Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ

WORKSHOP READER

Energetic utilization of agricultural residues in China and Germany

中德农业废弃物能源化利用项目

1st public workshop on „How to foster the utilization of agricultural residues in the biogas sector in China“

“如何促进中国农业废弃物的沼气化利用”研讨会

With support from
Federal Ministry of Food and Agriculture
by decision of the German Bundestag

FNR Fachagentur Nachwachsende Rohstoffe e.V.

In Cooperation with:

HEFEI UNIVERSITY

CHINA AGRICULTURAL UNIVERSITY 1905

ATB Leibniz-Institut für Agrartechnik Potsdam-Bornim e.V.

CONTENT

1. Welcoming address by DBFZ –– Prof. Michael Nelles

I am delighted to announce, that the project ‘Energetic utilisation of agricultural residues in China and Germany’ (ChinaRes, Funding Code: 22025816) was established in November 2017, due to the financial support of the German Federal Ministry of Food and Agriculture. This allowed the Deutsches Biomasseforschungszentrum gemeinnützige GmbH (DBFZ), located in Leipzig (Germany), with the assistance of the Chinese Academy of Agricultural Engineering (CAAE) to hold a public workshop on ‘How to foster the utilisation of agricultural residues in the biogas sector in China?’ on the 14th of November 2017 in Shuangqiao/Beijing (China).

Over the past few months, we have made some great steps to intensify our collaboration between China and Germany. On the 13th of September 2017, we successfully inaugurated the Sino-German Centre for Biomass research with the unveiling of the Centre’s Plate. The inauguration ceremony and science workshop took place in the presence of representatives from the DBFZ, the German Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), and the Chinese Academy of Agricultural Engineering (CAAE). It is our goal to strengthen the existing research contacts and initiate new joint projects in the field of bioenergy and waste management. Aside from the scientific topics, the new Cooperation Centre will also contribute to a better interconnectedness and networking of stakeholders from both countries. Prior to the inauguration ceremony at the DBFZ, there have been two similar launches in China. The Sino-German Centre for Biomass Research was launched on the 18th of August 2017 at the CAAE in Beijing. The main objective of this Centre is to find solutions for the various challenges with the Chinese agriculture and to investigate their relations to climate protection and nature conservation.

The Director of CAAE, Prof. Dr. Bin Sui, and I would like to express that the new Centre is planning to initiate joint research projects and find viable solutions for the many-sided challenges regarding the utilization of agricultural residues.

Finally, the "Sino-German Regional Centre for Biomass Research" (C-DBFZ Anhui) was established on the 11th of August 2017 at Hefei University. Prof. Dr. Jingmin Cai (President of the Senate at Hefei University) together with Minsheng Wang (Vice Mayor of Hefei), Daming Zhang (Vice Director of SAFEA in the Province of Anhui) and Zhongyong Yu (Director of the Administration Office for the Lake Chao, Anhui) unveiled the Plate for the new Regional Centre. This Centre will also focus on the material and energetic use of agricultural residues, but will limit its activities to the province of Anhui (65 million inhabitants). The inauguration of the new Centre is another milestone in the long lasting history of the joint cooperation between Hefei University and various German institutions.

Again, I would like to welcome you to our public workshop in the frame of the new project “ChinaRes” and I hope we will make a good progress and will have some fruitful discussions.

I like to thank all participants for their valuable and comprehensive presentations, which are summarized in this reader.

2. Welcoming address by CAAE –– Prof. Zhang Yuhua

Professor Michael Nelles, Distinguished Guests, Ladies and Gentlemen, good morning!

It's a great pleasure to meet you again in CAAE. Due to some other official affairs, vice president Zhao Lixin and Prof. Meng Haibo cannot attend this workshop. At the outset, I wish to congratulate, on behalf of vice president Zhao Lixin and Prof. Meng Haibo, the opening of the Public Workshop and ChinaRes-Project meeting, and extend sincere welcome to all our guests and friends.

Take this opportunity, I’d like to give you a brief introduction of CAAE. Chinese Academy of Agricultural Engineering is state-owned, and subordinated by the Ministry of Agriculture. CAAE now consists of 11 institutes, nearly 600 staff members in total. In recent years, around the agricultural engineering industry chain, we’ve done much innovation work on resources monitoring, protected agriculture, products processing and circulation engineering, waste comprehensive utilization in the field of agriculture.

CAAE has 5 MoA Key Laboratories on Resource recycled utilization, Agro-products on-site treatment, Agro-waste energized utilization, Construction of protected-agriculture, and Remote sensing of farmland utilization. Plus, MoA Biomass Engineering Center, and MoA Seed Processing Center are 2 new platforms for our innovation. We have 2 academic journals, which are the transaction of Chinese Society of Agricultural engineering and International Journal of Agricultural and biological Engineering.

Today, this meeting place is the MoA Biomass Engineering Center. It owns a total area of over 4000 square meters, which is divided into 7 public labs, 12 specific labs, and 5 pilot processing labs. Now We have 500 sets of different instruments and equipment in these labs, still we will get more instruments for improvement.

Since 2008, we have established a closely cooperation with DBFZ. We both sent researchers to visit each other, conducted academic exchanges together and held academic workshops in China and Germany respectively. This year, we both set up the Sino-German Biomass Research Center in CAAE this August, and signing ceremonies were held. In September, Prof. Zhao Lixin visited DBFZ for signing a cooperation agreement in Leipzig, and held a seminar. It further enhanced our cooperation between the two sides.

It is a great pleasure for us to hold this workshop in CAAE. As one of the organizers, we promise you that we will offer a careful service work for you. At last, welcome you to come here for further exchange again, and wish you everything is fine in China.

Thank you!

3. Agenda Kick-off and first Workshop ChinaRes

Public Workshop:

“How to foster the utilisation of agricultural residues in the biogas sector in China?”
公开讨论：如何促进中国农业废弃物在沼气领域的应用

3.1 Programme

Time 时间	Item 内容	Presenter 报告人	Comments 备注
09:00 – 09:45	Registration 注册		
09:45 – 10:15	Welcome by host and organizer 欢迎仪式	Prof. Meng Haibo, 孟海波研究员， CAAE 农业部规划设计研究院 Prof. Michael Nelles, DBFZ 德国生物质研究中心	15min each 每人 15 分钟
10:15 – 10:35	Key note: The Chinese agricultural biogas sector – current challenges and future perspectives 主旨报告：中国农业沼气-目前的挑战与前景	Dr.Feng Jing 冯晶博士 CAAE 农业部规划设计研究院	
10:35 – 10:55	Key note: The German agricultural biogas sector - current challenges and future perspectives 主旨报告：德国农业沼气-目前的挑战与前景	Prof. Michael Nelles, DBFZ 德国生物质研究中心	
10:55 – 11:10	Tea Break 茶歇		

11:10 – 11:25	Effluent utilization and nutrient management plan in agriculture in the North China Plai 中国华北平原地区沼肥农业应用于营养管理计划	Dr. Marco Roelcke, DCZ, GIZ 中德农业中心，德国国际合作机构	
11: 25 – 12:25	Introduction of participant 参会人员介绍	CAAE, REEA, DBFZ+ATB, CAU, CUPB, HFUU, and others	5min each 每个单位 5 分钟
12:25 – 14:15	Networking Lunch 午餐		
14:15 – 14:45	Introduction to the ChinaRes project 介绍 ChinaRes 项目	Britt Schumacher, Kay Schaubach DBFZ 德国生物质研究中心	10 min, incl. discussion 含 10 分钟讨论
14:45 – 15:15	Manure management and biogas plants – the operational and technical challenge in China 中国粪污管理与沼气工程 – 运行与技术挑战	Sun Liying 孙丽英 REEA 农业部生态总站	
15:15 – 15:45	Processes and business cases – the economic challenge in China 工艺与商业案例 – 中国沼气在经济方面的挑战	Prof. Dong Renjie, 董仁杰教授 CAU 中国农业大学	
15:45 – 16:00	tea break 茶歇		
16:00 – 17:00	Open table discussion “Potentials and barriers for optimized operation of livestock farming and biogas plants” 开放讨论“畜禽养殖与沼气工程优化运行 潜力与障碍”	all participants, 所有参会人员	visitors may give impulse talks (5min) to present themselves and interest in project 每人（5 分钟）自由发表看法以及对项目兴趣点

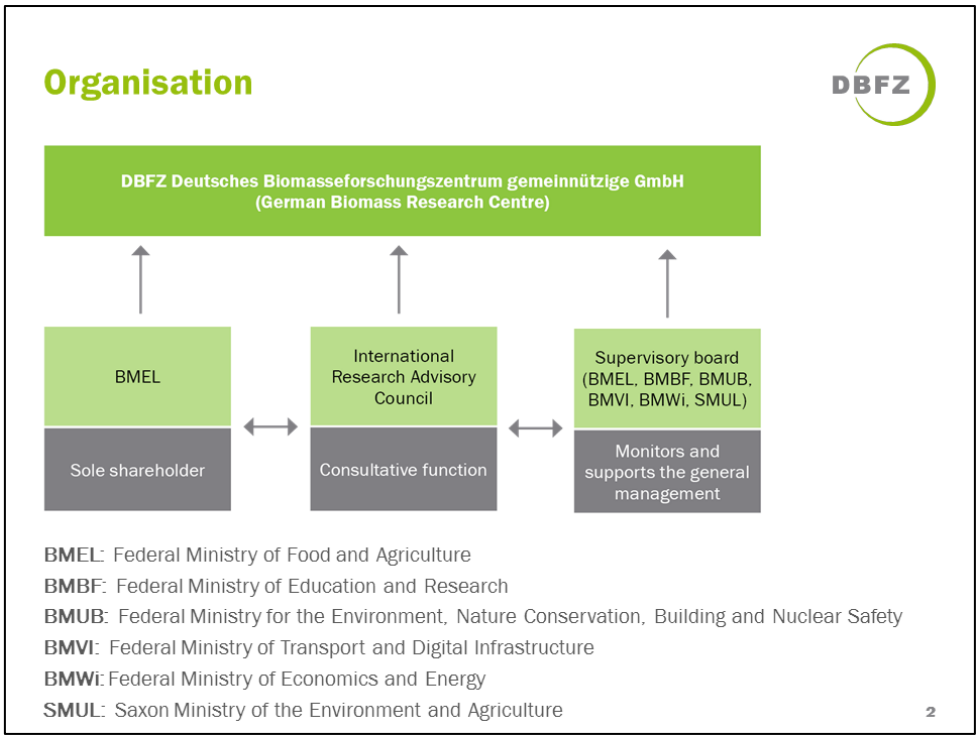
17:00 – 17:15	Wrap up and acknowledgements 总结与致谢	Qian Mingyu 钱名宇
18:00	social event with dinner 晚餐	

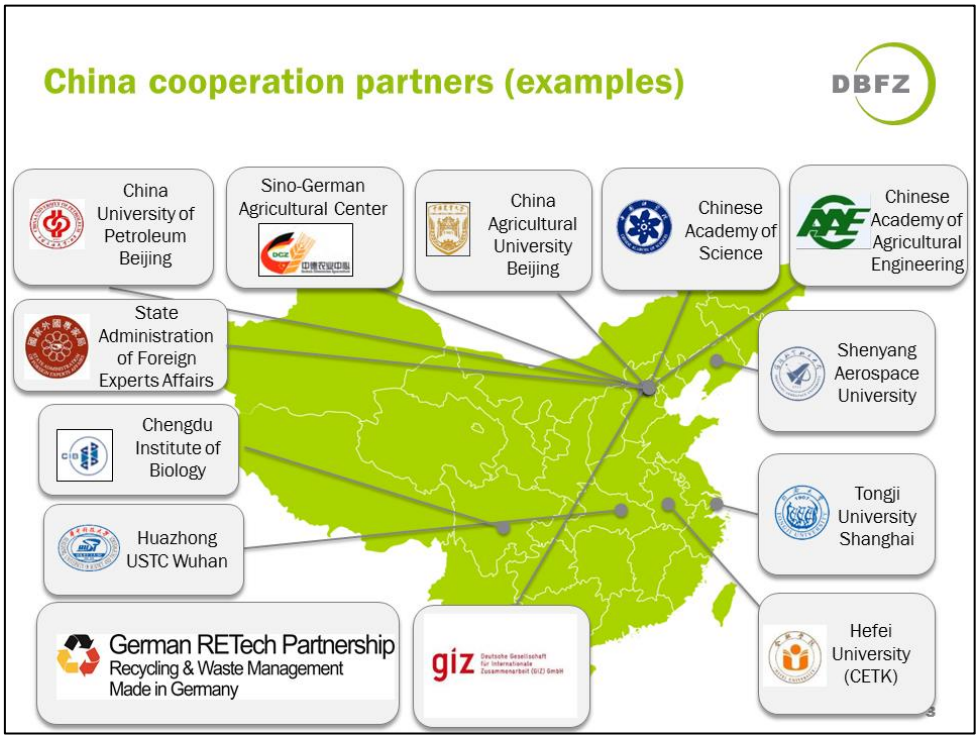
3.2 Participants

Name 姓名	Institution 单位
Michael Nelles (Prof.)	DBFZ
Britt Schumacher	DBFZ
Kay Schaubach	DBFZ
Meng Haibo	CAAE
Yao Zonglu	CAAE
Feng Jing	CAAE
YU Jiadong	CAAE
Huang Kaiming	CAAE
Zhang Xi	CAAE
Sun Liying	REEA
Marco Roelcke	GIZ CN, DCZ
Qian Mingyu	GIZ CN
Zhou Hongjun (Prof)	CUPB
Jiang Hao(Associate Prof)	CUPB
Fan Jingchun	CUPB
Dong Renjie (Prof),	CAU
Guo Jianbin (Associate Prof)	CAU
Wu Ke (Prof)	HFUU
Jin Jie (Prof)	HFUU
Chen Jun	HFUU
Bao Teng	HFUU

4. Presentations Workshop ChinaRes

4.1 Welcome presentation by DBFZ




China cooperation partners (examples)
DBFZ
China University of Petroleum Beijing
Sino-German Agricultural Center
China Agricultural University Beijing
Chinese Academy of Science
Chinese Academy of Agricultural Engineering
State Administration of Foreign Experts Affairs
Shenyang Aerospace University
Chengdu Institute of Biology
Tongji University Shanghai
Huazhong USTC Wuhan
German RETech Partnership
Recycling & Waste Management
Made in Germany
giz
Hefei University (CETK)


Universität Rostock
Traditio et Innovatio
DBFZ
CETK
中德合作环境技术转化中心
6.00%
0.10%
2.00%
1.00%
18.10%
3.80%
0.30%
1.90%
66.90%

Opening workshop “Chinese German Research Center for Biomass Research” Anhui (C-DBFZ Anhui), Hefei University, August 2017

DBFZ

安徽中德区域生物质研究中心
Chinesisch-Deutsches regionales Zentrum für Biomasseforschung

合肥学院 Universität Hefei

德国生物质研究中心 DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH

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Universität Rostock Traditio et Innovatio

RETech China-Working-Group

German RETech Partnership
Recycling & Waste Management Made in Germany

The German RETech Partnership is an independent network of companies and institutions operating in the German waste management and recycling sector. It aims to promote worldwide technology transfer and provide access to German expertise.

德国**RETech**合作组织是德国联邦政府环保、经济和能源的相关部门组织，德国环保行业众多公司和研究机构参与的一个独立运营机构。其宗旨是促进与推动全球范围内的相关技术交流与转化，使德国技术成功走向世界。

Michael Nelles: Member of the Managing Board & Director of the China-Working Group

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German RETech Partnership
Recycling & Waste Management
Made in Germany

DBFZ

Who is on RETech‘s Advisory Board?
顾问委员会成员

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

- **Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety**
- **德国联邦环境、自然保护、建筑与核安全部**

Federal Ministry for Economic Affairs and Energy

- **Federal Ministry for Economic Affairs and Energy**
- **德国联邦经济与能源部**

Federal Ministry for Economic Cooperation and Development

- **Federal Ministry for Economic Cooperation and Development**
- **德国联邦经济合作与发展部**

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Cooperation with the State Administration of Foreign Experts Affairs (SAFEA)

DBFZ

“SAFEA is responsible for certifying foreign experts to work in the Chinese mainland and organizing overseas training for Chinese technical and managerial professionals”.

DBFZ got SAFEA Certificate for foreign experts:

“DBFZ, together with 14 other top institutes worldwide, passed the certification process of the Chinese State Administration of Foreign Experts Affairs (SAFEA) at the end of 2016. **This certificate entitles DBFZ to offer training and further education in China.** In particular, it is planned to provide vocational education and training on biomass and bioenergy, to foster the joint scientific research and applied technology development and transfer, to analyse industrial policies, and to do market assessment. **In order to provide the expertise on biomass and bioenergy, DBFZ will deepen its cooperation with the established scientific partners in China.”**

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Opening workshops “Chinese German Research Center for Biomass Research” in Peking and Leipzig
DBFZ
中德生物质研究中心签约暨揭牌仪式


Chinese Academy of Agricultural Engineering
China University of Petroleum Beijing
China Agricultural University Beijing
Hefei University (HFUU)
Welcome to the Workshop
“How to foster the utilization of agricultural residues in the biogas sector in China”
1st public workshop of the project
“Energetic utilization of agricultural residues in China and Germany”
CAAE; Shangqiao, Beijing, China, 2017/11/14
Deutsches Biomasseforschungszentrum
gemeinnützige GmbH
DBFZ
ATB
Leibniz-Institut für Agrartechnik und Bioökonomie
With support from
Federal Ministry of Food and Agriculture
by decision of the German Bundestag

4.2 Key note: The Chinese agricultural biogas sector – current challenges and future perspectives

一、背景 Background

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1.1 农业废弃物处理情况 Production of Agriculture Waste

中国是世界上农业废弃物产生量最多的国家，2015年我国农业废弃物产生量和未有效利用情况：China produce the most amount of agriculture waste. In 2015， production and not used amount of agriculture waste are as following.

- 农作物秸秆约 10.4 亿吨，20%未有效利用 Straw about 1.04 billion tons, 20% not used properly.
- 畜禽粪污约 38 亿吨，40%以上未有效利用 Manure about 3.8 billion tons, above 40% not used properly
- 尾菜约 2.3 亿吨，大部分未有效利用 Vegetable waste about 230 million tons, most not used

Agriculture waste has become an important source of non - point source pollution in China



1.2沼气工程定位 Functions of Biogas in China

以沼气和生物天然气为主要处理方向，以就地就近用于农村能源和农用有机肥为主要使用方向，力争在“十三五”时期，基本解决大规模畜禽养殖场粪污处理和资源化问题。

President Xi Jinping has pointed out: Producing biogas and biomethane should be the main pathway and producing energy and fertilizer should be the main utilization for treating livestock manure. At the end of “thirteen five” period, we will solve the problems caused by manure from large scale livestock farms

沼气工程是农业废弃物资源化利用的重要路径，是农业废弃物处理的主要手段、种养循环农业的关键纽带。

Biogas engineering is an important path of agricultural waste resource utilization, the main means of agricultural waste treatment, and the key link of planting and breeding of recycling agriculture.

1.2 沼气工程定位 Functions of Biogas in China

◆ 农业废弃物处理的主要手段 main solution of agricultural waste pollution

20%农作物秸秆、56%畜禽粪便的未得到有效利用。发展农村沼气可有效处理农业农村废弃物，改善农村环境。

20% of the crop straw and 56% of the livestock and poultry manure are not effectively utilized. The development of rural biogas can effectively deal with agricultural and rural waste and improve the condition of rural environment in China.

1.2 沼气工程定位 Functions of Biogas in China

◆ 农村能源的重要补充 important supplement to clean energy

2015年全国能源消费中煤炭占比为64%，天然气对外依存度32.1%。我国承诺到2030年非化石能源占一次能源消费比重提高到20%左右。

In 2015, 64% of China's energy consumption was accounted by coal and 32.1% of natural gas needs to be imported. China has pledged that the non-fossil fuels shall account for 20% of primary energy consumption by 2030.

1.2 沼气工程定位 Functions of Biogas in China

◆ 种养循环农业的关键纽带 key link of breeding and planting for recycle agriculture

全国果园、菜园、茶园总面积2.32亿亩，亩均化肥用量均远高于美国和欧盟等，增加了生产成本，导致了土壤板结、土壤和水体污染等问题。

Total area of orchard, vegetable garden, tea garden is above 15 million ha. And amount of chemical fertilizer used in China is much higher than that in US or EU, which caused the soil harden and pollution problems in soil and water.

