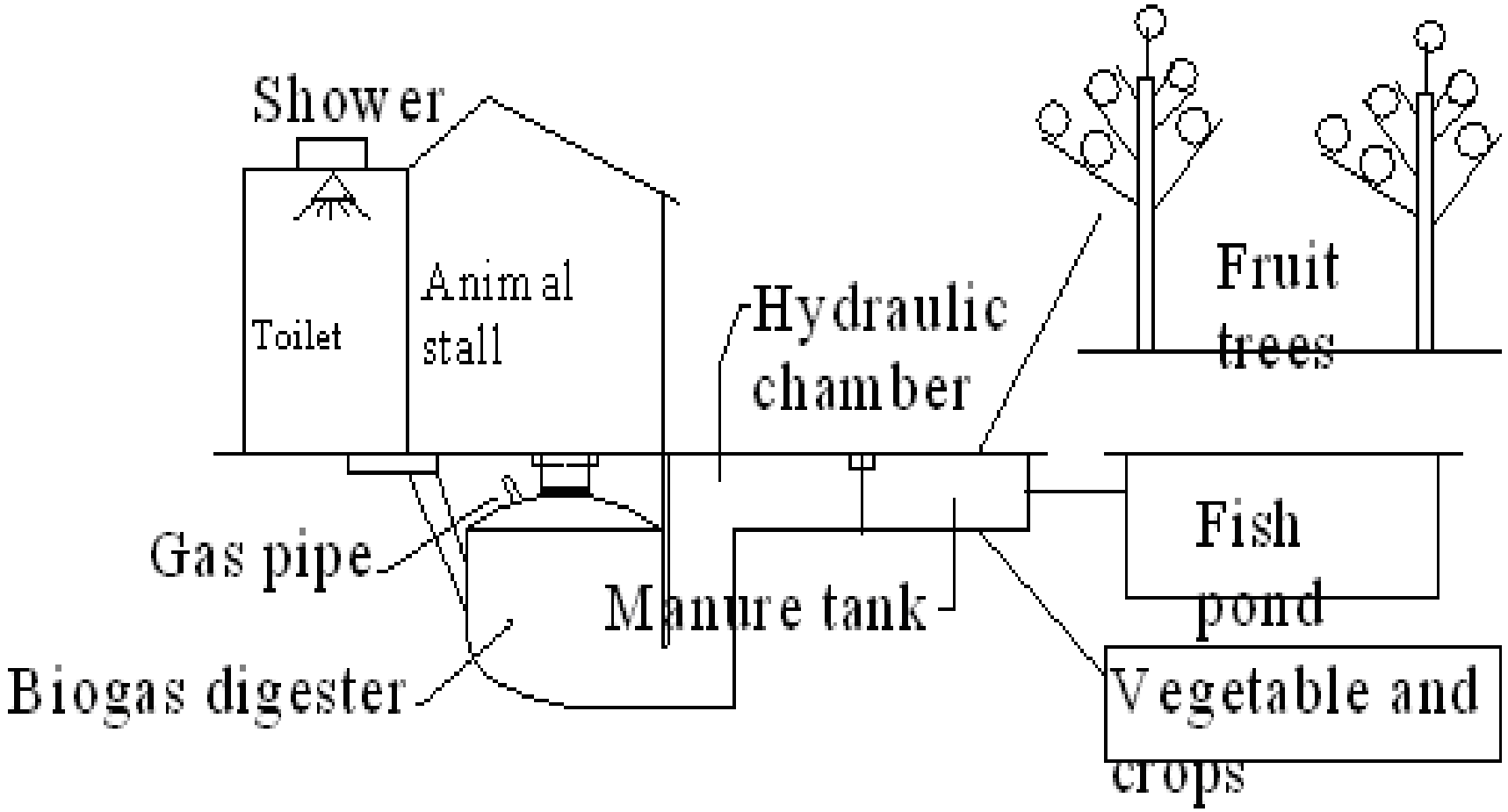
Greenhouse, vegetable, pig stall and biogas digester

以沼气为纽带的各种生态农业生产模式的推广应用
Biogas Integrated Utilization

温室能源生态模式

greenhouse energy ecology model

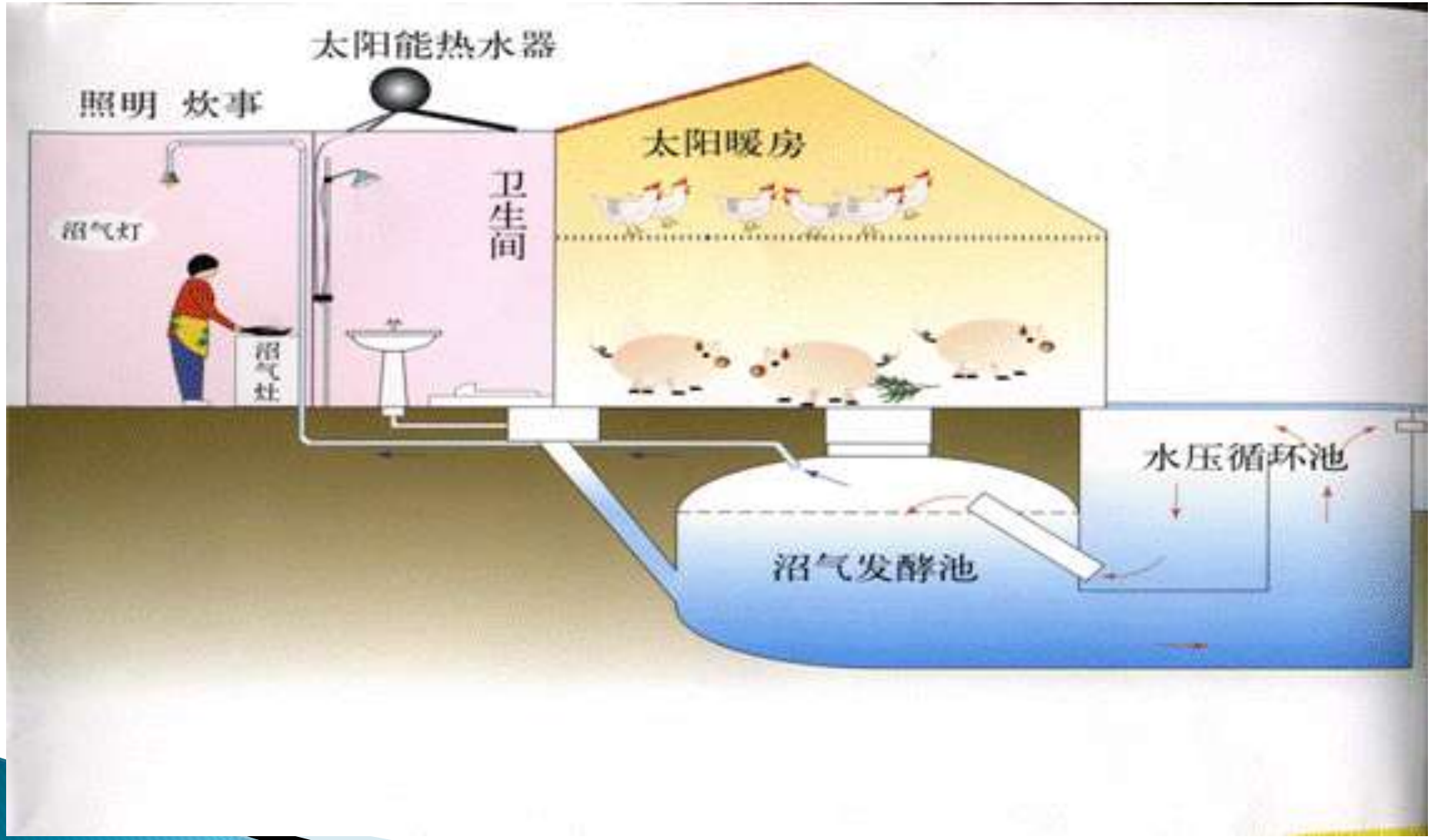




“Pig sty －Biogas digester－Fruit trees” Model

Animal husbandry- Biogas digester- Plantation

Energy- ecology model



Main features of biogas digesters

Household type

---hydraulic type with gas storage integrated

---underground without heating

---cylinder-domed with 6-10m^3 /digester

---cement & paraffin as sealing material

---pig stable-digester-toilet integrated

---biogas for cooking & lighting

---liquid effluent as fertilizer

---brick or stone with concrete for long lifetime

---low-cost in construction & maintenance



户用沼气工程结构
Household biogas plant-construction:







Biogas sanitation

Human excreta from dry or low flush toilets and biodegradable organic fraction of household waste could enter a (domestic) anaerobic (wet or dry) digester to produce biogas.

For a biogas plant only regarded from an **energy point of view**, it is better to have some animal manure or additional feed of organic waste.

For biogas plant **as a sanitation option** it is more important to look for the sanitization of the incoming black-, brown-, or wastewater and organic wastes. Therefore the input material stays longer in the digester, and the retention time (SRT - HRT) will be adopted with an optimum of sanitation degree and biogas production.

- The wall was used to guide the flow of sewage, extend the H

SRT longer than HRT

!!!

The choice of 4 sanitation system

(Chinese Ministry of Health)

Faecal science

- Approximately 30–45 kg (wet weight basis) of faeces are produced per person and year in developed countries, corresponding to 10–15 kg of dry matter (Lentner *et al., 1981; Feachem et al., 1983; Schouw et al., 2002; Jönsson & Vinneråas, 2004;* Jönsson *et al., 2005; Vinneråas et al., 2006). Del Porto & Steinfeld (1999)* compiled data from several studies and reported an average faecal excretion rate of 150 g/p,d.
- The amount of faeces produced depends on the composition of the food consumed.
- Foods low in fibre such as meat and other products result in smaller amounts (mass and volume) of faeces (Guyton, 1992).
- Faecal excretion rates in developed countries are lower than those in developing countries, with excretion rates for Americans and Europeans estimated at between 100 and 200 g/p,d. while for developing countries estimates are on average 350 g/p,d in rural areas and 250 g/p,d in urban areas (Feachem *et al., 1983).*
- **In China, Gao et al. (2002) measured 315 g/p,d** while Pieper (1987) measured 520 g/p,d in Kenya.
- In measurements by Schouw *et al. (2002)* in Southern Thailand, wet faecal generation rates were found to be 120–400 g/p,d.
- Vinneråas et al. (2006), using measurements from two blocks of flats in Sweden, estimated faecal excretion rate at 140 g/p,d amongst the Swedes, and water content at about 78%.
- At faecal excretion rates between 100 and 150 g/p,d, water content is about 75%, but this increases with increasing weight, and is approximately 90% at faecal weights of 500 g/p,d (Feachem *et al.,* 1983).
- Faecal excretion is on average one stool per person and day, but it may vary from one stool per week up to five stools per day (Lentner *et al., 1981;* Pharmacia, 2000).

Source: Charles Niwagaba, Human Excreta Treatment Technologies – prerequisites, constraints and performance, SLU Uppsala, Department of Biometry and Engineering Licentiate thesis 005, 2007 ISSN 1652-3261

Daily biogas production per person from human faeces

Persons No.	1
Wet mass (kg)	0.12
Dry matter mass (kg)	0.035
Organic matter mass (kg)	0.030
Biogas (mol)	0.58
Biogas volume (l)	12.99
Methane (mol)	0.377
Methane volume (l)	8.445
Carbon dioxide (mol)	0.203
Carbon dioxide volume (l)	4.547