二、发展历程History and Current Status

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2.1 发展历程 Development history

- 自2004年起，每年中央一号文件都对发展农村沼气提出明确要求；Since 2004, the central government made explicit demands on the development of biogas in rural areas every year
- “十二五”期间，预算内投资142亿元用于农村沼气建设，加上地方和企业投资，全国规模化沼气工程已发展到11万余处；During the 12th five-year plan period, 14.2 billion RMB from government funds was invested in rural biogas, number of biogas plants increased to above 110,000
- 2015年后，中央投资重点支持规模化大型沼气工程项目和生物天然气工程试点项目建设；After 2015, the central government invested in large-scale biogas and biomethane plants
- 到2017年，中央预算内投资60亿元，支持建设73个规模化生物天然气试点项目和1423个大型沼气工程项目。By 2017, 6 billion RMB from central government has been used in construction of 73 large-scale biomethane production plants and 1,423 large-scale biogas plants

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2.2 发展条件变化Change of framework conditions

- 畜禽养殖方式向规模化和集约化方向发展

livestock breeding type changed to scale and intensification

- 我国城镇化步伐加快、农村空心化程度加剧

pace of urbanization in China is accelerating, young rural labors went to cities

- 农村生活用能日益多元化和便利化，化石能源和电力供应充足、获取便利，使用方便，价格低廉，压缩了农村沼气发展空间

fossil energy, electricity supply is more abundant , easier to obtain, cheaper

2.3 扶持政策 Policy Changed

- 《全国农村沼气发展“十三五”规划》*National rural biogas development plan for the 13th five-year plan —from MOA, China*
- 《开展果菜茶有机肥替代化肥行动方案》（农农发〔2017〕2号）*Action plan on replacing chemical fertilizer with organic fertilizer in planting fruit, vegetable and tea—from MOA, China*
- 《国务院办公厅关于加快推进畜禽养殖废弃物资源化利用的意见》（国办发〔2017〕48号）*speeding up the utilization of breeding waste—from office of the State Council*
- 《国家发展改革委办公厅农业部办公厅关于整县推进畜禽粪污资源化利用工作的通知》（发改办农经〔2017〕1352号） *promotion of the utilization of breeding waste from the whole county level —from MOA and National Development and Reform Commission*

2.4 扶持项目 Support project

- 农业废弃物资源化利用试点项目 Projects for resource utilization of agricultural wastes
- 国家农业可持续发展试验示范区 National agricultural sustainable development test demonstration
- 农业综合开发区域生态循环农业项目 Project for construction of ecological recycle agricultural
- 秸秆综合利用试点项目 Project of Straw comprehensive utilization

三、问题与挑战 Problems and Challenges

3.1 厌氧发酵技术 Anaerobic Digestion Technology




- 混合原料预处理技术成熟 The pretreatment of mixed raw materials is mature
- 形成了成熟的干法、湿法厌氧发酵技术 A mature dry and wet anaerobic fermentation technology was developed
- 产气效率高， > 1.5 m^3/m^3.d Gas production efficiency

- 混合原料预处理技术不成熟 Raw material pretreatment technology is not mature
- 厌氧消化不同步，中间产物控制难、传质传热差 Anaerobic digestion is not synchronous, intermediate products control difficult, mass transfer heat transfer
- 产气效率低， < 1 m^3/m^3.d Gas production efficiency

与国外先进水平相比，我国资源利用效率低

Anaerobic fermentation efficiency is low in China

3.2 沼渣沼液利用 Utilization of Digestate



- 以地定畜，沼渣沼液深施还田 The biogas slurry can be used in land directly
- 臭气等污染物控制技术成熟 Pollution control technology of odor during composting
- 沼液深度处理利用技术成熟 advanced treating technology of biogas slurry

- 种养业不匹配，沼渣沼液直接还田利用难 Too large amount, the land around the biogas plant does not have enough capacity for biogas slurry
- 制肥及臭气等污染控制技术水平低 Low level of pollution control technology of odor
- 沼液高效处理利用技术缺乏 The utilization technology of biogas slurry treatment is lacking

与国外先进水平相比，我国沼渣沼液二次污染风险大

Compared with the advanced level of foreign countries, the secondary pollution risk of biogas slurry in China is very high

3.3 装备水平 Equipment Prodution


- 厌氧发酵及资源化装备设计模块化、生产标准化、产品系列化 Anaerobic fermentation and resource-based equipment design modularization, production standardization, product serialization
- 工程运行在线监控系统成熟完善 The operation of the online monitoring system is mature


- 预处理、厌氧消化、沼气提纯、沼渣沼液资源化装备水平低，缺乏模块化设计、标准化生产 low level of equipment for biogas production and lack of modular design and standardized production
- 工程运行智能调控水平低 Low level of intelligent control of engineering operation

与国外先进水平相比，我国装备智能化、标准化、产业化水平低

Compared with foreign advanced level, China's equipment intelligence, standardization, industrialization level is low

四、解决方案 Solutions

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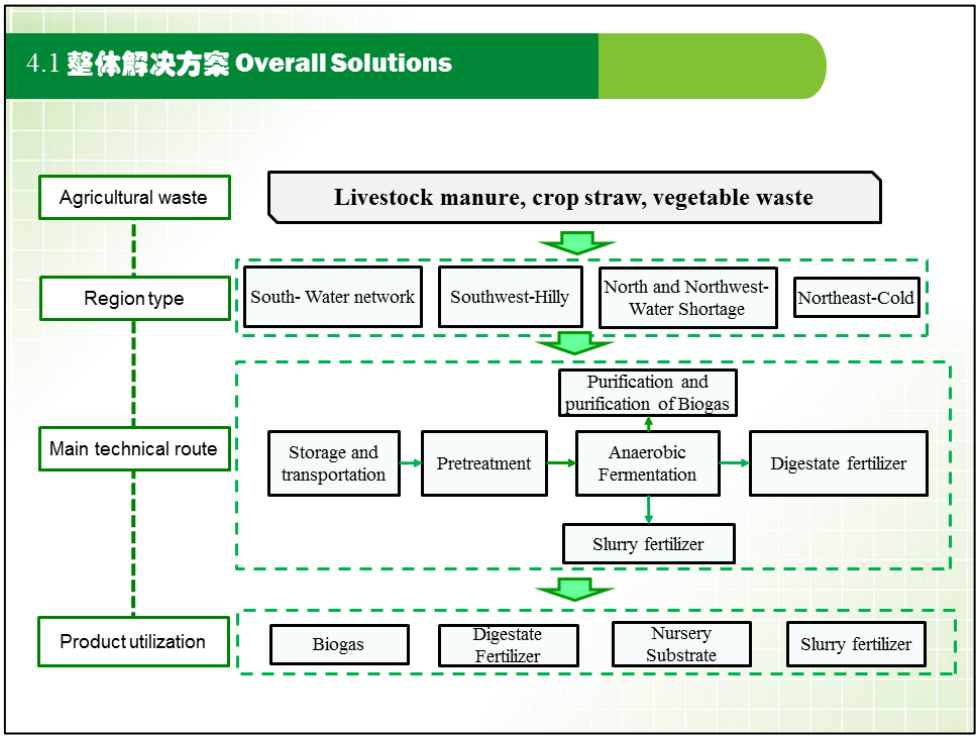
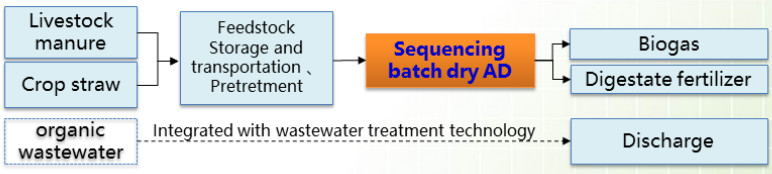


4.2 南方平原水网区 South Aera— Water network

➢**区域特点：**南方水网区气候温暖湿润、河网密布、面源污染易发、沼液消纳能力弱。Regional features: warm and humid, the river network is dense, the risk of non-point pollution is high, low capacity of biogas slurry.

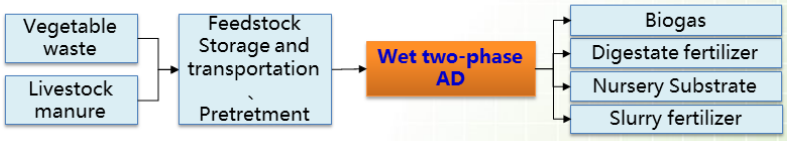
➢**主要模式：**畜禽粪便与农作物秸秆通过原料收储运和预处理，进行干法序批式厌氧消化，生产沼气和沼渣肥料，养殖污水经过废水处理达标排放。Main patterns: manure and straw transportation and pre-treatment, sequencing batch dry anaerobic fermentation, producing biogas and digestate fertilizer, wastewater from breeding after treatment reach discharging standard.

➢**关键技术：**原料收储运技术模式构建、原料预处理技术、干法序批式厌氧消化技术、沼渣制肥技术、沼肥农田安全施用技术Key technologies: Straw and manure storage and transportation patterns, Straw pretreatment technology, sequence batch dry anaerobic fermentation technology, digestate composting technology, land utilization technology of digestate fertilizer



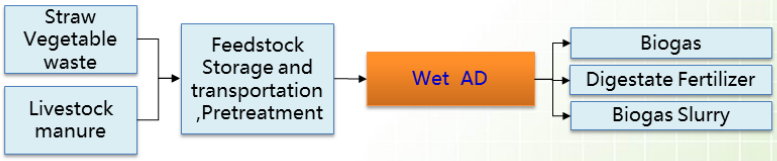
4.3 南方丘陵区 Southwest area-Hilly

- **区域特点：**气候温暖、尾菜产生量大、土壤有机质含量较低。**Regional features:** warm climate, large quantity of vegetable waste, low organic matter content in soil.
- **主要模式：**尾菜和畜禽粪污经过通过原料收储运和预处理，进行湿法两相耦合厌氧消化，主要产品包括沼气、沼渣和沼液，其中沼渣可作为肥料和蔬菜基质，沼液作为肥料施用。**Main patterns** : vegetable waste and manure transportation and pre-treatment, wet two-phase anaerobic digestion, the main products include biogas, digestate and biogas slurry, digestate as nursery substrate , biogas slurry as fertilizer application.
- **关键技术：**原料收储运技术模式构建、原料预处理技术、湿法两相耦合厌氧消化、沼渣和沼液制肥技术、沼渣基质化利用技术、沼肥农田安全施用技术。**Key technologies**: vegetable waste and manure storage and transportation patterns, pretreatment technology, two-phase anaerobic digestion, fertilizer producing technology with digestate and biogas slurry, nursery substrate producing technology with digestate, land utilization technology of digestate fertilizer.



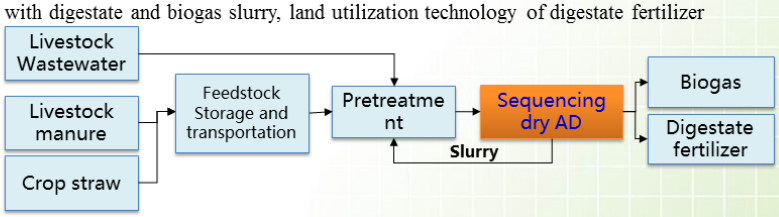
4.4 黄淮海和西北区 North and Northwest- Water Shortage

- **区域特点：**气候干燥、秸秆产生量大、沼液消纳能力强。**Regional features**: dry climate, large amount of straw, strong biogas ability.
- **主要模式：**玉米秸秆、尾菜、养殖粪污等通过原料收储运和预处理，进行湿法单相厌氧消化，主要产品包括沼气、沼渣和沼液，其中沼渣和沼液作为肥料施用。**Main patterns:** corn straw, vegetable waste and manure transportation and pre-treatment, wet single-phase anaerobic digestion, the main products include biogas, digestate and biogas slurry
- **关键技术：**原料收储运技术模式构建、原料预处理技术、湿法单相厌氧消化、沼渣和沼液制肥技术、沼肥农田安全施用技术。**Key technologies:** storage and transportation patterns, raw material pretreatment technology, wet anaerobic digestion, fertilizer producing technology with digestate and biogas slurry, land utilization technology of digestate fertilizer



4.5 高寒区 Northeast-Cold

- **区域特点：**气候寒冷、秸秆产量大、冬季沼液处理难。**Regional features:** cold weather, large straw yield and winter biogas treatment
- **主要模式：**玉米秸秆、养殖粪便等通过原料收储运和预处理，进行干法连续式厌氧消化，养殖废水和干法发酵产生的沼液用于原料预处理，主要产品包括沼气、沼渣，沼渣作为肥料施用。**Main modes:** corn straw and manure transportation and pre-treatment, continuous dry anaerobic digestion, wastewater and produce biogas slurry are used for the treatment of feedstock, main products include biogas and digestate.
- **关键技术：**原料收储运技术模式构建、原料预处理技术、干法连续式厌氧消化、沼渣和沼液制肥技术、沼肥农田安全施用技术。**Key technologies:** storage and transportation patterns, raw material pretreatment technology, continuous dry anaerobic digestion, fertilizer producing technology with digestate and biogas slurry, land utilization technology of digestate fertilizer



4.3 Key note: The German agricultural biogas sector - current challenges and future perspectives

Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ

German agricultural biogas sector –
Current challenges and future perspectives
德国农业沼气-目前的挑战与未来前景

Prof. Dr. Michael Nelles, Dr. Walter Stinner, Tina Schmalfuss

Public Workshop: “How to foster the utilisation of agricultural residues in the biogas sector in China?”, CAAE; Shuangqiao, Beijing, China, 2017/11/14

Content 目录

DBFZ

- **Current situation** 目前的情况
- **Change of framework conditions** 框架条件的改变
- **Change of energy concept** 能源观念的改变
- **Change of substrate concepts** 原料观念的改变
  - Alternative energy crops **替代能源作物**
  - Agricultural residues 农业废**弃物**
- **Manure utilization, potential and characteristics** 粪污利用、潜力与特性
- **Biogas in future bioeconomy** 沼气与未来生物经济

2

Base for Legal and Technical Biogas-Development 沼气发展的法律与技术基础

DBFZ

1990s Technical pioneering 上世纪90年代技术先驱

- 1991 Legal Basis: Electricity-Feed-In-Act (StromEinspG)法律基础：电力入网法案
- 1996 Waste Management and Waste Disposal Act (KrW-/AbfG)废弃物管理与处理法案

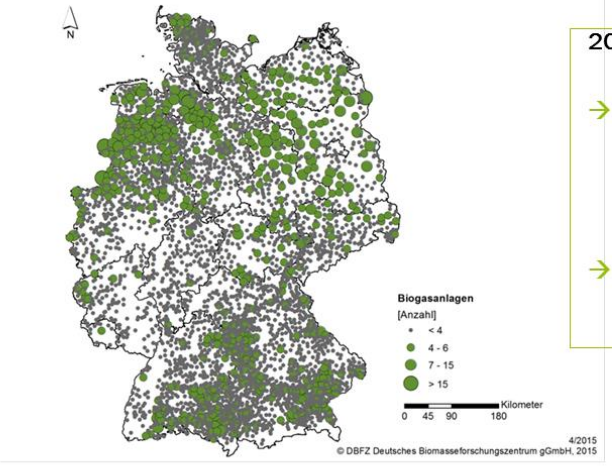
2000–2012 Distribution and Professionalization 分布与专业化

- 2000 Renewable Energies Act (EEG) 可再生能源法
- 2004 Premium for energy crops 能源作物保险
- 2012 focus on residues and cost reduction 着重于废弃物与成本降低
- 2014 focus on cost reduction 着重于成本降低

3

Biogas Plant Distribution in Germany (98% agricultural plants) 德国沼气工程分布（98%为农业沼气）

DBFZ



2016: ~8,700 plants

→ **~8,500 plants**
On-site electricity conversion of biogas and satellite-CHP
厂内与厂外发电项目

→ **196 plants**
Upgrading to biomethane
沼气提纯项目

Source: DBFZ: Stromerzeugung aus Biomasse. Zwischenbericht May 2015, Leipzig

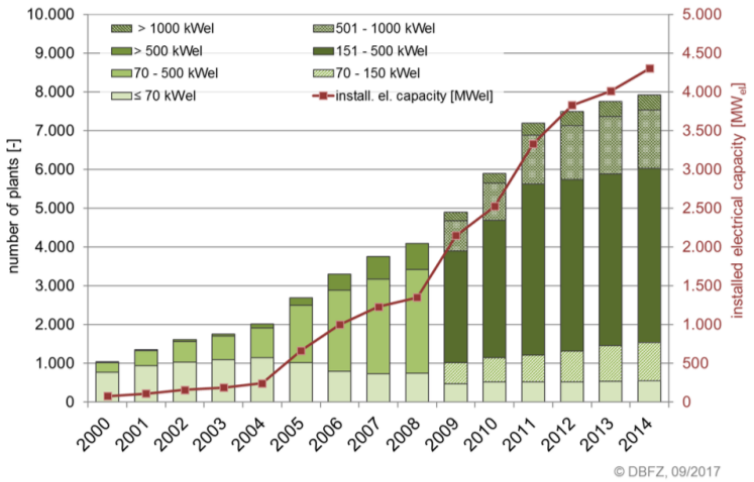
4

Biogas Plant Distribution in Germany
德国沼气工程分布

- **High animal densities in the North-West and in the South (2-4 Large-cattle units (LCU) per ha)** 西北部和南部养殖密度大（每公顷**2-4**头牛单位）
- **Low LCU in Eastern Germany (ca. 0,5), but bigger single herds** 东部养殖密度低（**0.5**），但是单个养殖场规模大
- **Average herd size in West Germany around 70 cows, in Eastern Germany ca. 500 cows** 西部平均单场规模**70**头牛，东部约**500**头
- **> Different economies of scale / transport costs for manure use in German regions** 不同地区的经济规模/粪污运输成本不同
- **80% of cattle manure digested in East Germany (Thuringia)** 德国东部**80%**的牛粪经厌氧处理（图林根）
- **70% of manure in East Germany instead of 50% in German average (Thuringia)** 东部**70%**粪污相当于德国**50%**的粪污（图林根）

5

Biogas Plant Development in Germany
德国沼气发展



→ 2016: ~8,700 biogas production plants incl. upgrading plants for biomethane in operation

→ 2016年在运行的项目约8700座，包括提纯项目

Source: DBFZ; installed electrical capacity acc. to [illegible]

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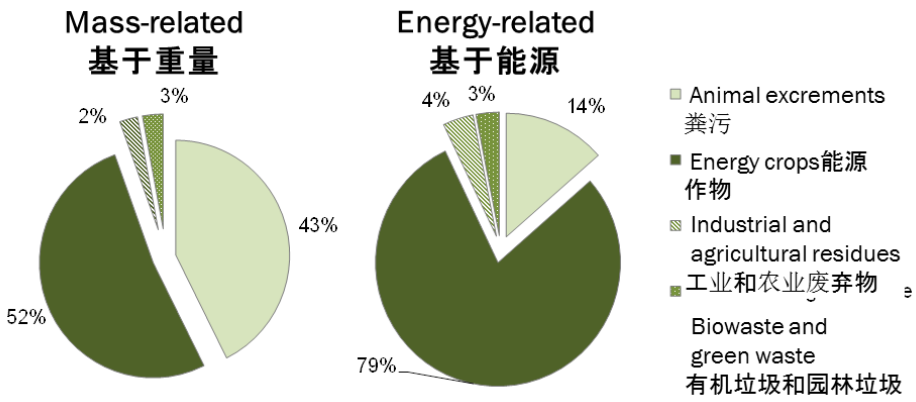
Substrate Distribution in Germany
原料分布



Source: DBFZ: Stromerzeugung aus Biomasse. Zwischenbericht May 2015, Leipzig

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Change of framework conditions
框架条件的改变

- **Stop of the special incentive for energy crops**

  终止了对能源作物的特殊补贴
- **Change from fixed incentives system to tendering process**

  由固定补贴系统向招标方式改变
- **Exception only for manure digestion plants <75 kWel installed power and plants for municipal organic waste**

  不包括小于75kWel装机容量的纯粪污沼气项目和城市有机废弃物沼气项目

8

Challenge of framework conditions change
框架条件改变带来的挑战

- **No new plants for energy crop digestion**
- 无新建以能源作物为原料的沼气项目
- **New business models necessary for new and existing plants**
- 对于新建和已建沼气项目需要新的商业模式
- **Strong need for cost reduction and new business models**
- 急需降低成本和新的商业模式
- **Especially for existing plants after 20 years of guaranteed incentives (change to tendering procedure or other business model)**
- 尤其对于超过20年失去补贴保证的已建项目（改为招标或其他商业模式）

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Change of energy concepts
能源观念的改变

- **Biomass is the most limited source in the energy system**生物质是能源系统中最受限制的原料
- **Wind and solar power are much cheaper and less limited** 风能和太阳能更便宜且限制少
- **Future energy systems will consist strongly on fluctuating wind and solar power**
未来能源系统将由波动剧烈的风能和太阳能组成
- **Challenge of reliability of supply** 稳定供应是挑战
- **Biogas is able to be the joker in the system** 沼气将扮演系统中的百搭角色
  - Peak load in electrical grid 电网调峰
  - Traffic fuel 交通燃料
  - Smart heat, industrial and household fuel 智能热力、工业和家庭燃料
  - Power to gas….电制气
- **Flexible power/storage capacity has a higher value** 灵活发电/可存储有巨大价值

Change of substrate concepts -
Alternative energy crops 原料观念的改变-替代能源作物

- **Annual energy crops (esp. corn silage) most economic crop for fodder and biogas** 能源作物（特别是青贮）是最经济的饲料和沼气原料
- **High cropping density in intensive animal regions (where also biogas density is high)** 在养殖密集区能源作物种植密度高（同样这也是沼气密集区）
- **Biogas use has lower requirements on feed** 作为沼气原料比作为饲料要求低
- **> perennial crops with advantages for soil fertility, groundwater and biodiversity protection possible** 多年生作物对于土壤肥力，地下水和生物多样性保护更有利
- **Alternative crops like forage legumes, Wild flower mixtures *Silphium perfoliatum*, Szervasi-grass etc. have positive impact on land use** 替代作物比如豆科、野花、松香草等，对于土地使用有积极的影响

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Change of substrate concepts -
Agricultural residues 原料观念的改变-农业废弃物

- **Unused potentials of harvest residues like beet leaves, straw, etc.**
- 一些收割剩余物尚未使用，比如甜菜叶，秸秆等
- **Large potentials esp. of straw** 具有巨大的潜力，特别是秸秆
- **Big challenges of straw digestion in the field of rheology** 秸秆消化在流体力学方面挑战巨大
- **Deficiencies of Macro- and Micronutrients** 大量和微量元素的缺乏

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Change of substrate concepts - Pretreatment and digestion technology 原料观念的改变-预处理与消化技术

- **Different methods of pretreatment for straw/lignocellulose available** 已有多种预处理秸秆/木质纤维素的方法
- **Mechanical, other physical, chemical, enzymatic and biological methods available** 机械、其他物理的、化学的、酶的和生物的方法
- **Up to now no independent evaluation available** 截至目前，尚没有独立的对这些方法的评估
- **Challenges for technological/economical optimization** 技术/经济优化面临挑战

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Manure utilization 粪污利用

- **Liquid manure with low value to be transported** 运输液体粪污不值当
- **Strong economies of scale at manure digestion** 粪污发酵的经济规模要求大
- **Typical farm size in Eastern Germany 500 – 3000 Large cattle units (LCU)** 德国东部典型的养殖规模500-3000头牛单位
- **Typical farm sizes in Western Germany <100 – 300 LSU** 西部<100-300头牛单位
- **Ca. 15 kW per 100 LSU possible (ranging from 8 – 30, depending on kind of animal, litter, yield level, management of feed residues, grazing)** 每100头牛约15kW装机（范围从8-30，取决于动物类型、杂物、产气率、剩余饲料的管理、牧场）
- **Ca. 80% of cattle manure used in biogas plants in East Germany (example Thuringia)** 德国东部80%的牛粪用于产沼气
- **Only ca. 30 % of total manure in use in Western Germany**西部仅为约30%