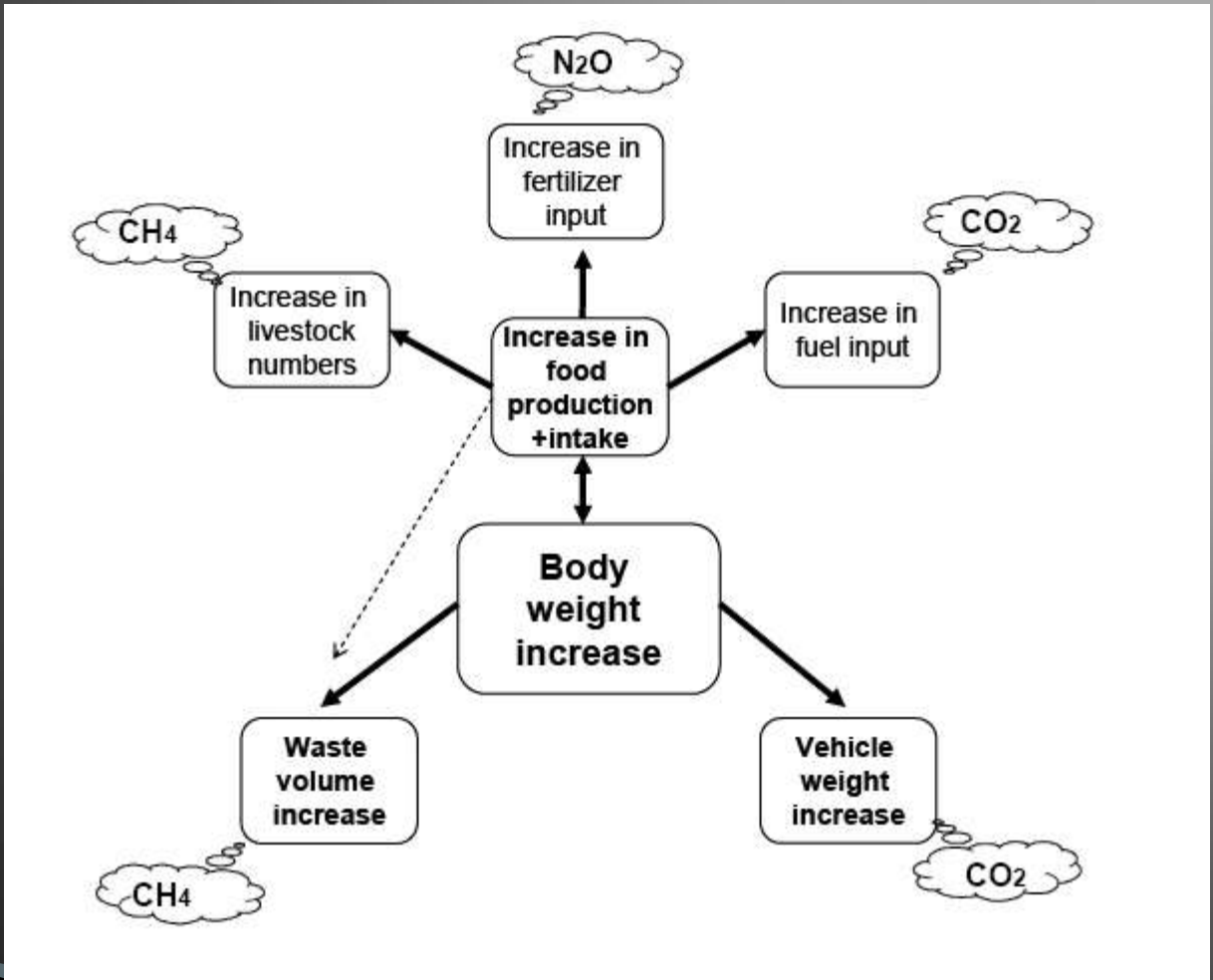
Source: Tiziana Pipoli, FEASIBILITY OF BIOMASS-BASED FUEL CELLS FOR MANNED SPACE EXPLORATION, ESA-ESTEC Advanced Concepts Team, Noordwijk ZH,– The Netherlands, 2006

Emission–'Baseline' for faeces recovery and avoiding methane emission

Country / Situation	wet mass kg/cap/day *(average)*	dry mater *75% water content*	organic dry mater (odm) *86% odm/dm*	methane litre/ kg odm *282 litre*	specific weight of methane *0.67 kg/m3*	GWP *21*	kg / cap/ year *366 days*	t-CO2 generated/ 100 persons/year *1000 kg/t*
High-protein diet in a temperate climate	0.12	0.030	0.026	7.276	0.005	0.102	37.467	**3.747**
Sweden	0.14	0.035	0.030	8.488	0.006	0.119	43.711	**4.371**
Europe and North America	0.15	0.038	0.032	9.095	0.006	0.128	46.833	**4.683**
The Netherlands	0.19	0.048	0.041	11.520	0.008	0.162	59.322	**5.932**
China	0.26	0.065	0.056	15.764	0.011	0.222	81.178	**8.118**
India	0.28	0.070	0.060	16.976	0.011	0.239	87.422	**8.742**
Peru	0.32	0.080	0.069	19.402	0.013	0.273	99.911	**9.991**
Vegetarian diet in a tropical climate	0.4	0.100	0.086	24.252	0.016	0.341	124.889	**12.489**
Uganda	0.47	0.118	0.101	28.496	0.019	0.401	146.744	**14.674**
Malaysia	0.48	0.120	0.103	29.102	0.019	0.409	149.866	**14.987**
Kenya	0.52	0.130	0.112	31.528	0.021	0.444	162.355	**16.236**

CH4 density (0.67 kg/m3 at room temperature (20C) and 1 atm pressure).

The greenhouse gas emissions impacts of increasing human food intake



Source: Axel Michaelowa, Björn Dransfeld, Greenhouse gas benefits of fighting obesity, Hamburg Institute of International Economics (HWWI), November 2006, ISSN 1861-504X

Environmental benefit

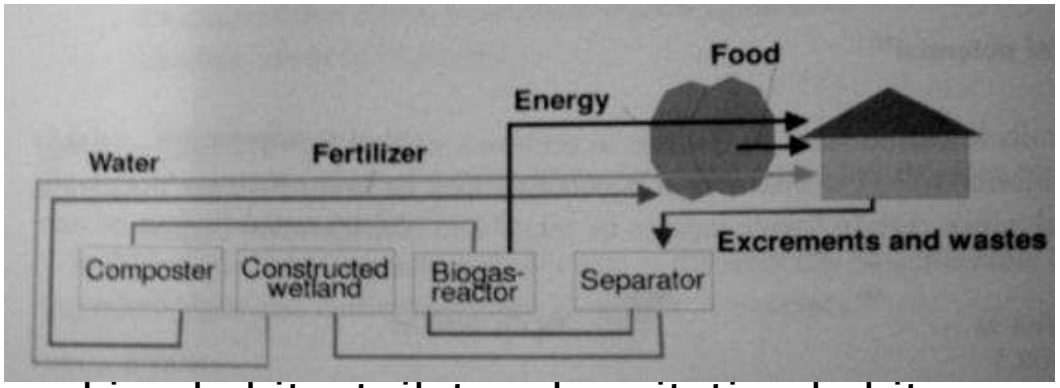
One biogas digester

=

3.5 mu forest

8 m^3

Experiences shows that one person can cover some of the cooking energy need through biogas from sanitation recyclates