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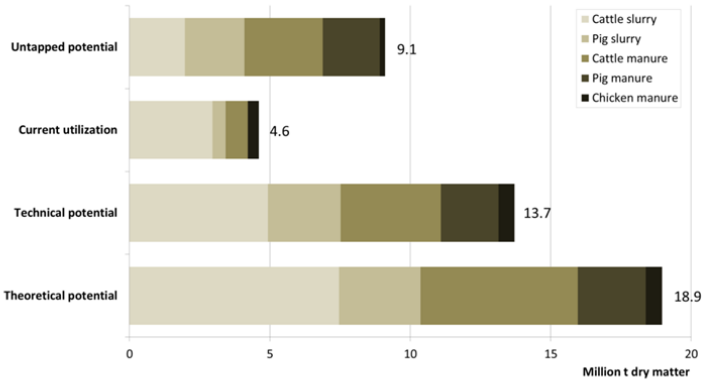
Slurry and manure from livestock in DE

Resource potentials 德国粪污原料潜力



Brosowski, A., Thrän, D., Mantau, U., Mahro, B., Erdmann, G., Adler, P., Stinner, W., Reinhold, G, Hering, T., Blanke, C.: A review of biomass potential and current utilisation - Status quo for 93 biogenic wastes and residues in Germany, Biomass and Bioenergy, 95, p. 257-272, DOI 10.1016/j.biombioe.2016.10.017

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Manure characteristics- (I) Dry-matter (DM) content 粪污特性(I)干物质

- **Dependent on stable system** 取决于棚舍系统
- **Factors are litter-use, dung-removal technology and stable ventilation** 因素包括废弃物使用、清粪工艺和棚舍通风
- **Typical DM- values in China for cattle and swine manure much lower than in Germany** 中国牛粪和猪粪的干物质价值普遍低于德国
- **Reason: Manure scrubber or perforated floors in Germany,** 原因:德国多用刮粪板或带孔的地板
- **Flat concrete, dung-removal by water in China** 中国多用水泥平地,水冲粪

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Manure characteristics- (II) Methane yields 原料特性（II）甲烷产率

- **Dependent on manure type, litter, Volatile Solids (VS) and age** 取决于粪污类型、杂物、VS和时间
- **Feed-in without pre-storage!** 进料有没有预混池

Substrate 原料	DM-content 干物质含量	Methane yield 甲烷产率 m^3 CH_4 per ton of fresh matter (FM), 吨鲜料甲烷
Cattle manure Germany 牛粪	8	10
Pig slurry Germany 猪粪	6	12
Pig slurry China 中国猪粪	3	6
Solid dung (fresh) 干粪（鲜）	25	50
Chicken manure (fresh, no litter) 鸡粪（鲜粪、无杂物）	15	37

Manure characteristics- (II) Methane yields 原料特性（II）甲烷产率

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Substrate	DM-content	Methane yield m^3 CH_4 per ton of fresh matter (FM),
Cattle manure Germany	8	10
Pig slurry Germany 德国猪粪	6	12
Pig slurry China 中国猪粪	3	6
Solid dung (fresh)	25	50
Chicken manure (fresh, no litter)	15	37

High water content in China by dung removal with water 由于水冲粪，中国猪粪含水多

Effects of low DM content
干物质含量低的影响

- **High reactor volume** 反应器容积大
- **High storage volume for digestate** 沼液储池大
- **Higher costs for digestate use as fertilizer (transport + spreading or upgrading-treatment)** 沼液用于肥料成本高（运输+喷洒或后加工）
- **High energy-need for heating up** 加热需能多
- **Example:** 例如
- **Heating-up of manure in Winter from 0° C to 40° C (digester-temperature)** 冬季加热粪污从0° C到40° C（罐内温度）
- **= 40* 1,163 kWh = 47 kWh (without any losses**无任何损失**)**
- **CHP-use of Chinese swine manure: 24 kWh of exhaust heat** 中国猪粪发电：余热**24kW**
- **>> High water-use in stable means energy limitation for biogas use or need for co-substrate!** 棚舍用水多意味着沼气利用受限或需要混合发酵

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Challenges for higher manure utilization rates
高粪污利用率的挑战

- **Cost efficient scale of manure digestion technology** 粪污厌氧技术的成本规模
- **Synergy optimization between stable and biogas plant** 棚舍和沼气厂的协同优化
  - No manure store below stable – scrubber instead of perforated floor 棚舍下不储存粪污 – 用scrubber代替有孔地板
  - Combined planning, saving of planning and construction site equipment costs 统一设计、降低设计、施工和设备成本
  - Combined piping 统一管道
  - Use of scrubber manure shaft + pump - saving of pre-storage 使用刮粪板+泵，节省预混池
  - Joint storage 联合储存
- **Reduction of water in stable – enhancement of dry-matter content** 棚舍降低用水量，增加干物质
- **Combination with cost effective other residues (e.g. straw)** 与其他便宜原料混合发酵（比如秸秆）

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Biogas in future bioeconomy
沼气与未来生物经济

- **Optimization of carboxylate production** 优化羧酸盐生产
  - Synthetic fuels 混合燃料
  - Platform chemicals 平台化学品
  - Crop protection agents 作物保护剂
- **Fiber processing by biogas process** 纤维工艺
- **Phytomining – biogas technology to treat biomass for rare earth elements mining** 植物冶金-利用沼气技术处理生物质获得稀有金属
- **Phytoremediation with biogas treatment to regenerate polluted sites** 利用沼气植物修复再生污染场地

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Process aspects 工艺方面

- **Liquid manure, especially cattle manure belongs to the most easy substrates** 液体粪污，特别是牛粪，是最容易的原料
  - Easy rheology 流体力学好
  - Well balanced nutrient contents 营养平衡
  - Easy bioprocess (possible inoculum) 易实现生物过程（接种物）
- **Chicken manure difficult due to high N-concentrations (ammonia inhibition) and sand content (sinking layers)** 由于含氮浓度高（氨抑制）以及含砂（沉淀）较难处理
- **Straw (litter or co-substrate) can equalize high N-concentrations** 秸秆（作为杂质或者混合发酵）可以平衡高氮浓度
- **Sawdust or woodchips problematic litter (undegradable, swimming layers)** 锯末或者木屑是有问题的杂质（沉淀或浮渣）
- **Long straw as litter > pretreatment (rheology)** 长秸秆作为杂质，预处理
- **Adequate management of disinfection and cleaning agents**灭菌剂和清洁剂的适当处理

22

Emission aspects 排放方面

- **Avoiding of methane (CH_4) emissions** 避免甲烷排放
- **Ideally direct feed-in without previous storage** 直接进罐不储存更理想
- **Avoiding of nitrous oxide emissions (N_2O) especially from solid manure chains** 避免氮氧化物排放，特别是从固体粪污中
- **No ammonia emissions from closed digestion tanks, but higher ammonia partial pressure by digestion (degrading of proteins to ammonia)** 封闭厌氧罐中无氨释放，但是厌氧消化造成高氨分压（蛋白质分解为氨）
- **> surface covering of tanks, soil integration of digestate** 罐体表面覆盖，沼渣与土混合
- **Degrading of odours (e.g. indols, scatols, organic fatty acidy)** 臭气分解（吲哚、粪臭素、有机脂肪酸）

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Hygiene aspects 卫生方面

Direct hygiene aspects: 直接消毒

- **Degradation of pathogens** 杀灭病原体
- **Hygienisation possible by thermophilic process or by pre- or post-hygienisation (exhaust heat from CHP)** 利用高温发酵消毒或者通过预处理或后处理消毒（发电机余热）

Indirect hygiene aspects even more important: 非直接的消毒更重要

- **Strictly feed-in of fodder residues without pre-storage** 没有预储存的饲料剩余物严格进料
- **Biogas-use of all manure** 所有粪污沼气
- **> Vectors (Insects, Rodents) loose habitat and fodder base**
- **> Animal farms loose attractiveness for secondary (long distance) vectors like birds and carnivors**

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Options for Utilization 利用方式

Combined heat and power (CHP) 热电联产

Peak load, e.g. combined with wind and solar power
风电和太阳能调峰

Heat utilization (CHP or boiler) for heating / drying / cooling 热利用(热电联产或锅炉)供热、干燥、制冷

Biomethane as fuel 生物甲烷作为燃料

Icons: DBFZ / Tina Schmalfuß

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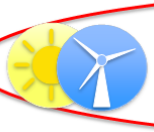
Options for Utilization – intention of smart biogas 利用方式-智慧沼气

Combined heat and power (CHP) 热电联产



Peak load, e.g. combined with wind and solar power
风险和太阳能调峰

Heat utilization (CHP or boiler) for heating / drying / cooling 热利用(热电联产或锅炉)供热、干燥、制冷

Biomethane as fuel 生物甲烷作为燃料

Icons: DBFZ / Tina Schmalfuß

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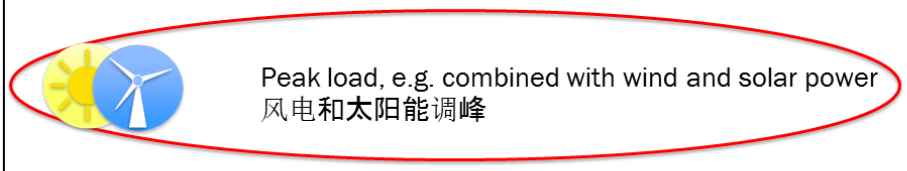
Options for Utilization – intention of smart biogas利用方式-智慧沼气



Peak load, e.g. combined with wind and solar power
风电和太阳能调峰

High need of flexibility
高灵活性需要

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4.4 Effluent utilization and nutrient management plan in agriculture in the North China Plain

Contents of presentation 报告内容

1. Introduction 介绍
2. Nutrient aspects 养分方面
3. Biogas digestate ammonia emissions 沼肥氨气挥发
4. Results from field measurements in Hebei Province 河北省大田试验结果
5. Nutrient management calculations 养分管理计算
6. Conclusions on use of biogas effluent as fertilizer 沼渣沼液用作肥料的结论

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1. Introduction 介绍

- In the peri-urban areas of Beijing livestock densities reach 10-15 livestock units (LU) ha^{-1} (1 LU = 500 kg)
  北京城郊地区的饲养密度达到每公顷 10-15 家畜单位（LU）(GVE)（1 LU=500 公斤）
- Pollution from livestock raising, wastewater is often dumped into rivers or canals
  来自家畜养殖业的污染，废水经常被倾倒入河流和运河
- Soil pollution (HM, antibiotics)　土壤污染（重金属、抗生素）
- Progressive de-coupling of plant production and animal husbandry 种植业和养殖业的逐渐分离
- Landless livestock farms – logistical problems due to surrounding small-scale farmers
  土地紧张的禽畜饲养场– 周围小规模的农户带来的物流问题
- China now faces a major nutrient management challenge
  中国现面临养分管理的重大挑战

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1. Introduction 介绍

1.2 Pollution from excess nutrients 来自过剩营养的污染

DER SPIEGEL (2013)

2. Nutrient aspects养分方面 （一）

2.1 Nutrient effect of nitrogen氮的养分效应

- Higher pH value of digestate in comparison with raw manure 与未经处理的粪便相比，沼肥中的pH较高:
  → Effect on ammonia losses 氨气挥发效果.

- NH_4^+-N constitutes roughly 65% (60-70%) of total N in digestates 沼肥中全氮的大约65 (60-70%)为氨态氮

Calculations using mineral fertilizer equivalents (MFE) 以化肥当量（MFE）计算:
1st year: MFE = (40-60%) 第一年：MFE= (40-60%)

Longer-term application of digestate (10-15 years): MFE (1st year) = 60-70%. **70% (mainly NH_4^+-N).**
沼肥的长期施用（10-15年）： MFE (第一年) = 60-70%. **70% (主要为铵态氮)。**

But: Ammonia losses must be extensively avoided! 但是：氨挥发必须极力避免!

Fachagentur Nachwachsende Rohstoffe e.V. (FNR), modified 德国可再生能源处，修订

2. Nutrient aspects养分方面 （二）

2.2 Nutrient effect of phosphorus, poassium 磷、钾的养分效应

- Availability of P, K, Mg for fertilizer calculations: 磷、钾、镁有效性的肥料计算:
  P = 100% K = 100% Mg = 100%
- Amount of solids in biogas plant determines the nutrient content of the digestate after fermentation

  重要：沼气发酵罐中的固体量，决定发酵后沼肥中的养分构成。

→ If many solids in effluent → high P content → cropland area limited by P requirements of field crops

若沼液中固体多→ 磷含量高 → 农田面积受限于作物对磷的需求

→ If solids removed from effluent, → cropland area limited by N (or K) requirements of field crops

若固体从沼液中分离 → 农田面积受限于作物对氮（或钾）的需求

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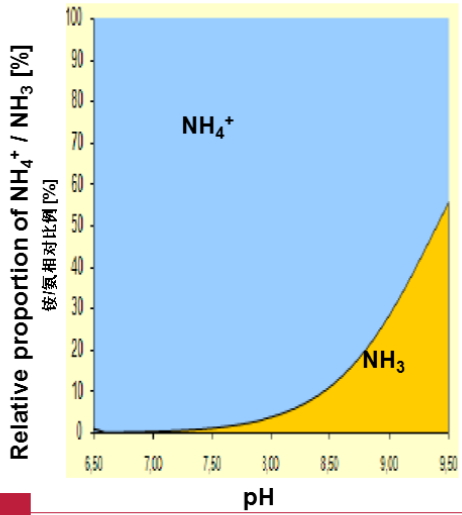
3. Biogas digestate ammonia emissions 沼肥氨排放

3.1 Ammonium / ammonia equilibrium at 20 °C, 20 °C 时的铵-氨平衡



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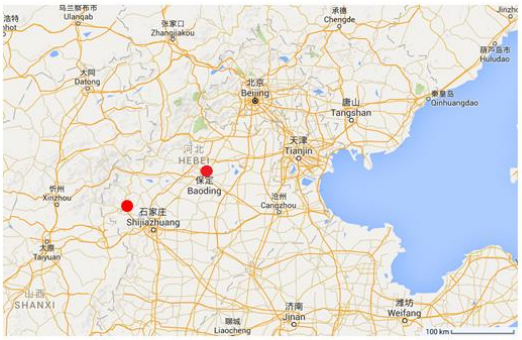
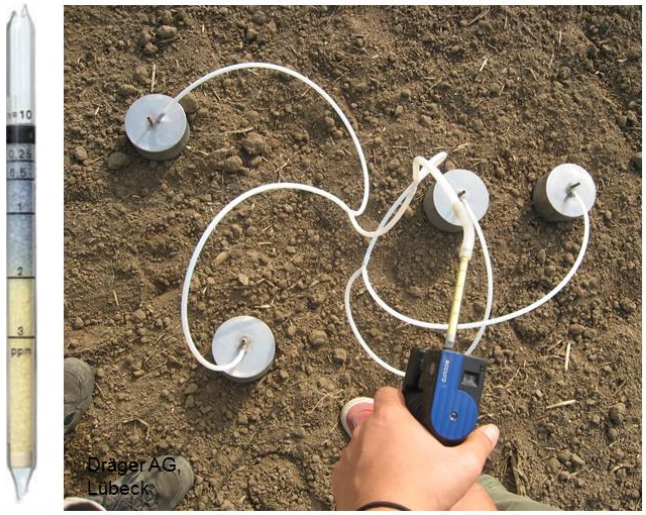
LfL Bavarian State Research Center for Agriculture; TUM Chair of Plant Nutrition (Fabian Lichti, 2012) 巴伐利亚州立农业研究中心；慕尼黑工大植物营养研究所（Fabian Lichti, 2012）

4. Results from field measurements in Hebei Province
沼肥氨挥发 - 河北省大田试验结果

- Years: 2015-17 (2015-17 年)
- Locations: Baoding, Zhengding
- Climate: subhumid （半湿润区）
- Mean annual temperature 13.4°C (年平均温度)
- Mean annual precipitation: 680 mm (年平均降雨量)
- Soil type: 潮褐土 Eutric Cambisol（饱和始成土）
- Soil pH (H_2O): 6.9 – 8.0 (0-20 cm)
- $CaCO_3$: 0.1 – 3.7% (0-20 cm)

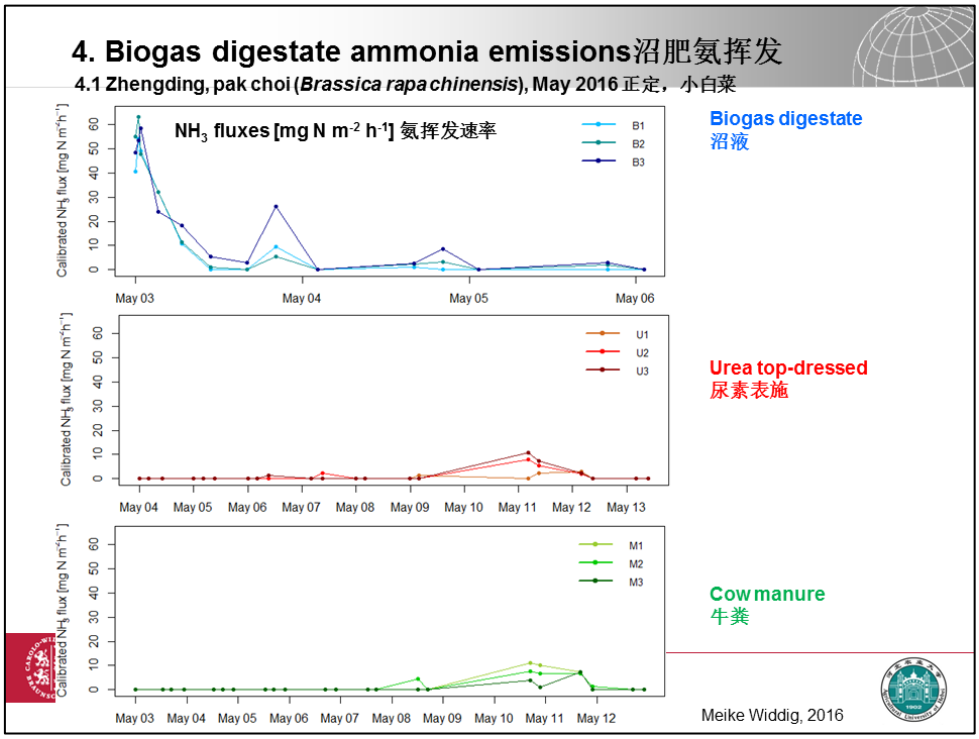


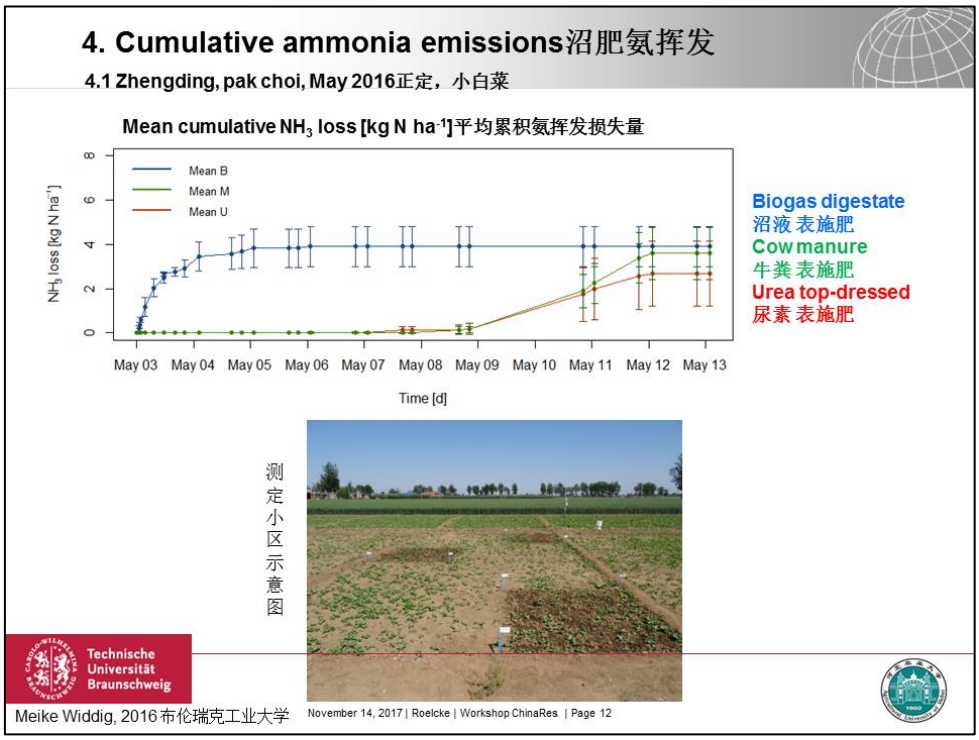
4. Biogas digestate ammonia emissions 沼肥氨挥发
Calibrated Draeger-Tube Method (DTM)



氨挥发测定装置：捕获装置、手泵等　　多功能气象站

Kevin Täubert, 2017 布伦瑞克工业大学


4. Biogas digestate ammonia emissions沼肥氨挥发
4.1 Zhengding, pak choi (Brassica rapa chinensis), May 2016 正定，小白菜
NH3 fluxes [mg N m-2 h-1] 氨挥发速率
Calibrated NH3 flux [mg N m-2 h-1]
B1
B2
B3
May 03
May 04
May 05
May 06
U1
U2
U3
May 04 May 05 May 06 May 07 May 08 May 09 May 10 May 11 May 12 May 13
M1
M2
M3
May 03 May 04 May 05 May 06 May 07 May 08 May 09 May 10 May 11 May 12
Biogas digestate
沼液
Urea top-dressed
尿素表施
Cow manure
牛粪
Meike Widdig, 2016


4. Cumulative ammonia emissions沼肥氨挥发
4.1 Zhengding, pak choi, May 2016正定，小白菜
Mean cumulative NH3 loss [kg N ha-1]平均累积氨挥发损失量
NH3 loss [kg N ha-1]
Mean B
Mean M
Mean U
May 03 May 04 May 05 May 06 May 07 May 08 May 09 May 10 May 11 May 12 May 13
Time [d]
Biogas digestate
沼液 表施肥
Cow manure
牛粪 表施肥
Urea top-dressed
尿素 表施肥
测定小区示意图
Technische Universität Braunschweig
Meike Widdig, 2016 布伦瑞克工业大学
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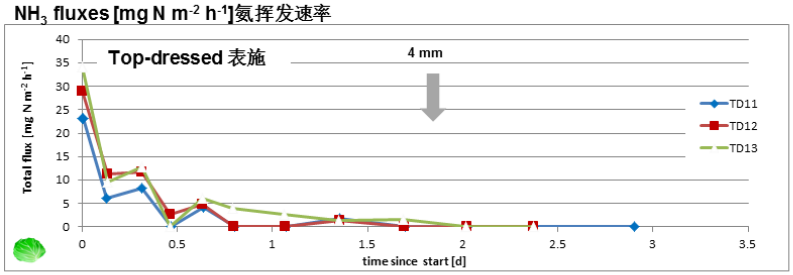
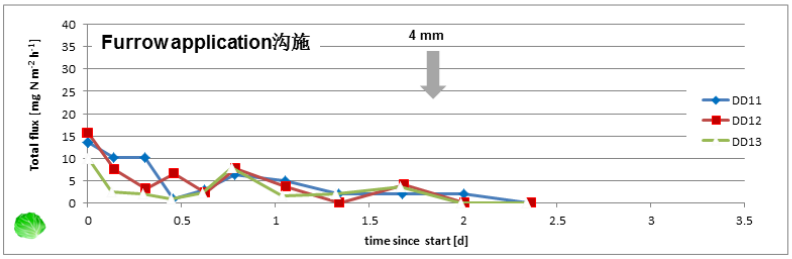
4. Biogas digestate ammonia emissions沼肥氨挥发