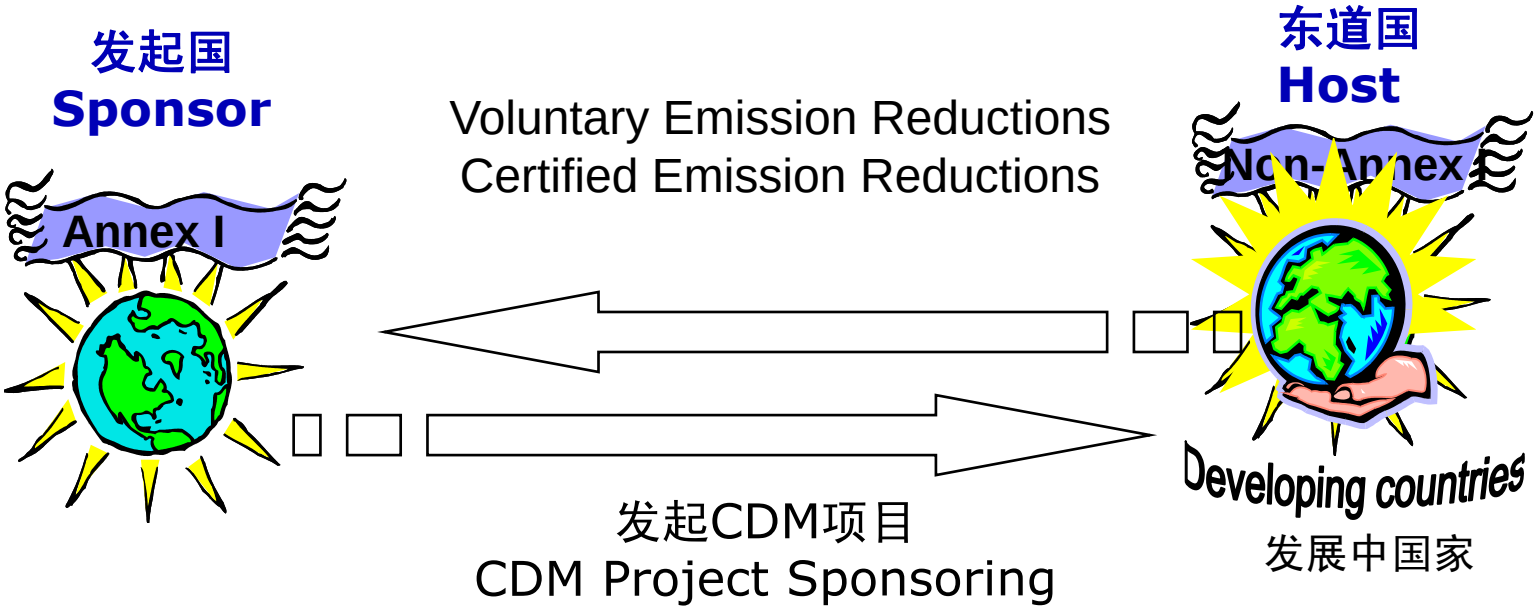
- 15% urban Lesotho
- 20% rural South Africa
- 30% rural tropical Bolivia
- 15% rural hilly Nepal
- 50% rural South China
- 15% rural Burkina Faso
- It is depending on climate, cooking habits, toilet and sanitation habits, burner efficiency and ..... diet

- With anaerobic **feacal sludge** / **brown water** treatment 15-20 m3 biogas per person and year could be produced.

For comparison:

- In Germany **sewage sludge** (not feacal sludge) is producing about 13 m3 biogas/capita and year, in Austria 7,5 m3 biogas/inhabitant equivalent and year
- This could cover 0,45 % (Germany) and 0.35% (Austria) of the total houshold energy need (electricity and heat) of a average family member.

Carbon Trade



CER: A tradable credit representing GHG emission reductons equivalent to one tonne of CO2e achieved through a CDM project.

VER: A tradable emission reduction that has not been generated via a formal, regulated system. Such "voluntary" reductions have varying degrees of environmental credibility and legal force, and thus command widely differing prices.

Hubei Eco-Farming Biogas Project Phase I
湖北生态农业沼气项目第1阶段

9,442 biogas digesters, 8 m3;	**9,442个沼气发酵池,8m3**
12,605 biogas digesters, 10 m3;	**12,605个沼气发池,10m3**
3,803 biogas digesters, 12 m3;	**3,803个沼气发酵池,12m3**
4,150 biogas digesters, 15 m3,	**4,150个沼气发酵池,15m3**
30000 households, 141,451 pigs.	**30000户家庭， 141,541猪**

replacing fossil fuel thermal energy needs of households who are raising pigs. **替代养猪家庭对化石燃料热能需求**

39,469 t CO2 equivalent in 2008; 59,200 t CO2e per year from 2009 to 2017; and 19,733 t CO2e in 2018.

在2008年39,469吨的CO2；从2009年到2017年每年59,200吨CO2排放；2018年19,733吨CO2排放。

Hubei Eco-Farming Biogas Project Phase I

CER Revenue Distribution planend

湖北生态农业沼气项目第1阶段CER 收入分配计划

- 78 % of the carbon credit sales revenues to the individual farmer households for loan repayment, biogas digester maintenance, and livelihood needs.