4.2 Zhengding, Chinese cabbage正定，大白菜

NH_3 fluxes [mg N m^{-2} h^{-1}]氨挥发速率





Starting date: Sept. 15, 2016

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5. Biogas digestate ammonia emissions 沼肥氨挥发

Zhengding, Chinese cabbage (*Brassica rapa chinensis*), September 2016

Mean absolute and relative NH_3 losses

Replication 处理重复	Type of application 施肥方式	Amount of applied NH_4^+-N [kg N ha^{-1}] 铵态氮施用量	Absolute NH_3 loss [kg N ha^{-1}] 绝对氨挥发损失量	Relative NH_3 loss [%] 相对氨挥发损失比例
1	Top-dressed表施	49.81	1.76 ± 0.52	**3.5** ± 1.0
	Furrow appl. 开沟混施	49.17	1.84 ± 0.45	**3.8** ± 0.9
2	Top-dressed	48.97	4.72 ± 0.73	**9.6** ± 1.4
	Furrow application	47.61	2.59 ± 0.33	**5.4** ± 0.7
3	Top-dressed	51.12	2.19 ± 0.40	**4.3** ± 0.8
	Furrow application	49.34	1.94 ± 0.52	**3.9** ± 1.1
4	Top-dressed	49.43	2.26 ± 0.17	**4.6** ± 0.3
	Furrow application	48.42	1.40 ± 0.43	**2.9** ± 0.9

表施沼液

沟施沼液

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5. Nutrient management calculations 养分管理计算

5.1 German scheme for determining fertilizer requirement (example) 德国计算肥料需求的体制（举例）

Green maize 青饲玉米	N	P_2O_5	K_2O
Expected yield 预计产量: 50 t FM per ha 每公顷50吨鲜物质	x 0.004	x 0.0017	x 0.0048
Crop removal 作物收割 [kg/ha] + Unharvested parts 未收获 [kg/ha] = Nutrient requirement 养分需求 [kg/ha]	204 20 224	86 86	241 241
Recommended fertilization 建议施肥量 [kg/ha]	incl. soil N, deposition: **104** **包括土壤中的氮和大气氮素沉积**	**86**	**241**
Fertilization plan 肥料计划 [kg/ha]	50% mineral N, 50% digestate: 52 50%无机氮肥，50%沼肥: 52		
Biogas digestate contents [kg/m³] 沼肥组分	全氮4.4 (x 60% NH_4^+-N铵氮) = 2.7	1.9	5.0
50% of N from digestate [kg/ha] 50%的氮由沼肥提供	**52** / 2.7 kg NH_4^+-N/m³ = **19 m³**	36	96
Additional mineral fertilization [kg nutrients/ha] 另需化肥 [公斤养分/公顷]	52	49	145

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Landwirtschaftliches Technologiezentrum (LTZ) Augustenberg (modified) 农业工程中心(LTZ)奥古斯腾堡（修订）

5. Nutrient management calculations 养分管理计算

5.2 Properties of digestate of biogas plant in a Pilot Pig Farm near Beijing 京郊试点猪场的沼肥属性

Item 指标	Stamm	Guo
DM 干物质 [% of FM]	0.81	
oDM 有机干物质 [% of DM]	54.0	
Total Kjeldahl N 全氮 [kg/m³ FM]	0.84-1.54	0.83
Total P 全磷 (Total P_2O_5) [kg/m³ FM]	0.18 (0.41)	0.06 (0.14)
Total K 全钾 (Total K_2O) [kg/m³ FM]	0.47 (0.57)	0.49 (0.59)
NH_4^+-N 铵态氮 [kg/m³]	0.895-1.608	
EC 电导率 [mS/cm]	12.3	
pH	7.6-7.8	

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Stamm (2013) Bonn University; Guo (2012) 中国农业大学

5. Nutrient management calculations 养分管理计算

5.3 Crop nutrient requirements (Beijing region) (example)
作物营养要求 （北京地区）（举例）

Crop type 作物类型	Grain/fruit yield level [jin/mu] [kg/ha] 粮食/果子产量 [斤/亩]	Mean N uptake [jin N/mu] [kg N/ha] 平均氮需求量 [斤氮/亩]	Mean P uptake [jin P_2O_5/mu] [kg P_2O_5/ha] 平均磷需求量 [斤磷/亩]	Mean K uptake [jin K_2O/mu] [kg K_2O/ha] 平均钾需求量 [斤钾/亩]
winter wheat 冬小麦	640 4,800	19 145	6 46	16 117
summer maize 夏玉米	896 6,720	26 193	11 82	27 200
Orchards 果园	3,150 23,625	15 113	10 77.9	21 160

jin/mu * 7.5 = kg/ha

Heimann et al., 2013 布伦瑞克工业大学

5. Nutrient management calculations 养分管理计算

5.4 Fertilization plan winter wheat-summer maize double-crop rotation (Beijing region) (example) 为冬小麦-夏玉米两季轮作制定肥料计划（北京地区为例）

Per 1 ha and year 每年每公顷	N	P_2O_5	K_2O
winter wheat/summer maize Mean nutrient requirements [kg /(ha*yr)] 冬小麦/夏玉米 平均养分需求	Winter wheat 冬小麦: 145 Summer maize夏玉米: 193 **Total 共计: 338**	Winter wheat冬小麦: 46 Summer maize夏玉米: 82 **Total: 128**	WW: 117 SM: 200 **Total: 317**
Fertilization plan 肥料计划:		100% digestate 沼肥	
Biogas digestate contents [kg/m³] 沼肥组分	1.57 全氮 x 70% (NH_4^+-N铵氮) =1.10	0.899	0.990
100% of P from digestate [kg/ha] 所有磷由沼肥提供	157 (NH_4^+-N铵氮)	**128.3** / 0.899=**143 m³/ha** = **9.5 m³/mu**(立方米/亩)	141
Additional mineral fertilization [kg nutrients/ha] 另需化肥 [公斤养分/公顷]	181	0	176

Heimann et al., 2013 布伦瑞克工业大学; Luo et al., 2014 中国农业大学

5. Nutrient management calculations 养分管理计算

5.5 Prices of most commonly applied mineral fertilizers in China (average purchasing price for farmers in 2013) and their nutrient contents 中国最普遍施用的化肥价格（农民平均购买价）和其养分含量

Fertilizer type 肥料类型	Chinese name 中文名	Price per kg bulk fertilizer [RMB Yuan] 每公斤价格[元]	pure nutrients 纯养分 [% N]	pure nutrients 纯养分 [% P_2O_5]	pure nutrients 纯养分 [% K_2O]
Urea	尿素	2.00	46	0	0
DAP (diammo-nium phosphate)	磷酸二铵	3.80	18	46	0
SSP (single superphosphate)	过磷酸钙	0.80	0	18	0
TSP (triple superphosphate)	重过磷酸钙	2.50	0	46	0
NPK fertilizer (15/15/15, Cl)	三个15复合肥 Cl	3.00	15	15	15
NPK fertilizer (15/15/15, S)	三个15复合肥 S	3.30	15	15	15
KCl	氯化钾	3.20	0	0	60

Source: Fertilizer company in Hefei City, Anhui Province, June 2013

5. Nutrient management calculations 养分管理计算

5.6 Saving mineral fertilizer costs winter wheat-summer maize double-crop rotation (Beijing region) (cost calculation example)节约化肥成本冬小麦-夏玉米两季轮作（以北京地区为例计算成本）

Per 1 mu and year 每亩每年	N	P_2O_5	K_2O
winter wheat/summer maize Mean nutrient requirements [jin N, P_2O_5, K_2O/(mu*yr)] 冬小麦/夏玉米 平均养分需求 [斤氮、磷、钾/亩*年]	Winter wheat冬小麦: 19.33 Summer maize夏玉米: 25.73 **Total共计: 45.06**	Winter wheat: 6.11 冬小麦：6.11 Summer maize: 11.00 夏玉米：11.0 **Total: 17.11**	WW: 15.58 SM: 26.82 **Total: 42.40**
Biogas digestate contents [kg/m³] 沼肥组分 [kg/m³]	1.57 x 70% (NH_4^+-N铵氮)=1.10	0.899	0.990
Nutrients saved by digestate [jin N, P_2O_5, K_2O/(mu*yr)] 沼肥提供的纯养分	**20.93** (NH_4^+-N)	**17.11** (P_2O_5)	**18.79** (K_2O)
Costs saved [Yuan/(mu*yr)] 节约的成本[元/亩*年] Yuan/mu * 2 ≈ EUR/ha	**45.51 Yuan元 urea 尿素** **220.96 Yuan元 DAP 磷酸二铵** **209.33 Yuan元 三个15复合肥**	**38.02 Yuan 元 SSP 过磷酸钙** **70.67 Yuan元 DAP 磷酸二铵** **171.09 Yuan 元 三个15复合肥**	**50.11 Yuan元 KCl 氯化钾** **187.92 Yuan元 三个15复合肥**

Heimann et al., 2013 布伦瑞克工业大学; Luo et al., 2014 中国农业大学

5. Nutrient management calculations 养分管理计算

5.7 Calculation of area demand (example) 土地面积需求计算（举例）

Per 1 ha and year 每公顷每年 (Nutrient requirements calculated on basis of P 以磷为基准计算养分需求)	
Total volume 总体积 (Annual amount of effluent) [m^3] （每年沼肥需求量）[m^3]	33,950
Calculated volume per ha 每公顷得出体积 (100% of P from digestate 所有磷由沼肥提供)	143 m^3/ha
Calculated volume per mu每亩得出体积 (100% of P from digestate 所有磷由沼肥提供)	9.5 m^3/mu
Annual area demand [ha/yr] 每年土地面积需求[公顷/年]	**33,950 m^3/yr : 143 m^3/ha = 238 ha/yr**
Annual area demand [mu/yr] 每年土地面积需求[亩/年]	**33,950 m^3/yr : 9.5 m^3/mu ≈3,570 mu/yr**

Luo et al., 2014 中国农业大学

6. Conclusions on use of biogas effluent as fertilizer 沼渣沼液做肥料的结论

- Only C is reduced: high loads of N, P, K still remain in the digested effluent
  只有碳减少了：高含量的氮磷钾仍在沼液中
- Digestate very suitable for maize with its high N demand; if loss-reducing techniques used → can help save high amounts of mineral N fertilizers
  适用于玉米，因为玉米对氮需求量高；如果采取防止养分流失的措施→则可以节省大量氮肥
- Mineral N fertilization has to be reduced since the available biogas effluent N makes up at least 60% (-70%) of the total N
  化肥氮肥必须减少，因为沼肥中的可用氮占到全氮的最少60%（至70%）
- If continuous application over several years: High balance surpluses for P and K
  若连续几年施肥：磷和钾含量会过剩
- Frequently P is limiting factor for cropland demand (besides N)
  磷通常是农田养分需求的限制因素（除了氮）
- Digestates should also be targeted on crops with high P and K requirements
  沼肥应当也着眼于磷和钾需求高的作物
- Double-cropping systems, as frequent in China, are very positive. Nutrients taken up all year round
  双季轮作在国内很普遍，对养分利用有积极作用。养分可以被全年利用
- Application of digestate to cereals and orchards is recommended; but viewed as critical to leafy vegetables, which are mostly shallow-rooting and for direct human consumption
  建议对谷物和果园施肥；对根浅的和用于人类食用的叶菜施肥→不被推荐

Möller et al., (2009), Institute of Plant Nutrition, Hohenheim Uni 霍恩海姆大学植物营养研究所; Thüringen Ministry of Agriculture Report (2013)

Please feel free to ask questions!

欢迎提问 marco.roelcke@giz.de or m.roelcke@tu-bs.de

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GIZ 德国国际合作机构 Sino-German Project of Optimization Biomass Utilization 中德生物质能优化利用项目 (2009-2013)
Heinrich-Böll Foundation 海因里希·伯尔基金会 (2015)
DAAD-CSC PPP project „Quantifying ammonia emissions from cropland after application of different organic fertilizers including biogas digestate from intensive animal husbandry operations in the North China Plain” (2016-2017) 国家留学基金管理委员会 (CSC) 和德意志学术交流中心 (DAAD) 2015年中德合作科研项目 (PPP)

Technische Universität Braunschweig

November 14, 2017 | Roelcke | Workshop ChinaRes | Page 23

4.5 Introduction of participant - DBFZ

Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ

Introduction of participant - DBFZ
参会单位介绍 - DBFZ

Dr. Britt Schumacher

Public Workshop: “How to foster the utilisation of agricultural residues in the biogas sector in China?”, CAAE; Shangqiao, Beijing, China, 2017/11/14

DBFZ – Development, Task, Structure
DBFZ – 发展，任务，结构

DBFZ

Development 发展:

- Founded on February 28th, 2008 in Berlin as a non-profit LLC (gGmbH)
- 2008年2月8日成立于柏林，为非盈利研究机构
- Sole shareholder: The Federal German Government represented by the Federal Ministry of Food and Agriculture (BMEL)
- 唯一控股单位：德国联邦食品和农业部代表的德国联邦政府

Scientific task 科研任务:

- Support of the efficient establishment of biomass as a valuable resource for sustainable energy supply within the scope of applied research
- 生物质资源用于可持续能源供应的应用研究

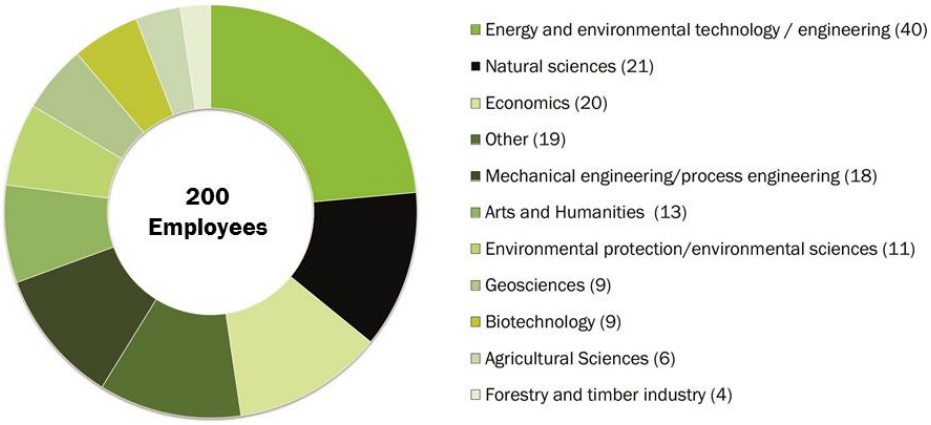
Structure结构:

- ~ 200 employees in administration and research departments 约200名雇员涵盖行政与科研

Managing directors 主任:

- Prof. Dr. mont. Michael Nelles (scientific)
- Daniel Mayer (administrative)

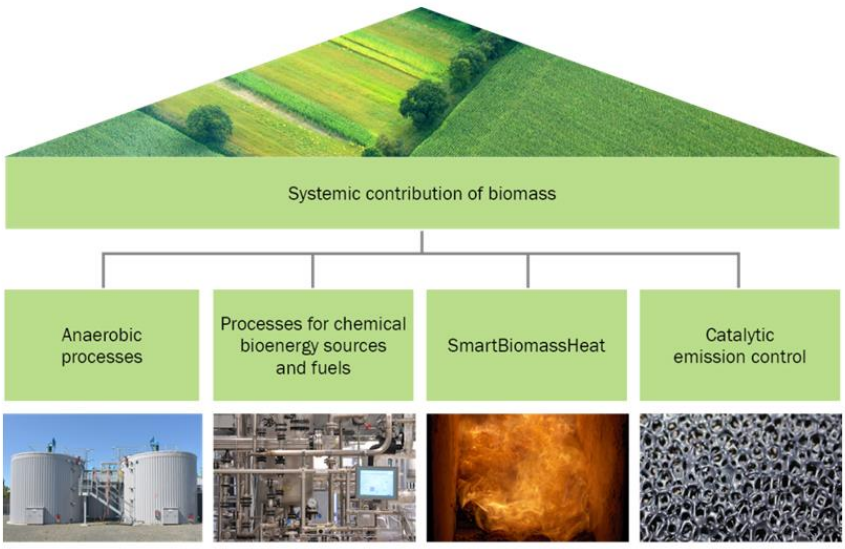
Qualifications of our staff 我们员工的构成



Fields of study [number of people]
研究领域
as per 19 January 2015

3

DBFZ – Research Focus Areas 研究领域



Pictures: DBFZ; Gabriele Jepsen - Fotolia.com (photo above)

4

DBFZ – Anaerobic Processes 厌氧研究

„Biogas plants must become more flexible in terms of their substrates and energy delivery. Only then will they be able to continue making a major contribution to the safeguarding of energy supplies in future“ 沼气厂的原料和能源供应上必须变得更加灵活。只有这样才能够持续为未来的能源供应保障做出贡献
(Dr. Jan Liebetrau, DBFZ)

Objectives of the research focus area研究目标
- Flexibility in terms of substrates and litigation 原料灵活性
- Process monitoring and control 过程监测与控制
- Reduction of emissions 降低排放
- Increasing efficiency and reducing costs 提高效率降低成本
- Coupling of material and energy use of biomass 结合原料与能源应用

Key reference projects (Selection) 主要项目(节选)
- Flexibization of Bioenergy as regional compensation option in the German electricity grid (Regiobalance) 德国电网中生物能源作为地区补充方案的灵活性研究
- Operation-related emissions from biogas plants (BetEmBGA) 沼气厂运行排放
- Potential to improve the performance of bio-gas plants - energy efficiency of repowering measures 沼气厂运行效果提升潜力 – 改造的能效