  78% 的碳信用收益用于农民还贷、沼气发酵池维护和农民生活所需。

- 2 % to Hubei Qingjiang Zhongye Company for technical service provided

  2%用于支付湖北清江种业公司技术服务费。

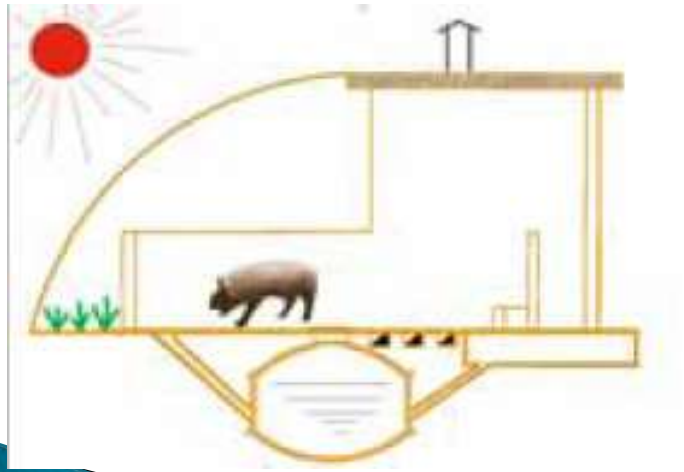
- 10 % to the village biogas service stations/centers for provision of technical services and farmer training;

  10% 用于农村沼气服务站/中心对农民的技术服务和培训

- 10 % for project management and monitoring by Project Management Offices (PMO) established within Enshi Prefecture and project county energy bureaus.