5

Applied Research at DBFZ
DBFZ的应用研究

Biogas Pilot Plant 沼气厂

Fuel Technical Centre
燃料技术中心

Combustion Lab 燃烧实验室

Engine Test Bed
发动机测试床

Fuel Conditioning Lab 燃料调节实验室

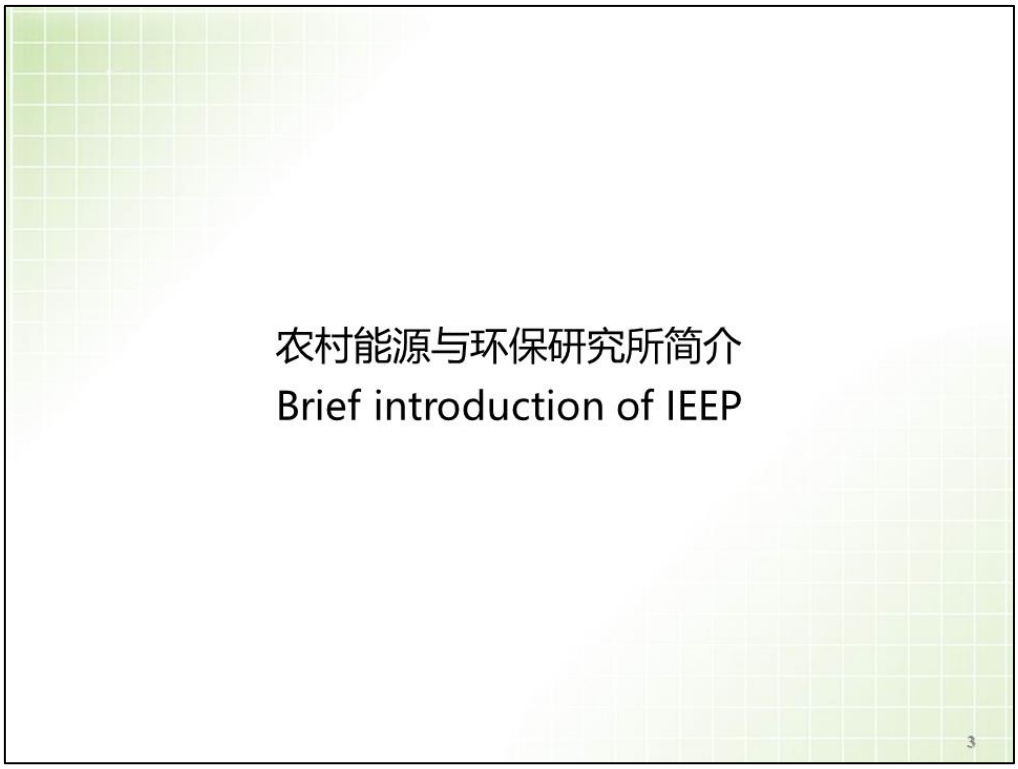
Analytical Lab
分析实验室

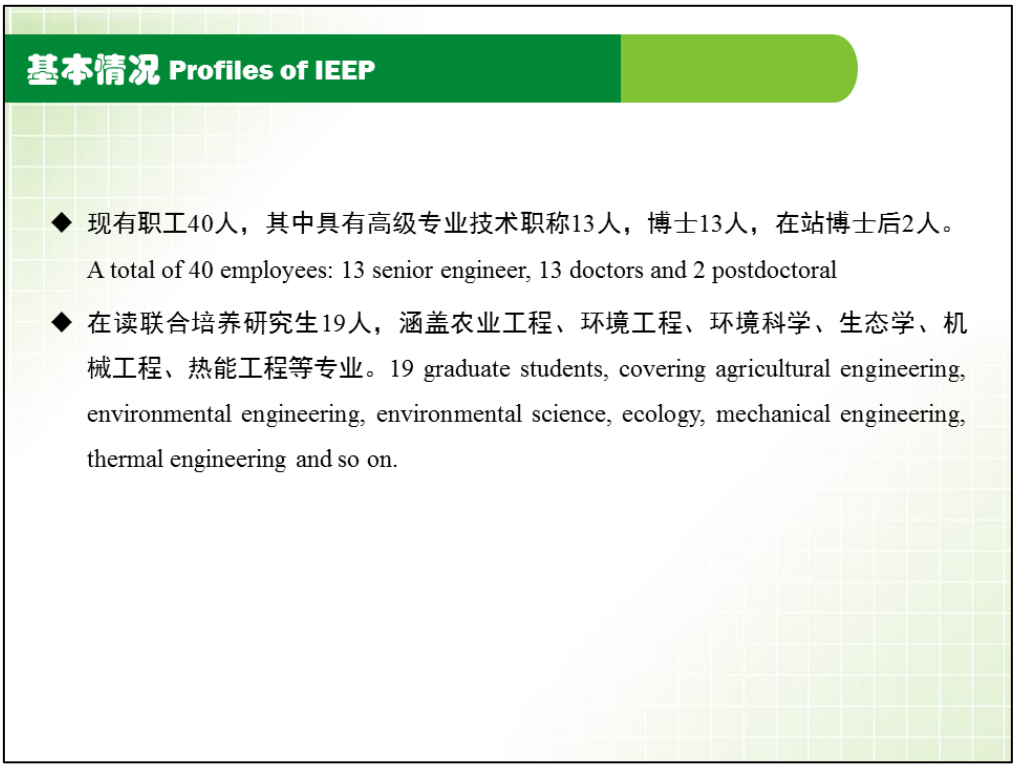
Pictures: DBFZ / Jan Gutzeit

6

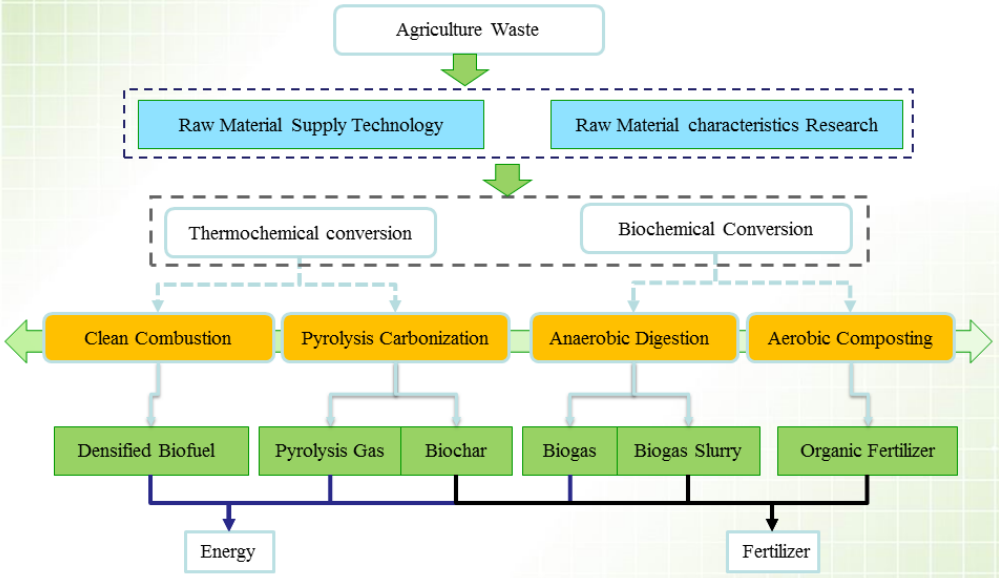

Deutsches Biomasseforschungszentrum
gemeinnützige GmbH
DBFZ
Smart Bioenergy – innovations for a sustainable future
Come and join us!
智慧生物能源 – 为了可持续的未来创新
欢迎加入我们
Contact
Dr. Britt Schumacher
Tel. +49 (0)341 2434 – 540
E-Mail: Britt.Schumacher@dbfz.de
Kay Schaubach
Tel. +49 (0)341 2434 – 468
E-Mail: Kay.Schaubach@dbfz.de
DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH
Torgauer Straße 116
D-04347 Leipzig
Phone: +49 (0)341 2434 – 112
E-Mail: info@dbfz.de
www.dbfz.de

4.6 Introduction of participant - CAAE





研究方向 Research direction



科研条件 Research Facilities

农业部生物质工程中心
Biomass Research Centre, MoA,

农业部资源循环利用技术与模式综合性重点实验室
Key Laboratory of Energy Resource Utilization from Agricultural Residues, MoA

农业部农业废弃物能源化利用重点实验室
Key Laboratory of Technology and Pattern of Resource Circle Utilization, MoA

8个公共实验室、15个专业实验室、2个中试实验室

8 public laboratories, 15 specialized laboratories and 2 pilot laboratories

完备的实验仪器设备及配套装置，共计476台套

total 476 sets of instruments and equipment, including LC-MS, ICP, TGA, GC, etc.


实验室 Laboratory
Public Laboratory
Specialized laboratory
Pilot-scale laboratory


谢 谢！
Thank you!

4.7 Introduction of participant - CAU

秸秆湿储存技术
WET STORAGE OF CROP RESIDUES WITH DIFFERENT PROPERTIES

- Storage for the year-round substrate supply
- Complex characteristics (cellulose, lignin, water content et al.)
- High Dry matter loss (could be as high as 30%)

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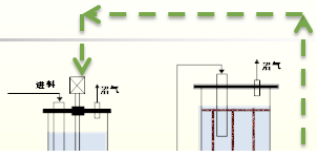
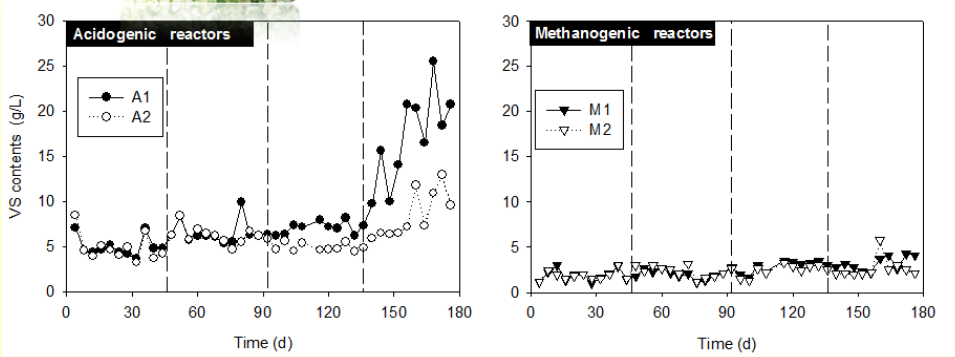
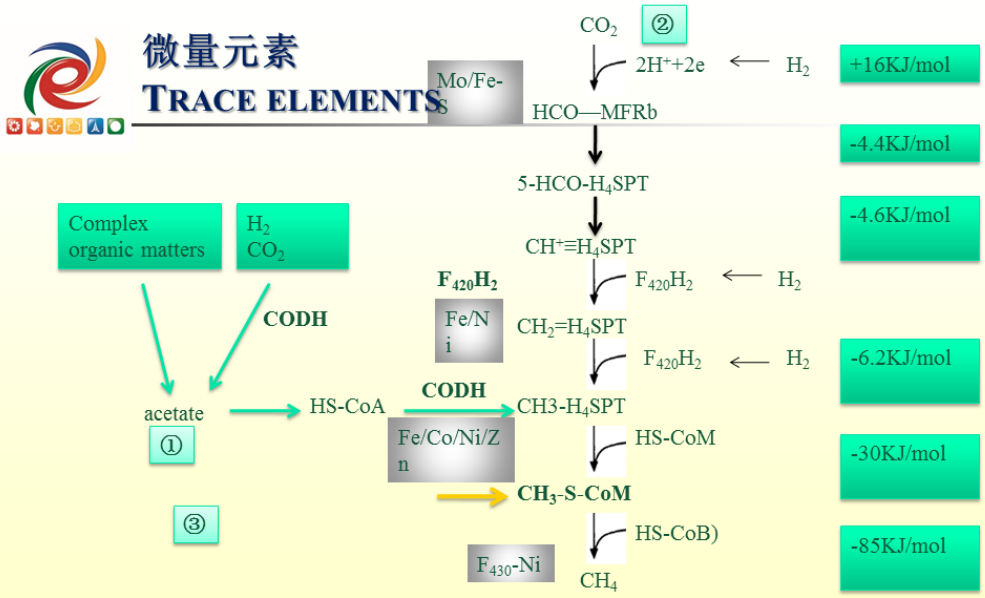
尾菜厌氧消化产酸特性及回流调控研究
VEGETABLE RESIDUES AD OPTIMIZATION





2018/1/13 Zuo Z, Wu S, Zhang W, et al. 2013 Bioresource Technology 4

微量元素 TRACE ELEMENTS

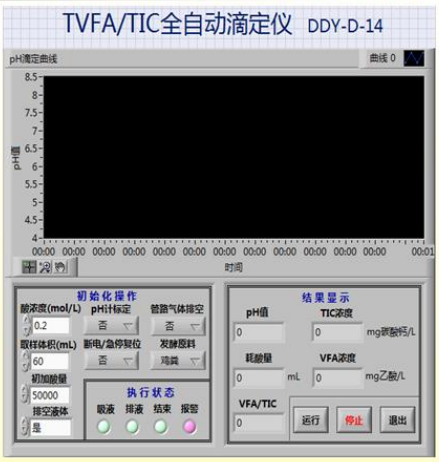


1. Zandvoort M H, Hullebusch E D, Fermoso F G, et al. Trace metals in anaerobic granular sludge reactors: bioavailability and dosing strategies[J]. Engineering in Life Sciences, 2006, 6(3): 293－301

2. Shima S, Warkentin E, Thauer R K, et a1. Structure and function of enzymes involved in the methanogenic pathway utilizing carbon dioxide and molecular hydrogen[J]. Journal of Bioscience and Bioengineering, 2002, 93(6): 519－530.

2018/1/13 5

厌氧发酵过程监测与反馈控制 PROCESS MONITORING AND FEED-BACK CONTROL



吴树彪, 陈新颖, 刘良, 郭建斌*, 董仁杰. 规模化沼气工程总挥发酸与碳酸氢盐碱度自动滴定装置[J]. 农业机械学报, 2015,（接收）

2018/1/13

测定畜禽粪污的成分
MANURE CONTENTS MONITORING

- 干物质
- 有机质
- 电导率
- pH
- 总氮、有机氮、无机氮、氨
- 总磷P2O5、磷酸盐
- 总钾K2O等
- 金属（钙、铜、镁、纳、锌）

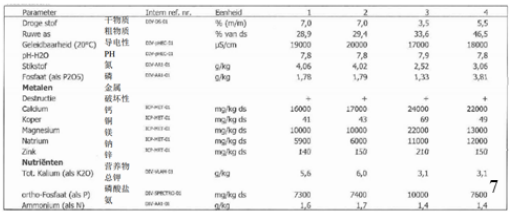
- 重金属（镍、铅、铬、镉、砷、汞）
- 抗生素
- 蛔虫卵
- 腐熟度

表 5：荷兰的牛粪浆、牛粪浆的固体部分、固体牛粪、育肥猪粪浆、猪粪浆的固体部分以及蛋鸡固体粪便的一般成分和氮/磷比例

	干物质 (g/kg)	有机物质 (g/kg)	N-tot* (g/kg)	N-min* (g/kg)	N-org* (g/kg)	P_2O_5* (g/kg)	K_2O* (g/kg)	N/P_2O_5
牛粪浆	85	64	4.1	2.0	2.1	1.5	5.8	**2.7**
牛粪浆的固体部分	250	188	7.8	1.6	6.2	4.4	5.8	**1.8**
固态牛粪便	194	152	5.3	0.9	4.4	2.8	6.1	**1.9**
育肥猪粪浆	93	43	7.1	4.6	2.5	4.6	5.8	**1.5**
猪粪浆的固体部分	250	116	10.5	3.8	6.7	12.4	5.8	**0.9**
固态鸡粪（蛋鸡）	573	416	25.6	2.5	23.1	19.6	15.5	**1.3**

*: N-tot = 总氮，N-min = 氨态氮，N-org = 有机氮，P_2O_5 = 磷酸盐，K_2O = 碳酸钾，N/P_2O_5= 总氮/磷酸盐

粪污取样检测



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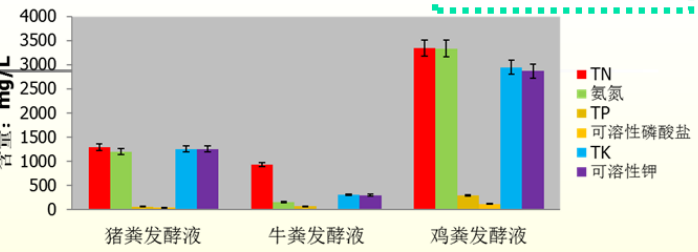
7

沼液中的养分（N、P、K）
NUTRIENTS IN DIGESTATES

化肥含N最低11%，P44%，K50%以上。但沼液最高也就是N 0.3%。

厌氧发酵沼液中含有大量植物生长所需的氮磷钾等营养成分。



种类(mg/L)	TS（%）	VS（%）	COD	TN	NH_4^+	TP	S-PO_4	TK	S-K
猪粪发酵液 Pig manure based	0.73	0.34	5145	1291.51	1201.83	65.35	45.92	1256.06	1252.81
牛粪发酵液 Cow manure based	0.65	0.38	4050	934.23	157.76	71.67	2.51	312.41	302.08
鸡粪发酵液 Chicken manure based	2.21	1.13	13540	3337.88	3335.31	292.35	121.17	2946.27	2868.7
餐厨发酵液 Kitchen based	2-3.5		8500		400-1500	50-100		20-40	

[1] 沈炳国, 黄安娜, 王能杰, 等. 宁波大型餐厨垃圾厌氧发酵装置简介[J]. 中国沼气, 2011, 29(1): 34-36.
[2] 吴桂菊. 利用小球藻降解餐厨垃圾消化沼液的试验研究[D]. 重庆大学, 2013.
[3] 李祎雯, 曲英华, 徐奕琳, 等. 不同发酵原料沼液的养分含量及变化[J]. 中国沼气, 2012, 30(3): 17-20.
[4] 张佳, 张德励, 王小伟, 等. 餐厨垃圾厌氧消化残余物污染特征分析[J]. 2013 中国环境科学学会学术年会论文集(第五卷), 2013.
[5] 申娅. 餐厨垃圾单相厌氧反应器高负荷运行试验研究[D]. 重庆大学, 2013.

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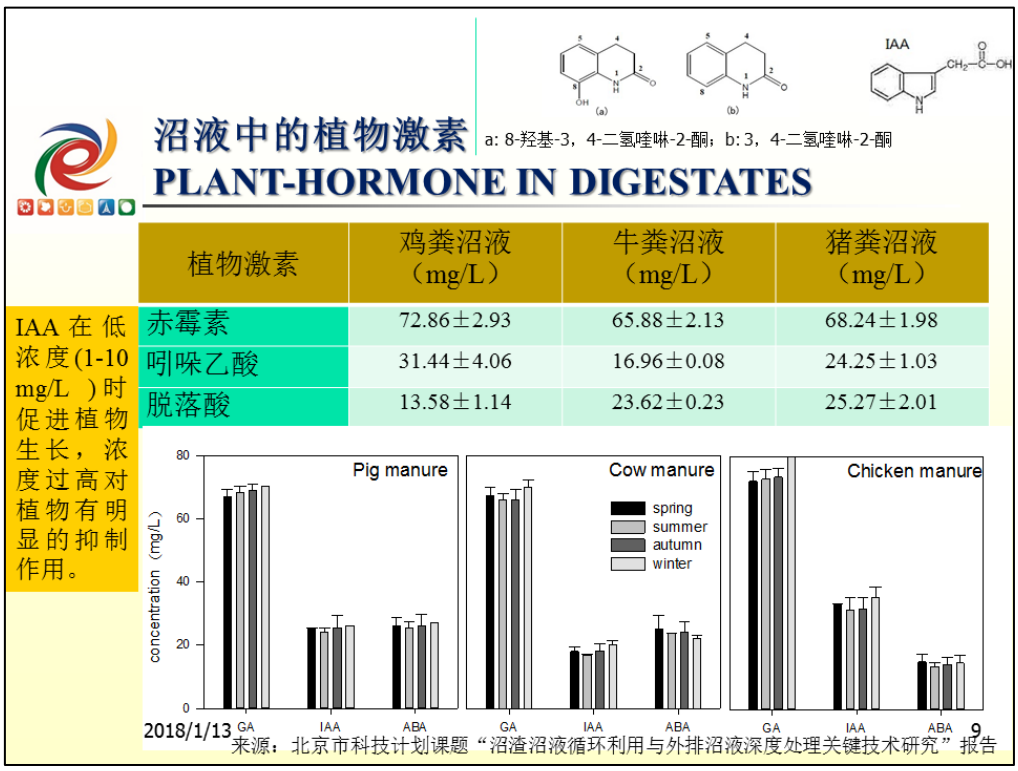
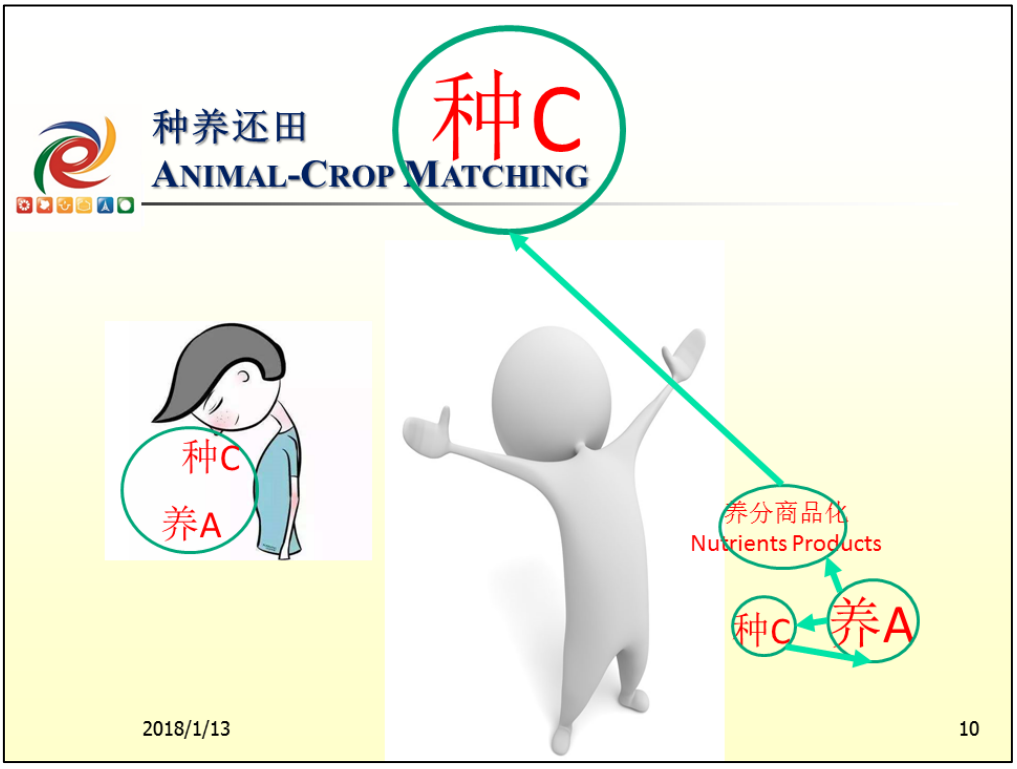

沼液中的植物激素
PLANT-HORMONE IN DIGESTATES
a: 8-羟基-3，4-二氢喹啉-2-酮；b: 3，4-二氢喹啉-2-酮
IAA
植物激素
鸡粪沼液（mg/L）
牛粪沼液（mg/L）
猪粪沼液（mg/L）
赤霉素 72.86±2.93 65.88±2.13 68.24±1.98
吲哚乙酸 31.44±4.06 16.96±0.08 24.25±1.03
脱落酸 13.58±1.14 23.62±0.23 25.27±2.01
IAA 在低浓度(1-10 mg/L)时促进植物生长，浓度过高对植物有明显的抑制作用。
Pig manure
Cow manure
Chicken manure
spring
summer
autumn
winter
concentration (mg/L)
GA
IAA
ABA
2018/1/13
9
来源：北京市科技计划课题“沼渣沼液循环利用与外排沼液深度处理关键技术研究”报告


种养还田
ANIMAL-CROP MATCHING
种C
种C
养A
养分商品化
Nutrients Products
种C
养A
2018/1/13
10

发布

中 国 国 家 标 准 化 管 理 委 员 会

中华人民和国国家质量监督检验检疫总局

201x-xx-xx实施

201x-xx-xx发布

沼肥肥效试验及评估方法

Regulations of Anaerobic Digestate Fertilizing Effect Test and Assessment

（送审稿）

沼肥肥效试验及评估办法
REGULATIONS FOR BIOGAS DIGESTATES FERTILIZER TESTING

Great !

GB/T xxxx-201x

中 华 人 民 共 和 国 国 家 标 准

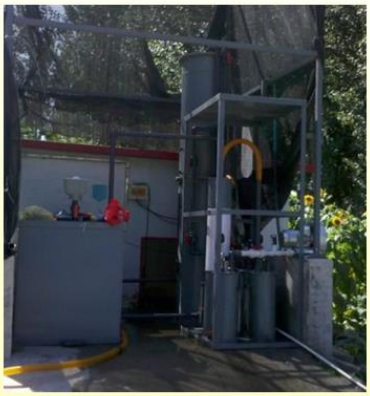
ICS 27.200

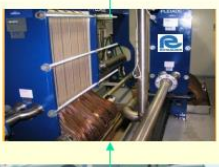
J73

2018/1/13

11

沼液氨氮吹脱
AMMONIA STRIPPING





2018/1/13

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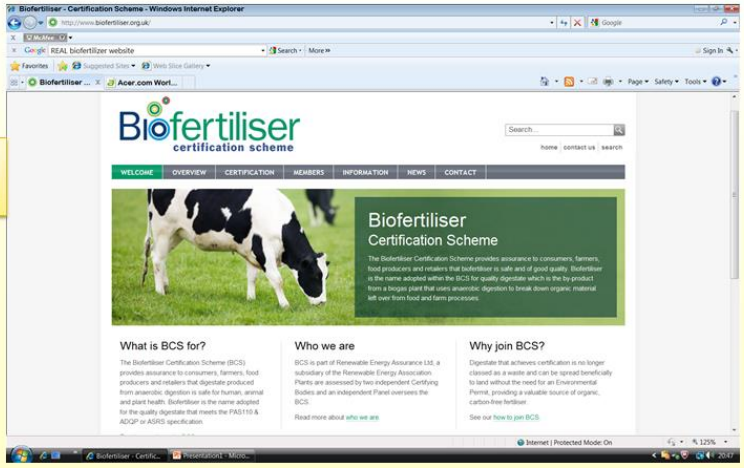
生物化肥
BIOFERTILIZER

In Italy, also China



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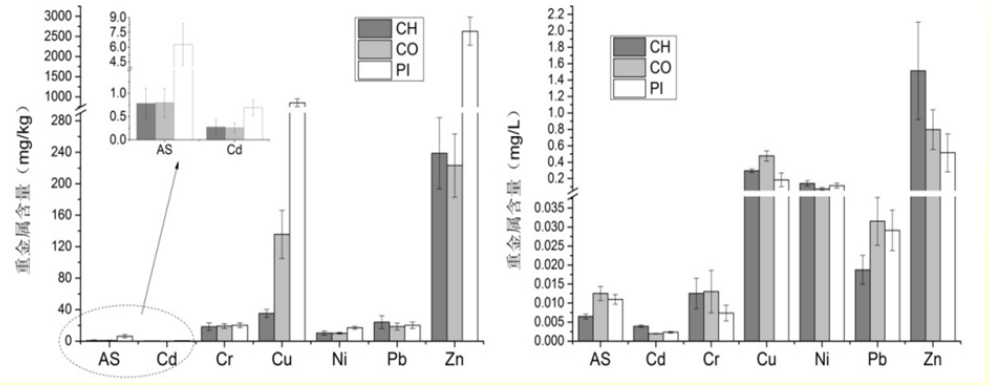
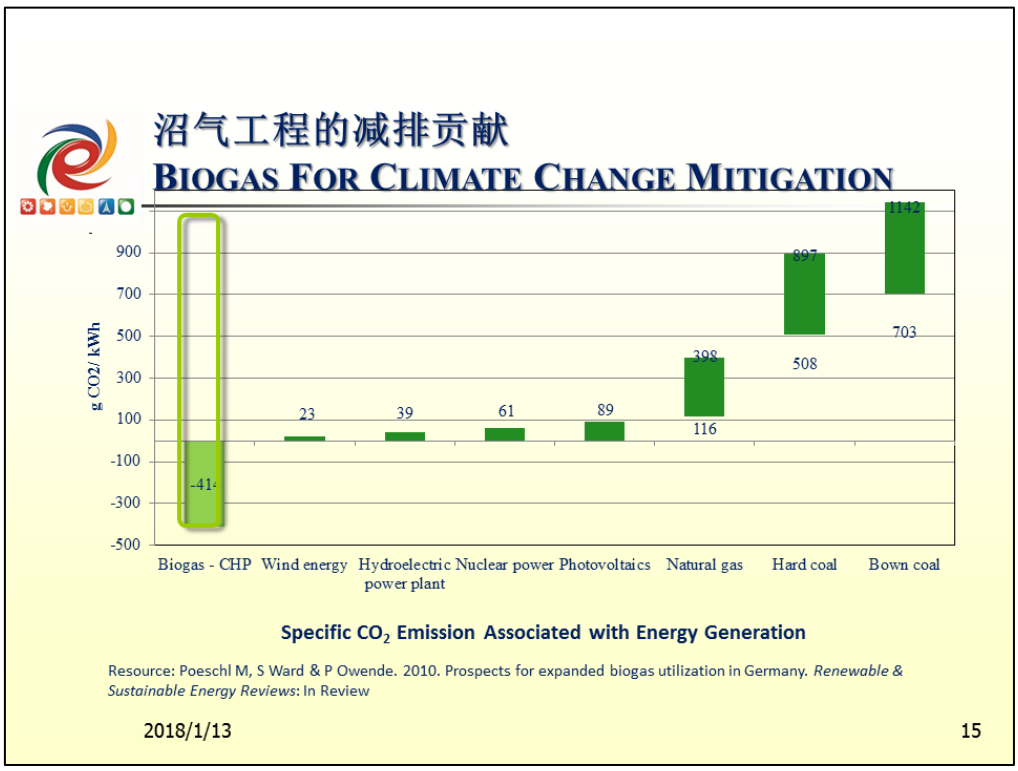
重金属问题
HEAVY METALS ACCUMULATION RISK

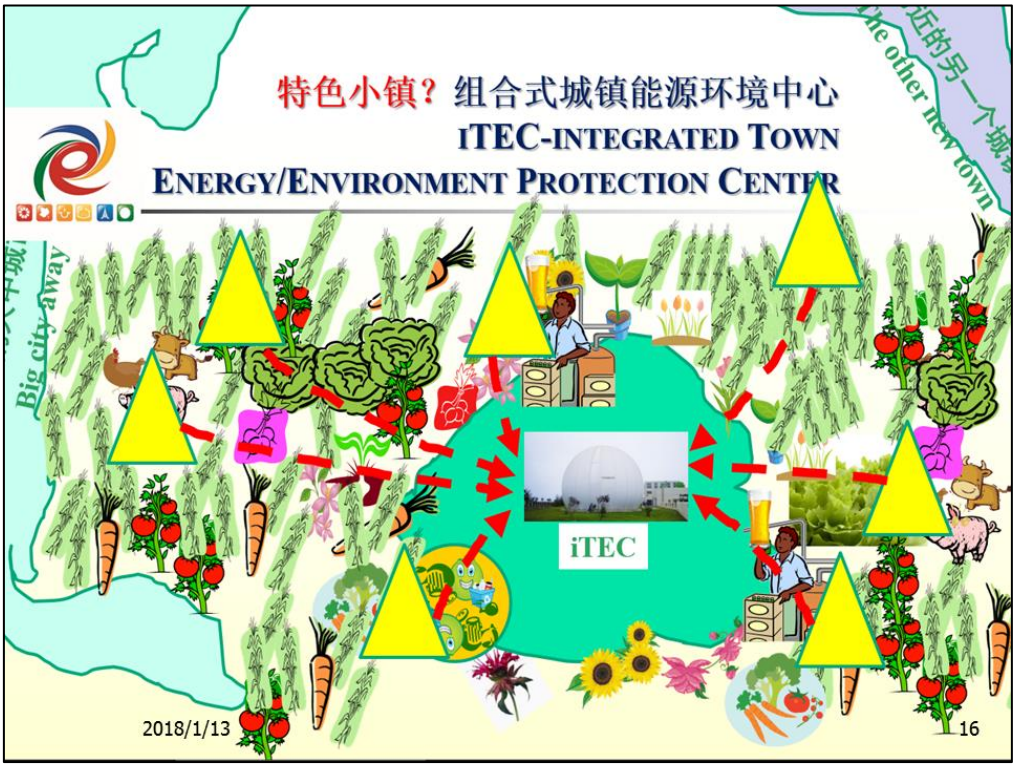


鸡粪（CH）、牛粪（CO）、猪粪（PI）发酵后沼渣中（左图）
和沼液中（右图）重金属含量

2018/1/13 14

来源：北京市科技计划课题“沼渣沼液循环利用与外排沼液深度处理关键技术研究”报告


沼气工程的减排贡献
BIOGAS FOR CLIMATE CHANGE MITIGATION
g CO2/ kWh
900
700
500
300
100
-100
-300
-500
-414
23
39
61
89
116
398
508
897
703
1142
Biogas - CHP
Wind energy
Hydroelectric power plant
Nuclear power
Photovoltaics
Natural gas
Hard coal
Bown coal
Specific CO_2 Emission Associated with Energy Generation
Resource: Poeschl M, S Ward & P Owende. 2010. Prospects for expanded biogas utilization in Germany. *Renewable & Sustainable Energy Reviews*: In Review
2018/1/13
15


特色小镇？组合式城镇能源环境中心
iTEC-INTEGRATED TOWN
ENERGY/ENVIRONMENT PROTECTION CENTER
Big city away
iTEC
2018/1/13
16

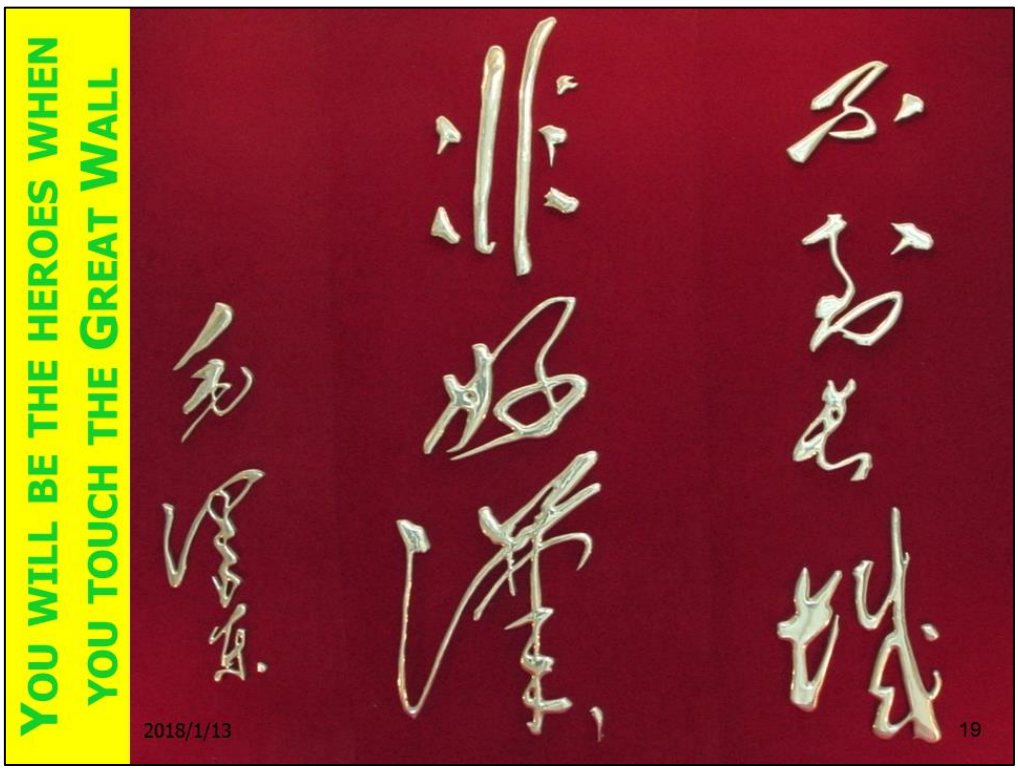
沼气工程服务：诊断、恢复、高效运行
BIOGAS CARE:
ACTIVATE EXISTING BIOGAS PLANTS

沼气医生
Dr. Biogas

2018/1/13 17

烟台格罗宁根大学的八大研究中心
RESEARCH CENTERS IN UGY

2018/1/13 18


YOU WILL BE THE HEROES WHEN
YOU TOUCH THE GREAT WALL
2018/1/13
19

4.8 Introduction of participant - CUPB

中国石油大学
CHINA UNIVERSITY OF PETROLEUM

Introduction of Institute of New Energy, China University of Petroleum-Beijing (CUPB-INE)

中国石油大学(北京)新能源研究院介绍

Hongjun Zhou
周红军

CUP
厚积薄发 开物成务

中国石油大学
CHINA UNIVERSITY OF PETROLEUM

China University of Petroleum Beijing 中国石油大学(北京)

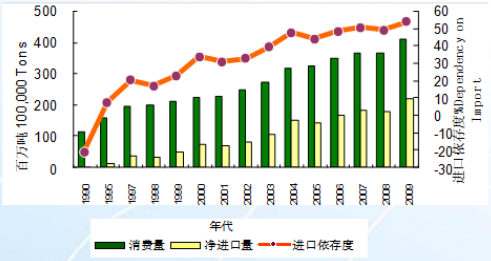
- 1953 Beijing Petroleum College Founded 北京石油学院成立
- 2005 Renamed as China University of Petroleum 更名为中国石油大学

A key national university under the Ministry of Education
教育部直属全国重点大学

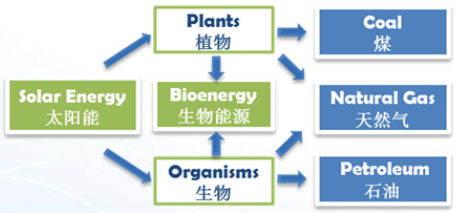
CUP
厚积薄发 开物成务

Foundation of INE-CUPB 新能源研究院成立

- INE-CUPB established in 2011. Bio-energy is one of the main research directions, with the aim to develope clean energy.
- 中国石油大学（北京）新能源研究院成立于2011年，以生物能源作为主要研究方向之一，开展清洁能源对化石能源的替代研究。



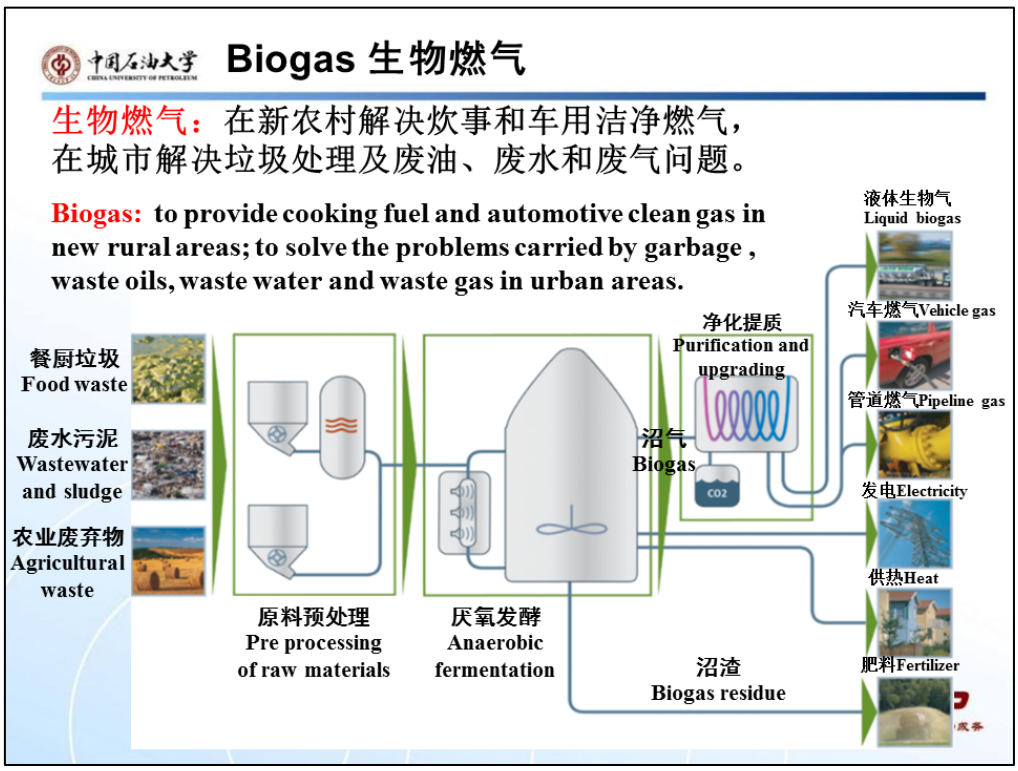
China’s oil consumption and imports (1990–2009)

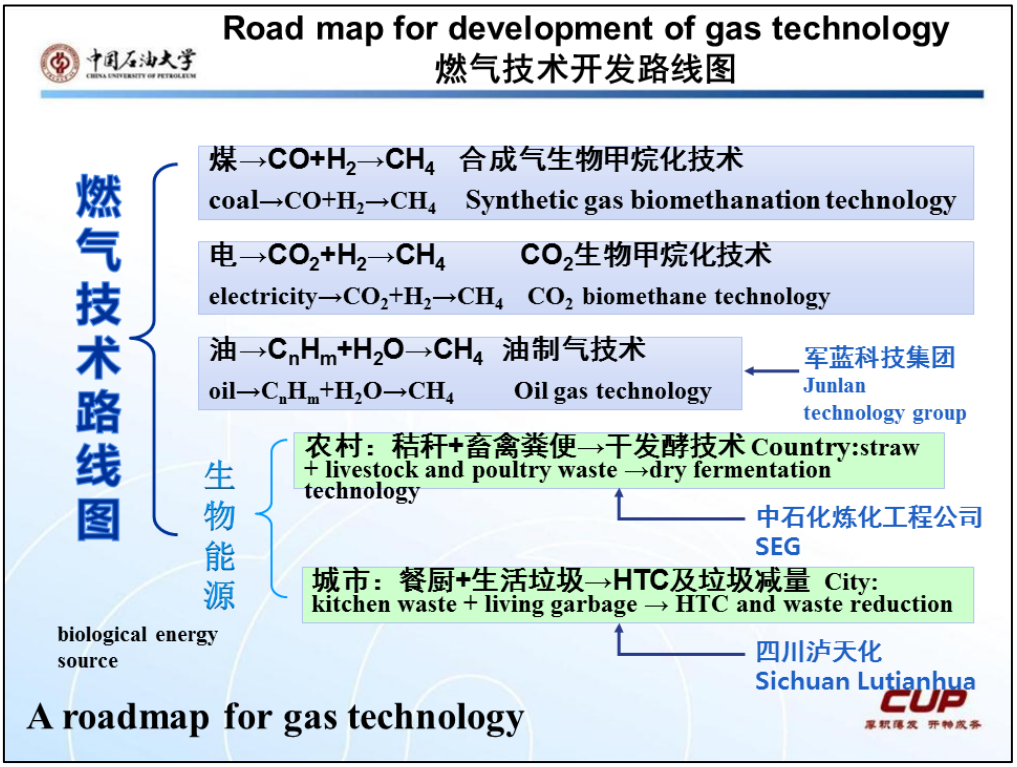


Evolution of fossil biomass energy

Research Areas 研究领域

- **Direction1: Bio-energy**
- **Direction 2: Clean Coal**
- **Direction 3: Energy Efficiency & CO_2 Mitigation**
- **Direction 4: Solar Energy**
- **Direct ion 5: Energy Storage and Fuel Cell**


Biogas 生物燃气
生物燃气：在新农村解决炊事和车用洁净燃气，
在城市解决垃圾处理及废油、废水和废气问题。
Biogas: to provide cooking fuel and automotive clean gas in new rural areas; to solve the problems carried by garbage , waste oils, waste water and waste gas in urban areas.
液体生物气
Liquid biogas
汽车燃气Vehicle gas
管道燃气Pipeline gas
发电Electricity
供热Heat
肥料Fertilizer
净化提质
Purification and upgrading
沼气
Biogas
CO2
餐厨垃圾
Food waste
废水污泥
Wastewater and sludge
农业废弃物
Agricultural waste
原料预处理
Pre processing of raw materials
厌氧发酵
Anaerobic fermentation
沼渣
Biogas residue


Road map for development of gas technology
燃气技术开发路线图
燃气技术路线图
煤→CO+H2→CH4 合成气生物甲烷化技术
coal→CO+H2→CH4 Synthetic gas biomethanation technology
电→CO2+H2→CH4 CO2生物甲烷化技术
electricity→CO2+H2→CH4 CO2 biomethane technology
油→CnHm+H2O→CH4 油制气技术
oil→CnHm+H2O→CH4 Oil gas technology
军蓝科技集团
Junlan technology group
生物能源
biological energy source
农村：秸秆+畜禽粪便→干发酵技术 Country:straw + livestock and poultry waste →dry fermentation technology
中石化炼化工程公司
SEG
城市：餐厨+生活垃圾→HTC及垃圾减量 City: kitchen waste + living garbage → HTC and waste reduction
四川泸天化
Sichuan Lutianhua
A roadmap for gas technology

Lab and project fields 实验室和项目现场

CUP

High-value agricultural product 农产品高值化

模拟人体消化系统，开发出一种中药/经济作物仿生加工工艺，经此工艺加工过的产品生物活性有了大幅提高，为中药/经济作物的高值利用提供一条新的思路。

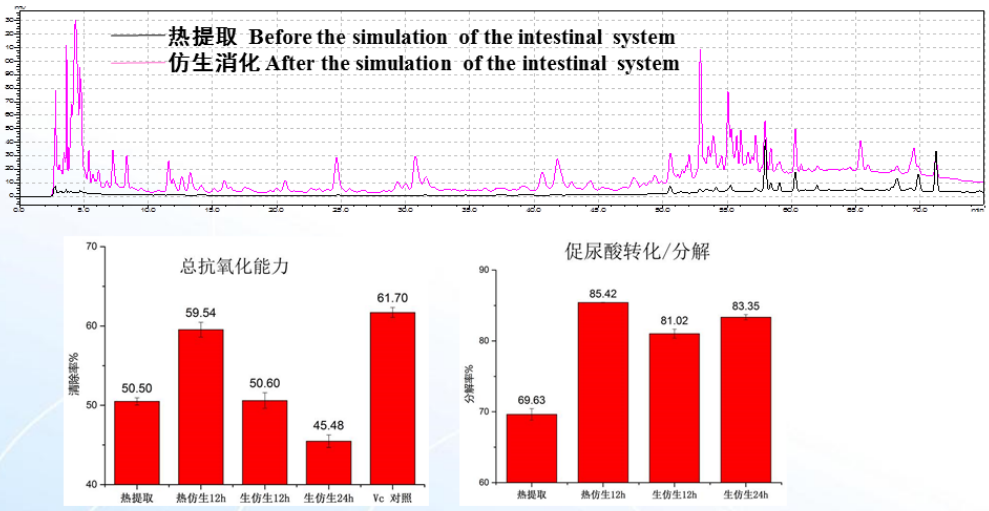
Simulation of the intestinal system: The compositions of traditional Chinese herbs can be metabolized or biotransformed by human intestinal bacteria, and may exhibit significant different biological effects. This method may help to realize the value increment of agricultural product.

中草药等经济作物 → 胃消化模拟 → 肠道消化发酵模拟 → 发酵液成分分析

Chinese herbs — **Simulation of the stomach system** — **Simulation of the intestinal system** — **Composition analyses**

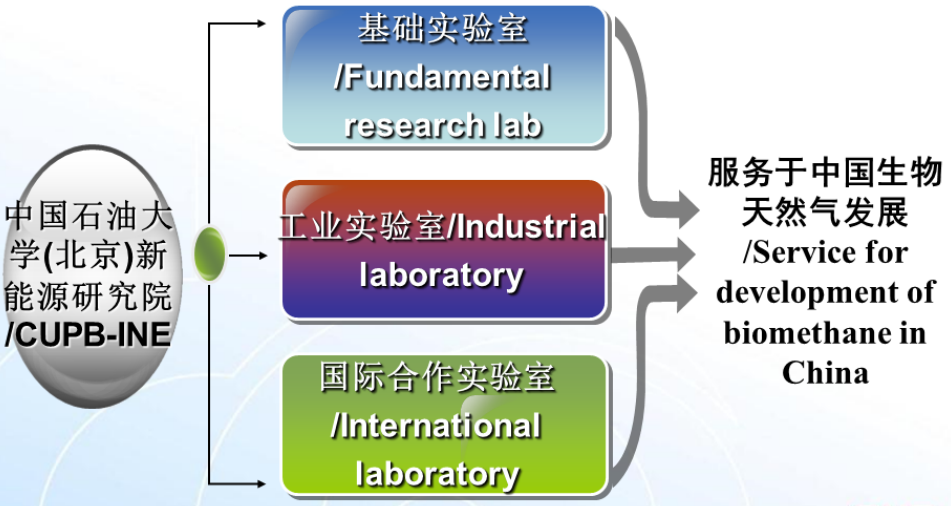
CUP

High-value agricultural product 农产品高值化



经过该工艺加工方法，草药的抗氧化活性和促尿酸分解活性都有了大幅提高。The antioxidation activities and uric acid degradations have been highly increased by using our method.