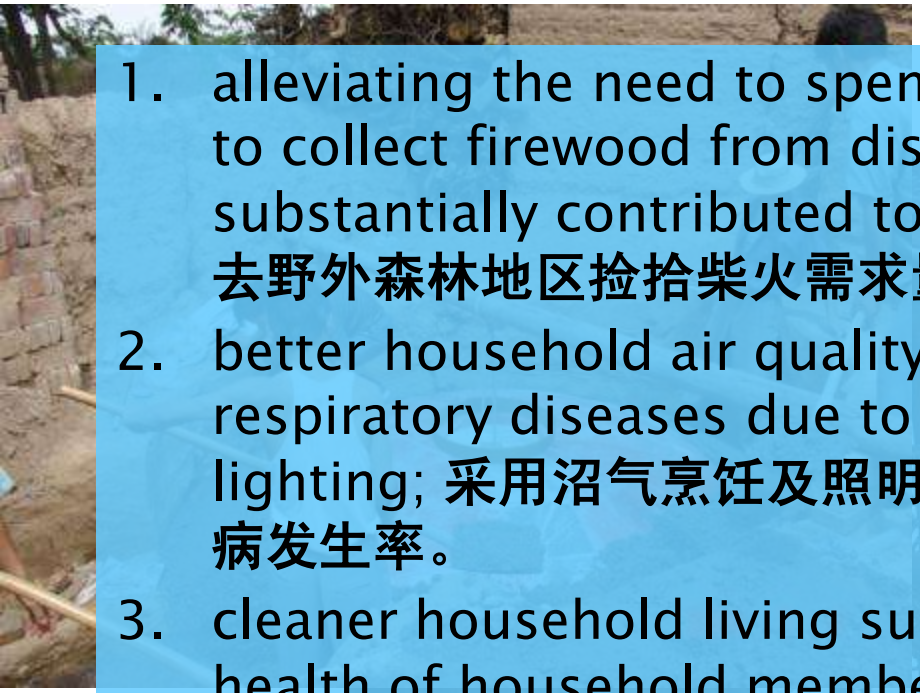
  10% 用于支付恩施市和县能源局项目管理办公室对本项目的管理和监督费用 。

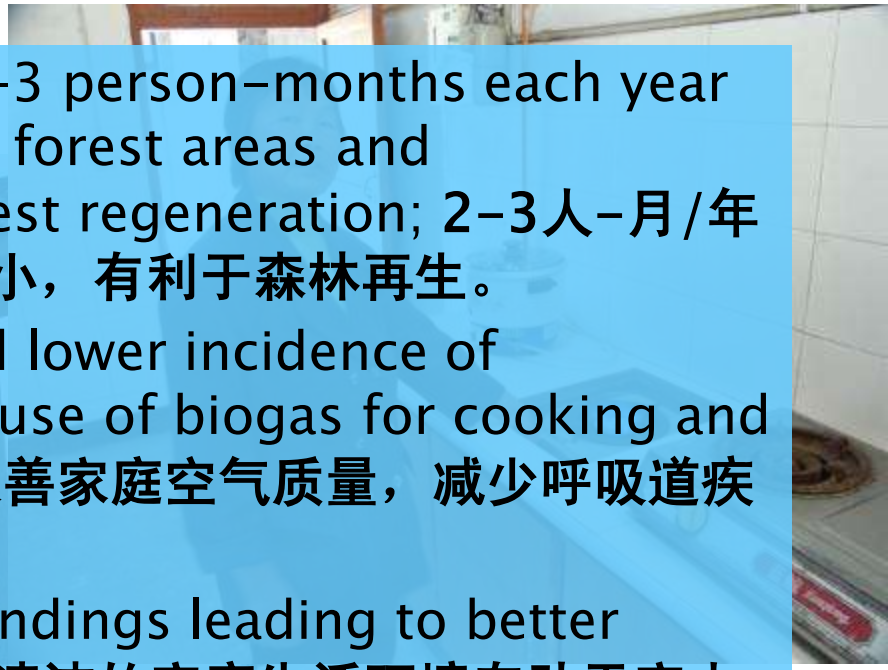
The impact of Integrated Biogas System (IBS) in rehabilitating heavily degraded land and community transformation



- With the introduction of the Northern 4-in-1 *(Biogas, Greenhouse, Toilet, Pig stable – IBS for the conversion of pig manure and toilet waste into clean biogas and organic fertiliser)* into a village in Shanxi using government subsidy and loans from Asia Development Bank (ADB), the well being of the whole village was improved.
- Not only has the IBS been able to provide clean biogas for cooking, lighting and hot water for the households, but the availability of liquid fertilizer rich in nutrients and organic matter was able to restore the fertility of the once degraded sandy land for the cultivation of the valuable lotus root crops.
- This has not only improved the health and well being of the villagers but the economy of the village was transformed and poverty was reduced.

Through Biogas significantly improved living environments
沼气项目大大改善了人居环境





1. alleviating the need to spend 2-3 person-months each year to collect firewood from distant forest areas and substantially contributed to forest regeneration; **2-3人-月/年去野外森林地区捡拾柴火需求量减小，有利于森林再生。**
2. better household air quality and lower incidence of respiratory diseases due to the use of biogas for cooking and lighting; **采用沼气烹饪及照明，改善家庭空气质量，减少呼吸道疾病发生率。**
3. cleaner household living surroundings leading to better health of household members; **清洁的家庭生活环境有助于家人健康。**
4. lessened environmental and soil pollution through the use of digester residues as organic fertilizers and pesticides; **发酵残余用作有机肥料和杀虫剂，减少环境污染及土壤污染。**
5. general improvements in living environments for the villages as a whole. **农村整体生活环境水平的提高。**

biogas impacts

- ✓ **Energy**
  - Cooking
  - Lighting
  - Food processing and conservation
  - Saving of energy expenditures
- ✓ **Savings in fuel wood**
  - Environmental protection by reduced deforestation
- ✓ **Sanitation**
  - Controlled treatment and reuse or discharge of wastewater
  - Controlled treatment and reuse or discharge of organic waste
- ✓ **Recycling of sanitation sub-products: organic matter and water**
  - Urban environment improved by parks, flowers, trees
- ✓ **Modernity**
- ✓ **Groundwater and climate protection**

XIE XIE 谢谢
THANK YOU

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