Outlook 展望




中国石油大学
CHINA UNIVERSITY OF PETROLEUM
Thank you

4.9 Introduction of participant - HFUU

- On Oct 30, 2015, Chinese Premier Li Keqiang and German Chancellor Angela Merkel visited Hefei University together.
- The two leaders announced together that a demonstration base for Sino-German education cooperation and a fund for the same purpose would be set up at Hefei University for further cooperation.

Research Platform

- ✓ **Sino German Biomass Research Regional Center(Anhui)**
- ✓ **Sino German Cooperative Environmental Technology Transformation Center**
- ✓ **Hefei Environmental Engineering Research Institute**
- ✓ **Academician Expert Workstation of Water Environment Control and Pollution Control in Hefei University**
- ✓ **Anhui Solid Waste Energy Utilization Engineering Technology Research Center**
- ✓ **City Solid Waste Treatment and Resource Utilization of Engineering Technology Research Center of Anhui Province**
- ✓ **Collaborative Innovation Center of Pollution Prevention and Ecological Control in Anhui**

Innovation Team

Dr. Michael Nelles

Professor, University of Rostock, Germany

The thousand person plan supporting engineering project of high-level foreign experts

Chinese Government Friendship Award

Dr. Achim Loewen

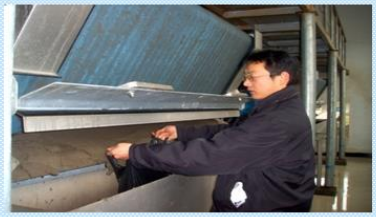
Professor, University of Rostock, Germany
Engaged in waste biomass, wastewater treatment and other fields

Mount Huangshan Friendship Award Winner

Industry technology leading and achievement transformation

Garbage component analysis and component detection, establish garbage data file of Hefei City.....

To assist the new crown company in Hefei Longquan landfill gas power generation through the United Nations CDM Executive Council (EB) certification issued, carbon emission reduction (CER) totaled 130 thousand tons, the first carbon trading revenue of about 975 thousand euros.



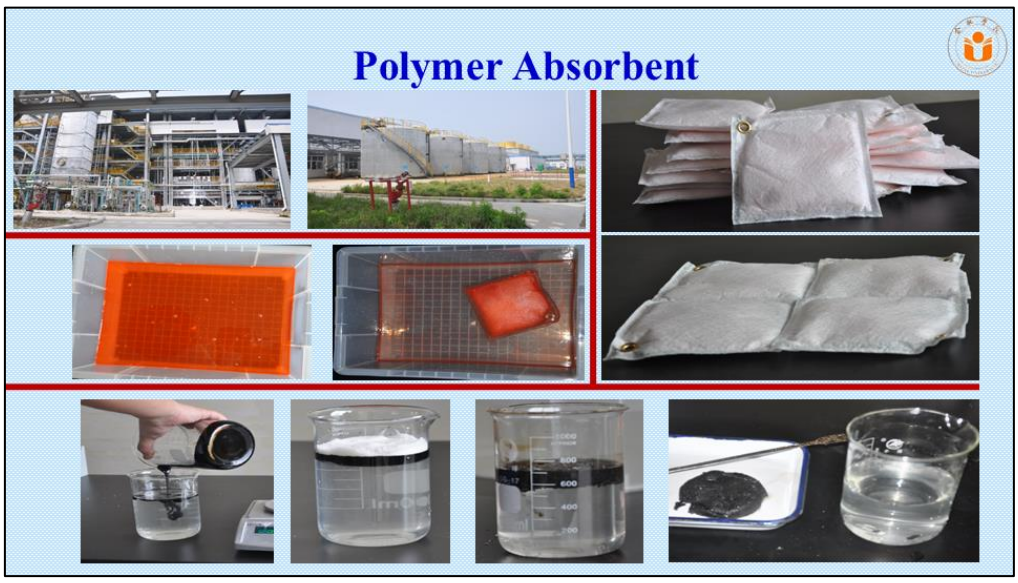
The city Thermoelectric Group Tianyuan thermoelectric company to cooperate in the implementation of sludge generation projects

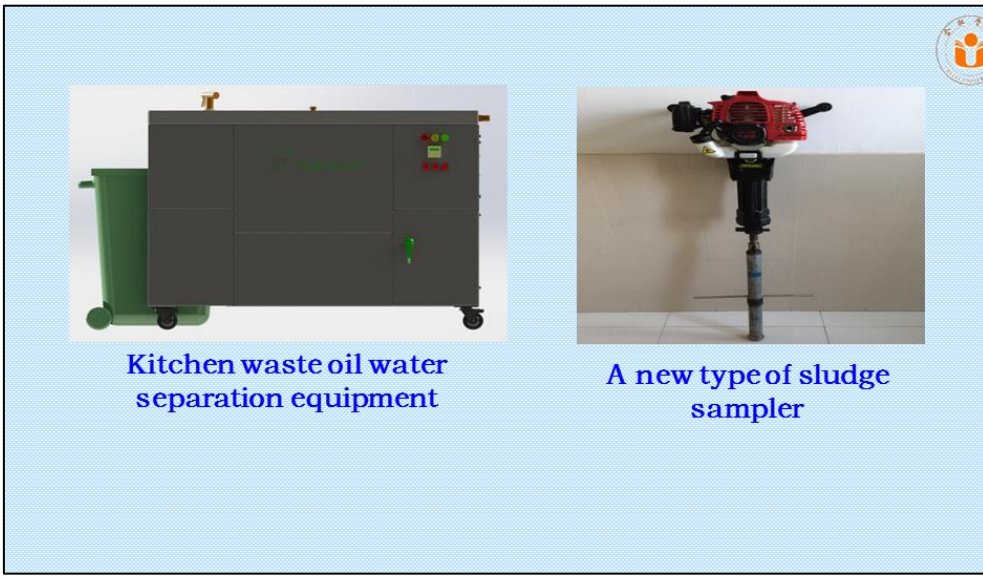
Energy saving waste incineration power generation project

Key technology research and engineering demonstration project of municipal sludge treatment

➢Authorized Patent

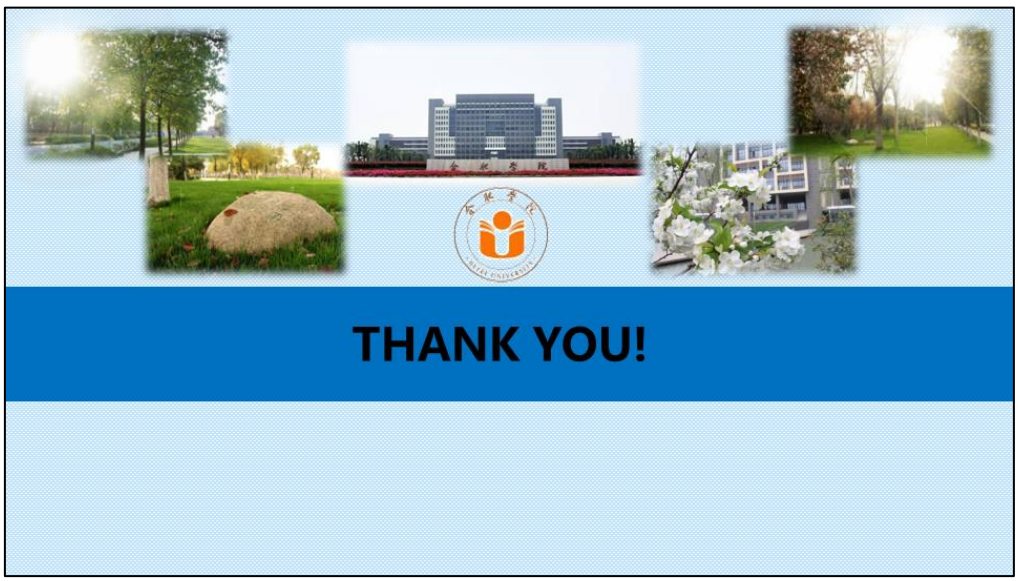
78 patents were authorized and 25 patents were invented in the past three years.


Polymer Absorbent


Kitchen waste oil water separation equipment
A new type of sludge sampler

Hefei University has established a long-term cooperative relationship with more than 30 environmental protection enterprises.

International Conference on Environmental Technology and Knowledge Conversion (the 6th)


THANK YOU!

4.10 Introduction to the ChinaRes project

Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ

Introduction of the ChinaRes-Project
ChinaRes项目介绍

Dr. Britt Schumacher, Kay Schaubach, Dr. Walter Stinner

With support from
Federal Ministry of Food and Agriculture
by decision of the German Bundestag

Public Workshop: “How to foster the utilisation of agricultural residues in the biogas sector in China?”, CAAE; Shangqiao, Beijing, China, 2017/11/14

New project: ChinaRes
新项目：ChinaRes

With support from
Federal Ministry of Food and Agriculture
by decision of the German Bundestag

DBFZ

Energetic utilisation of agricultural residues in China and Germany

中德农业废弃物能源化利用项目

Partners 合作单位

农业部规划设计研究院Chinese Academy of Agricultural Engineering (**CAAE**), 中国农业大学China Agricultural University (**CAU**), 中国石油大学（北京）China University of Petroleum-Beijing (**CUPB**), 合肥大学University Hefei (**HFUU**), 莱布尼兹农业工程与生物经济研究所Leibniz Institute for Agricultural Engineering and Bioeconomy (**ATB**), 德国生物质研究中心DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH (**DBFZ**)

Aims 目标

1. Improvement in the energetic utilisation of agricultural residues like solid dung or liquid manure in China and Germany 改进中德农业废弃物（比如粪污）的能源化利用
2. Reduction of emissions during the storage of animal faeces 降低畜禽粪便储存过程中的排放
3. Networking activities amongst Chinese and German stakeholders in the biogas sector 促进中德沼气行业交流

2

ChinaRes – Tasks 项目任务

With support from Federal Ministry of Food and Agriculture by decision of the German Bundestag

DBFZ

Tasks 任务

a) Summarised presentation of methods for livestock housing 畜禽**养**殖棚舍方法概述

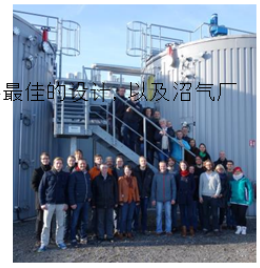
b) Identification of best-case plant concepts (barn, manure management and biogas plant) 判定最佳的工程概念（棚舍、粪污管理与沼气厂）

c) Identification of barriers for the energetic use of agro-residues 判定农业废弃物能源化应用的障碍

d) Development of technical concepts for a better design and a coordinated operation of barn and biogas plant 技术**开**发以获得最佳的设计，以及沼气厂和**养**殖场的协调**运**行

e) Comparison of results of China-Germany 中德结果比较

f) Networking activities amongst Chinese and German stakeholder in the biogas sector 中德沼气行业交流



Duration: November 2017 –October 2020

执行周期: 2017年11月到2020年10月

3

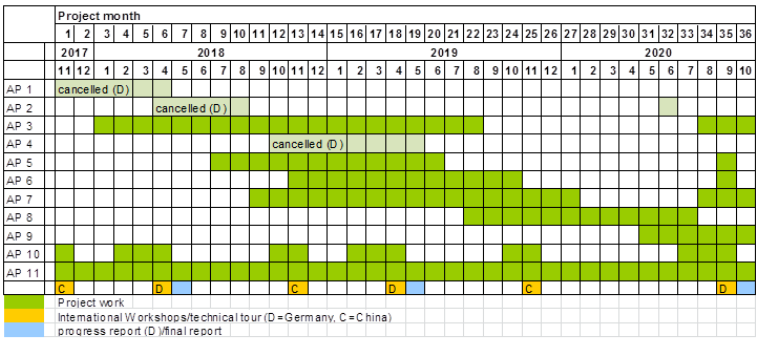
ChinaRes – WP/Schedule 工作包、时间表

DBFZ

1. Regional residue potentials 地区废弃物潜力(DBFZ)
2. Framework 框架(DBFZ)
3. Methods for housing and manure removal 棚舍与清粪工艺(ATB, DBFZ)
4. Biogas-technology 沼气技术(DBFZ)
5. Best-case plant concepts 最佳工程概念(DBFZ, ATB)
6. Barriers and optimisation potentials 障碍与潜力优化(DBFZ, ATB)
7. Technical concepts 技术概念(DBFZ)
8. Assessment of concepts 概念评估(DBFZ, ATB)
9. Recommendation for actions and distribution 行动和推广建议(DBFZ)
10. Organisation exchange with and travel to China resp. Germany 组织前往中德交流(DBFZ, ATB)
11. Networking activities 行业交流活动

4

ChinaRes – WP/Schedule 工作包、时间表



1. Regional residue potentials 地区废弃物潜力(DBFZ)
2. Framework 框架(DBFZ)
3. Methods for housing and manure removal 棚舍与清粪工艺(ATB, DBFZ)
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ChinaRes - Activities for distribution I 项目推广活动I

With support from Federal Ministry of Food and Agriculture by decision of the German Bundestag

1. Final report in Chinese and German for potential biogas plant operators 为沼气厂业主提供中德双语最终报告
2. At least one article in a popular journal as well as information of biogas organisations 至少在期刊以及沼气组织刊物上发表一篇文章
3. Submission of two reviewed papers 提交两篇文章
4. Submission of an abstract as application for a presentation at a national or international specialised fair or conference 在国家或者国际会议上提交一篇摘要

6

ChinaRes - Activities for distribution II
项目推广活动II

With support from Federal Ministry of Food and Agriculture by decision of the German Bundestag

DBFZ

5. Stakeholder-workshops at the beginning and at the end as well as a “technical tour“ in the middle of the projects in China and Germany 项目开始和结束时组织项目相关方召开会议，项目期间赴中德技术考察
6. Central website to disseminate background information, project finding, matchmaking etc. 建立项目网站发布项目信息，对接信息
7. Continuous contact to stakeholders in both countries incl. ad-hoc working groups 与两国利益相关方持续的保持沟通
8. Preparation of follow-up project; R&D as well as implementation 准备后续项目，研发以及执行

7

ChinaRes - Networking activities
项目交流活动

With support from Federal Ministry of Food and Agriculture by decision of the German Bundestag

DBFZ

Goal目标: support of exchange of stakeholders within and between countries支持两国行业交流

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9

4.11 Manure management and biogas plants – the operational and technical challenge in China

沼气行业面临的机遇与挑战
Opportunity and Challenge of Biogas Sector in China

李景明
Li Jingming

农业部农业生态与资源保护总站首席专家
中国沼气学会副理事长/执行副秘书长
Chief Expert of REEA, MOA
Deputy President, Executive Deputy General secretary of CBS

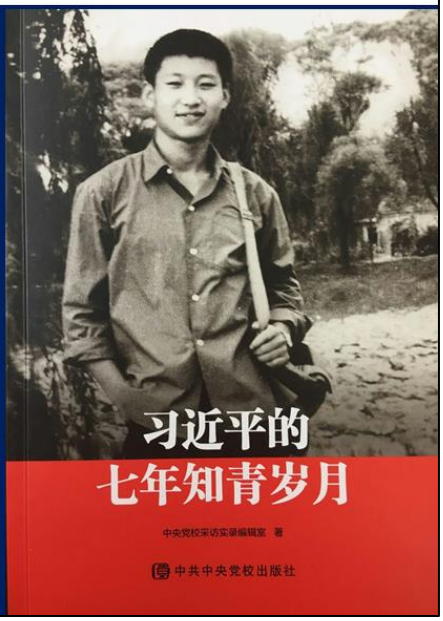
陕西省“第一口沼气池”
first household digester in Shaanxi Province

1974年，时任大队党支书的习近平带领梁家河村民建成了陕西省的第一口沼气池。1975年8月，全省沼气现场会在这里召开。

In 1974, Xi Jinping as Secretary of the Brigade Party Branch, built up the 1st household digester in Shaanxi. In 1975, Shaanxi Provincial biogas conference held here.

农业部农业生态与资源保护总站
Rural Energy & Environment Agency, Ministry of Agriculture, P.R.China

“我也是沼气专家”
“I am a biogas expert”



2004年，时任浙江省委书记的习近平同志接受延安电视台采访，在回忆起1974年带领梁家河村民一起建设陕西省第一口沼气池时，深情地说：“我又是支部书记，又是沼气专家”

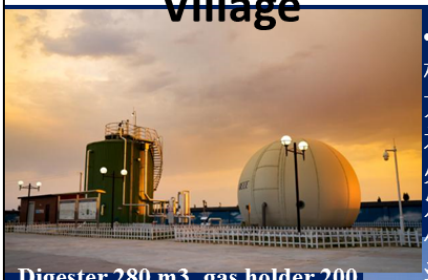
In 2004, Xi Jinping mentioned he is also a biogas expert, when he was interviewed by Yan’an TV.

梁家河村的“沼气展室”
biogas Exhibition in Liangjiahe Village

2015年，农业部生态总站在梁家河村设计布置了一个“沼气展室”，日接待上千观众。

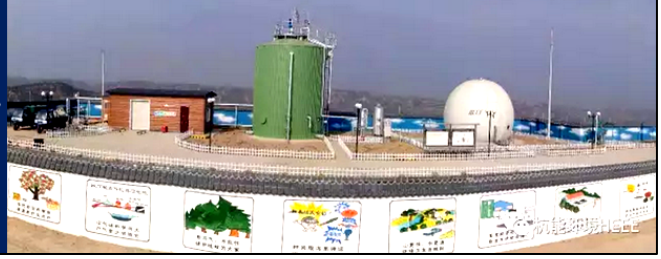
In 2015, REEA made a biogas exhibition in Liangjiahe Village, welcome more than 1000 visitors daily

梁家河第一座现代化沼气工程
1st industrial biogas plant in Liangjiahe Village



Digester 280 m3, gas holder 200 m3, digestate storage 130 m3, CHP 40 kW, treat manure 1800 tons/a, biogas 70,000 m3/a, electricity, 120,000 kWh/a, GHG reduction 800 tons CO2eq, solid fertilizer 100 tons, liquid digestate 1500 tons for 1000 mu Eco farming, investment 2.2 million, constructed in March, 2017

- 梁家河沼气示范工程采用热电肥联产工艺模式和模块化组装方式，建设厌氧发酵罐280立方米，双模贮气柜200立方米，沼液池130立方米，沼气发电机组40千瓦，占地约4亩。每年可处理1800吨畜禽粪污，年产沼气7万立方米，年发电量约12万度，年减排温室气体约800吨二氧化碳当量；年产沼渣100吨，沼液1500吨，沼液沼渣作为有机肥用于千亩现代生态果园。农业部投资220万元，于2017年3月建成。



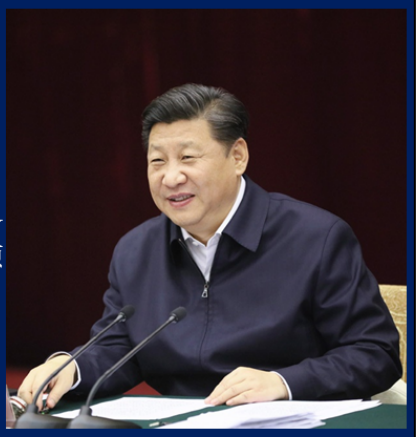
总书记关心畜禽粪污处理问题
Xi cares animal manure treatment

2016年12月21日，习近平总书记主持召开中央财经领导小组第十四次会议，关注6个民生工程。

Dec. 21, 2016, Xi held the 14th meeting of Leading Group for Financial and Economic Affairs, cares 6 topics affecting people’s well being.

加快推进畜禽养殖废弃物处理和资源化，关系6亿多农村居民生产生活环境，关系农村能源革命关系能不能不断改善土壤地力、治理好农业面源污染，是一件利国利民利长远的大好事。

Promote the treatment and resource utilization of animal husbandry waste, is a great job for more than 600 million farmers, to rural production and life environment, rural energy revolution, improve soil, and agricultural non-point source pollution control



农业部农业生态与资源保护总站
Rural Energy & Environment Agency, Ministry of Agriculture, P.R.China

提出两个主要方向
two main directions

– 要坚持政府支持、企业主体、市场化运作的方针，以沼气和生物天然气为主要处理方向，以就地就近用于农村能源和农用有机肥为主要使用方向，力争在“十三五”时期，基本解决大规模畜禽养殖场粪污处理和资源化问题。

Persist in government supports, enterprise as main body, marketable operation, take biogas and biomethane as main treatment direction, take locally utilization of rural energy and organic fertilizer as main utilization direction, aim to solve the problem of animal husbandry manure treatment during 13th FYP.

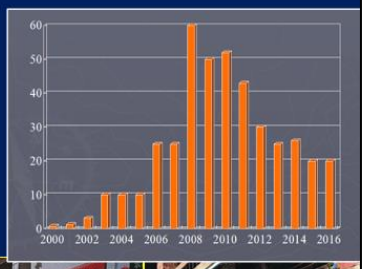
目 录 Outline

- 机遇 Opportunity
- 挑战 Challenge

农业部农业生态与资源保护总站
Rural Energy & Environment Agency, Ministry of Agriculture, P.R.China

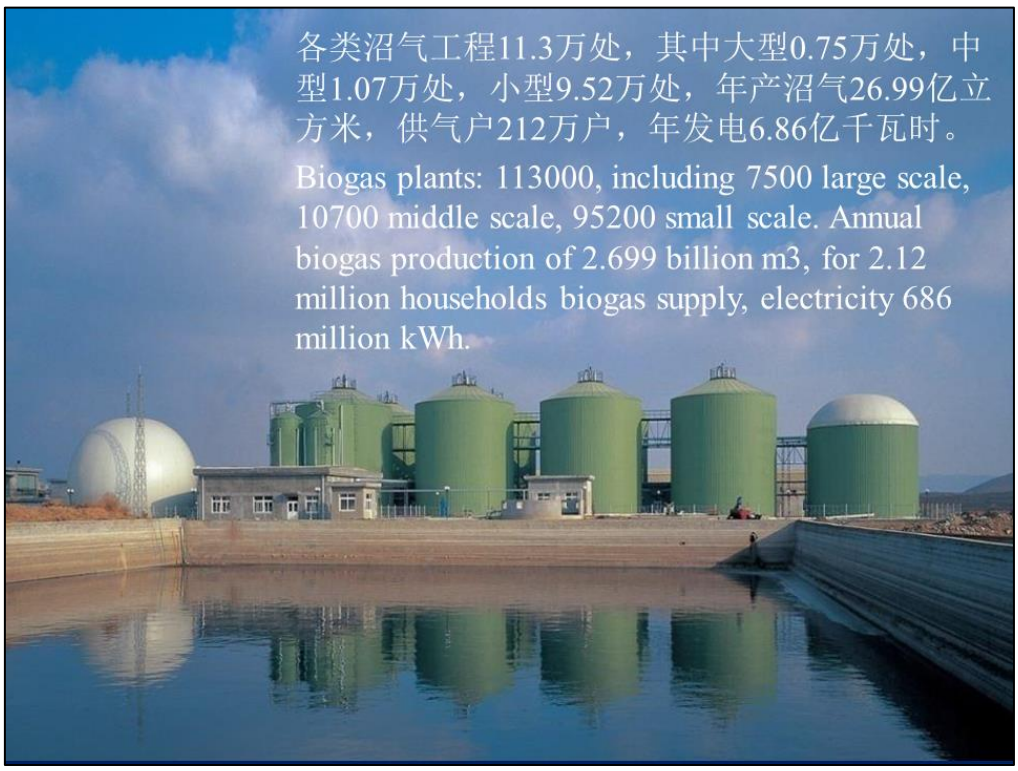
沼气行业始终得到政府支持
always supported by government

- 建国以来得到各届中央领导关心和支持； supported by every President since the establishment of China
- 相关法律和国家各阶段五年规划中都把沼气纳入支持对象；the support to biogas sector has been taken into account in laws and every FYPs
- 有关部委和部分地方政府也出台一系列政策；policies from Ministry and local government
- 2003年开始实施农村沼气建设国债项目，中央已累计投入超过424亿元。
- **Since 2003, central subsidy for biogas > 42.4 billion RMB**



农村户用沼气池4161 万户，年产沼气能力117.9亿立米，但市场需求和使用率已多年连续下降

Household digester 41.61 million, biogas capacity 11.79 billion m3, but the market needs and utilization rate decreases continuously



沼气和生物天然气产业逐步壮大
Biogas/biomethane industry getting stronger

企业数量超过2000家；>2000 enterprises

从业人员近25000人；

25000 employee

每年总产值62亿多元；

Gross annual value 6.2 billion RMB

实现年利税6亿多元；

Profit tax 600 million RMB

企业从设计、施工、投资、运营、管理、服务到产品、设备、装备、材料生产等，已经形成全产业链布局。

Cover whole industrial chain: design, construction, investment, operation, management, service, products, equipment, facilities, material production, etc.

天冠集团 TIANGUAN GROUP　四方光电　三益能环 SANYI GREEN ENERGY　民和生物 MINHE BIOLOGY　TIANREN　黑龙江省农业科学院农村能源研究所　农业部沼气科学研究所 INSTITUTE OF BIOGAS RESEARCH OF MOA　清华大学环境学院 SCHOOL OF ENVIRONMENT, TSINGHUA UNIVERSITY　JAAS 江苏省农业科学院 Jiangsu Academy of Agricultural Sciences　元易　北环 BEI HUAN

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Rural Energy & Environment Agency, Ministry of Agriculture, P.R.China

沼气/生物天然气行业呈现多样性
biogas/biomethane sector getting diversity

- 原料趋于多样性 feedstock
- 发酵工艺多样性 AD technology
- 工程模式多样性 engineering
- 生产制造多样性 Production & manufactory
- 应用领域多样性 utilization

农业部列为重中之重工作
Key works of MOA

2016年12月30日和2017年2月4日，农业部韩长赋部长分别主持召开了部常务会议，专题研究畜禽养殖废弃物处理和资源化等工作。

Dec.30,2016 and Feb.4,2017, Minister Han held MOA executive meeting, focusing on animal husbandry waste treatment and resource utilization

会议强调，要把畜禽养殖废弃物处理和资源化作为农业面源污染治理的重中之重，坚持问题导向，按照一年试点、两年推广、三年大见成效、五年全面完成的目标，着眼规模养殖场、养殖大县、制定标准、依法治理和督促检查，全力以赴抓好畜禽粪污处理和资源化工作。

Emphasized: take animal husbandry waste treatment and resource utilization as the key work of agricultural non-point pollution control, persist in problem-oriented. Aim to demonstration at 1st year, promotion at 2nd year, become effective at 3rd year, and complete at 5th year. Focusing on scaled animal farms and key counties, make standard, treatment and supervision based on law.

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有关单位迅速行动起来
related units fast action

2月底在北京成立了全国畜禽粪污资源化利用科技创新联盟，300多个企业成为第一批联盟成员；

End of this Feb, Beijing, establishment of China Animal Husbandry Manure Resource Utilization S&T Innovation Alliance, > 300 members.

6月底在湖南长沙召开了全国畜禽养殖废弃物资源化利用会议，汪洋副总理参加并讲话；

End of this Jun. Changsha, Hunan Province, Vice Premier Wang Yang participated and speech in the National Animal Husbandry Waste Resource Utilization Conference.

启动了畜禽粪污资源化利用行动计划、果菜茶有机肥替代化肥行动；

Startup of “Animal Husbandry Manure Resource Utilization Action Plan”, “replacement of mineral Fertilizer by organic fertilizer in fruit, vegetable, tea planting action ”

出台了国务院意见、部门文件、中长期发展规划。

Opinion from the State Council, document from authority, middle- and long-term development plan are issued.

国务院办公厅的《意见》
Opinion from the General Office of the State Council

- 2017年6月12日，国务院办公厅下发《关于加快推进畜禽养殖废弃物资源化利用的意见》，共3章14方面，是畜牧业史上第一个专门粪污处理的指导性文件；
- Jun.12,2017, “Opinion on promote the animal husbandry waste resource utilization” issued by General Office of the State Council, incl. 3 chapters, 14 aspects, is the 1st guideline document about manure treatment in China
- 政策包括**农机购置补贴、生物天然气工程和规模化大中型沼气工程**等财政政策，还包括**税收、用地和用电**等优惠保障政策等多个方面。
- Policy includes subsidy for agricultural machinery procumbent, biomethane projects and scaled biogas projects, and supportable policy for tax, land use and electricity use.

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Rural Energy & Environ

充分利用现有的政策制度
Fully use existing policies

2009年全国人大修订的《可再生能源法》规定“国家实行可再生能源发电、供气、供热全额保障性收购制度”；

2009, NPC revised “Renewable Energy Law”, stipulates renewable electricity, gas and heat shall be fully protective acquisition.

2010年发改委下发的《关于完善农林生物质发电价格政策的通知》规定，对农林生物质发电项目实行统一标杆上网电价每千瓦时0.75元的政策；

2010, NDRC issued “notice regarding complete price policy for agricultural- and forest- waste power generation”, stipulates a benchmark price of 0.75 RMB/kWh for agricultural- and forest-waste power generation project

2015年发改委下发了《资源综合利用产品和劳务增值税优惠目录》，提出利用畜禽粪污等农业废弃物生产沼气，享受增值税100%即征即退政策；

2015, NDRC issued “resource compressive utilization product and labor VAT preferential catalogue”, mentioned using agricultural waste produce biogas, can get 100% VAT drawback.

2017年农业部和财政部下发了《关于做好畜禽粪污资源化利用项目实施工作的通知》。

2017. MOA&MOF issued “notice regarding complete implementation works for animal husbandry waste resource utilization project”

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沼气“十三五”发展规划
13th FYP for biogas development

- 新建规模化生物天然气工程172个；172 new biomethane projects
- 新建规模化大型沼气工程3150个；3150 new scaled biogas projects
- 新建中小型沼气工程25500个；25500 new small and medium biogas plants
- 认定果（菜、茶）沼畜循环农业基地1000个；1000 certified fruit-, vegetable-, tea-, biogas-, husbandry-, circular agriculture bases.
- 新增沼气年生产能力50亿立方米，总产能达200亿立方米。Newly increased biogas capacity of 5 billion m3, accumulative value 20 billion m3

- **总投资500亿元。**
- **Total investment 50 billion RMB**

沼气行业走入转型升级通道
Biogas sector transformation and upgrading

- 2015年和2016年，国家各投资20亿元分别支持25个和22个生物天然气试点项目、以及386个和522个规模化大型沼气工程。2017年继续投资20亿进行试点探索，支持了18个生物天然气试点项目和485多个规模化大型沼气工程。
- 2015 & 2016, 2 billion RMB per year of central subsidy to support 25 and 22 biomethane projects, 386 and 522 scaled biogas projects. 2017, 2 billion RMB supports 18 biomethane projects and 485 scaled biogas projects.
- 正在开展试点项目中期评估。
- Interm evaluation for demonstration projects is ongoing

限制性法律同步实施
Restrictive regulations

2014年1月1日实施的《畜禽规模养殖污染防治条例》，要求畜禽养殖场（小区）建设畜禽粪污与雨水分流设施，贮存设施，**粪污厌氧消化和堆沤、有机肥加工、制取沼气、沼渣沼液分离和输送**等综合利用和无害化处理设施。可以委托他人建设综合利用和无害化处理设施，否则不得投入生产；Jan. 1, 2014, “regulation on scaled husbandry pollution control”, requires that animal farm (community) shall build up facilities for separating the manure and rain, storage, AD and composting, fertilizer production, biogas production, digestate separation and transportation, otherwise, the farm is not allow to operation.

2018年1月1日即将实施的《环境保护税法》,明确规定**直接向环境排放未经处理或向有处理资质的机构排放、堆放、处理**的企事业单位和生产经营者，都应缴纳相应的环保税。

Jan.1,2018, “law about environmental protection tax”, stipulates the enterprise which discharge untreated waste to environment, or discharge, stack, treat to institute which has license, shall pay the tax.

养殖类型 animal	污染当量值 Pollution eq
牛cow	0.1
猪pig	1
鸡、鸭等家禽 chicken & duck	30

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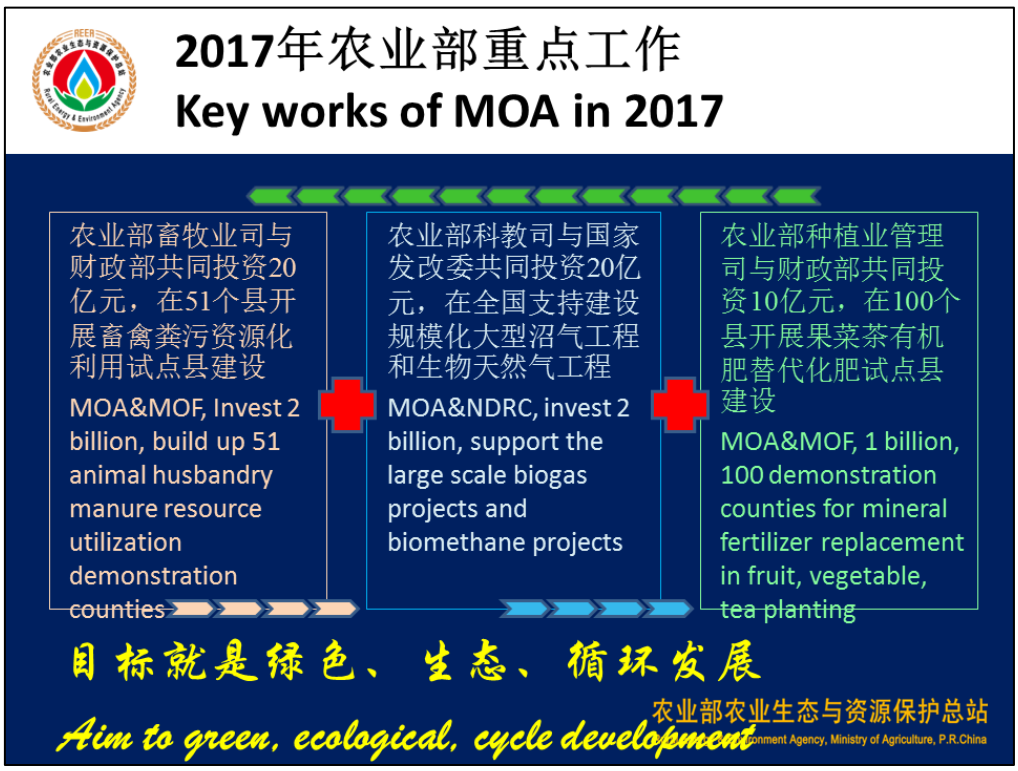
2017年农业部重点工作
Key works of MOA in 2017
农业部畜牧业司与财政部共同投资20亿元，在51个县开展畜禽粪污资源化利用试点县建设
MOA&MOF, Invest 2 billion, build up 51 animal husbandry manure resource utilization demonstration counties
农业部科教司与国家发改委共同投资20亿元，在全国支持建设规模化大型沼气工程和生物天然气工程
MOA&NDRC, invest 2 billion, support the large scale biogas projects and biomethane projects
农业部种植业管理司与财政部共同投资10亿元，在100个县开展果菜茶有机肥替代化肥试点县建设
MOA&MOF, 1 billion, 100 demonstration counties for mineral fertilizer replacement in fruit, vegetable, tea planting
目标就是绿色、生态、循环发展
Aim to green, ecological, cycle development
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沼气工程面临的挑战 Challenges
– 工程的规模：如何确定合适的规模？
– Size of project: how to define a suitable size
– 原料的来源：如何确保稳定的来源？
– Feedstock: how to guarantee a stable feedstock supply
– 产品的消纳：如何培育终端市场和用户？
– Use of product: how to cultivate end market and user
– 概念的创新：如何纳入现有政策、标准和目录？
– Innovation: how to fit into current policy, standard and catalogue
– 行业的监管：如何进行全产业链的监管？
– Supervision: how to supervise the whole industrial chain
– 立项的程序：如何简化程序？
– Procedure: how to simplify the project procedure
目的就是企业盈利、用户接受、持续运行
Aim to make enterprise gets profit, user accepts, sustainable operation
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展望 Outlook

- 沼气和生物天然气行业正面临历史上极好的发展机遇，将有很大的发展潜力和空间；
- Biogas and biomethane sector is facing the best development opportunity, has a large development potential and space
- 完全可以发挥好种养结合、循环利用的纽带作用，为农业部推行的“一控两减三基本”和“果沼畜”生态循环农业做出应有贡献；
- Fully use the bridge function for the plant-husbandry combination and cyclic utilization, contributes to MOA “one control, two reduction, three basic” strategy, and “fruit-biogas-husbandry ecological circular agriculture”
- 养殖老板们和种植业主们安心做好养殖、种植和防疫防病的本职工作，粪污处理及沼肥利用就放心交给沼气和生物天然气行业吧！
- Animal and crop farms do their own job about animal breeding, planting and epidemic prevention, the leave manure treatment and digestate utilization to biogas sector

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谢 谢

Thanks

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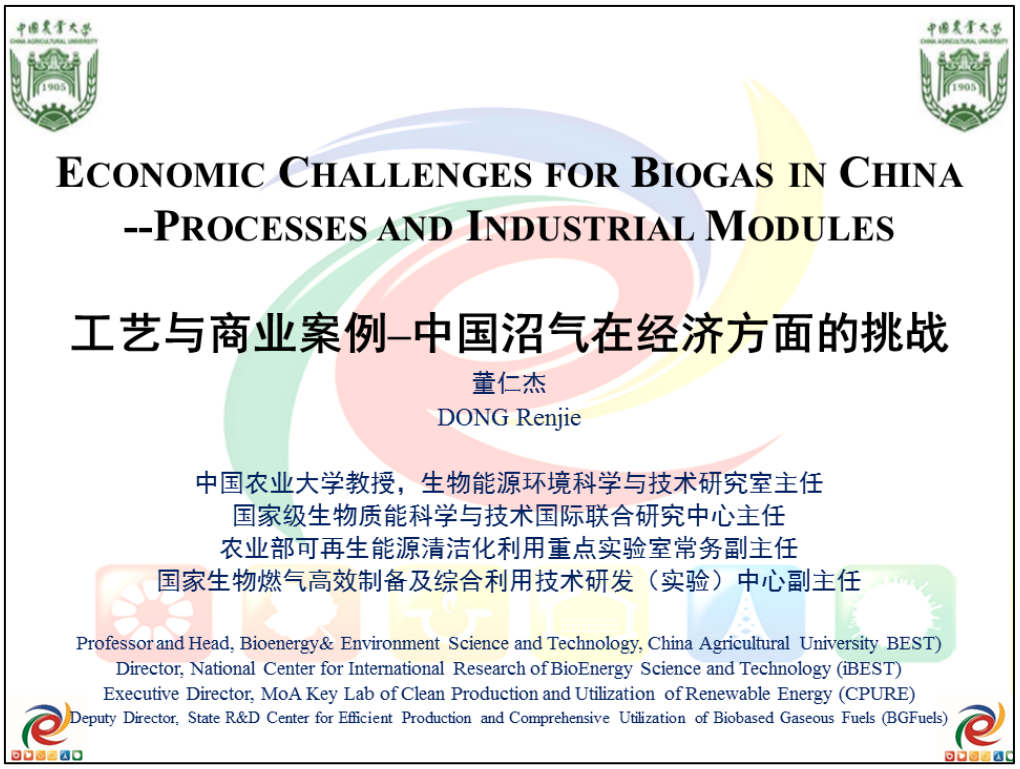
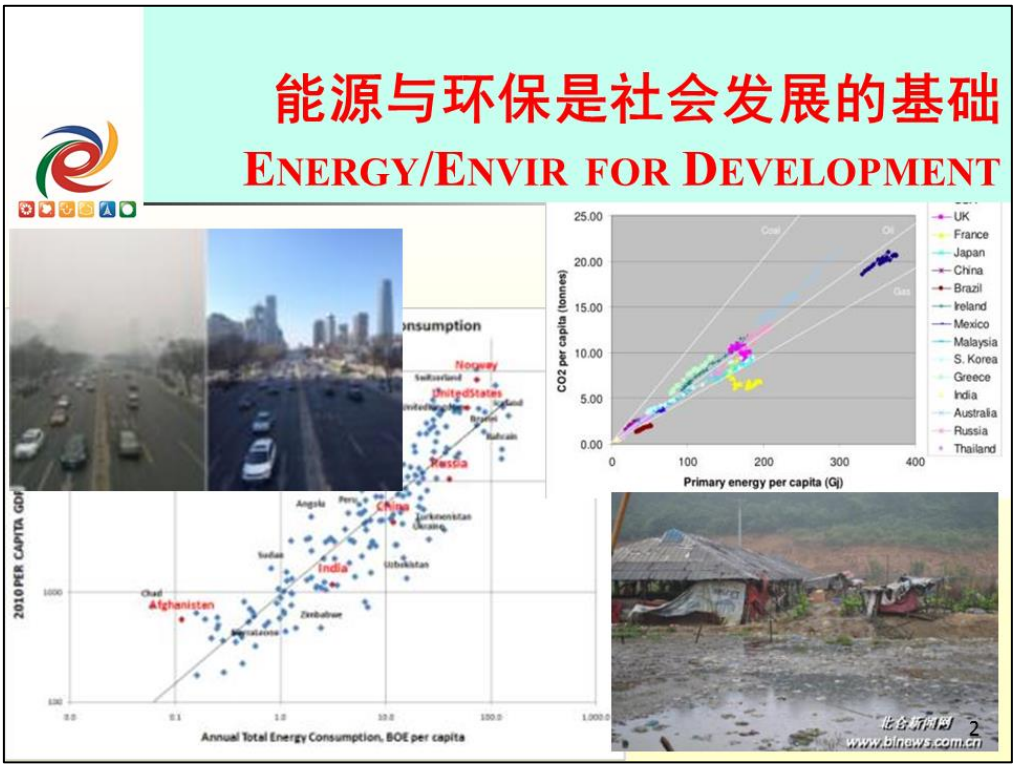
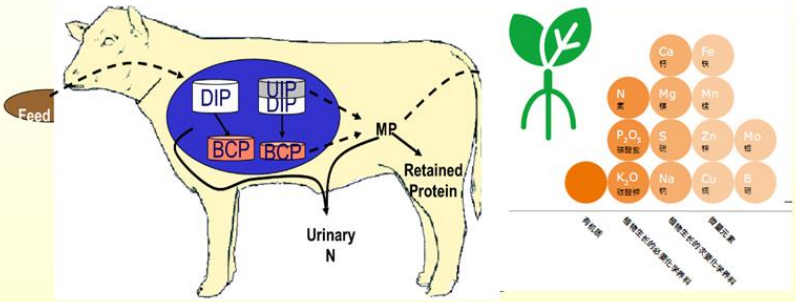
电子邮件： lijingm@agri.gov.cn

4.12 Processes and business cases – the economic challenge in China





换个角度看污染
THINK ABOUT WASTE FROM DIFFERENT ANGLE



N、P、K---Nutrients 肥料
C--- Energy 能源
H-O---Water 水

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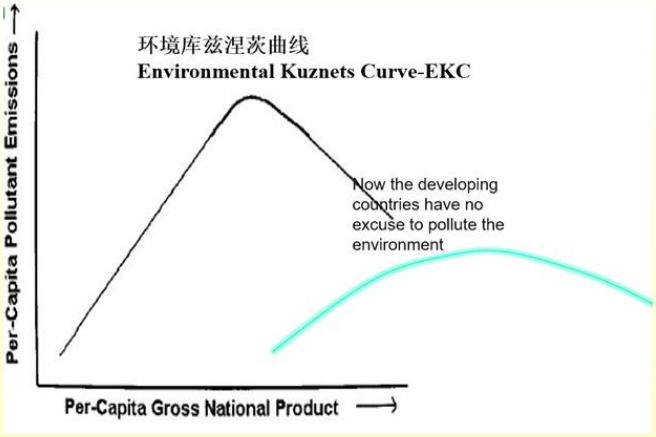
绿色发展
SUSTAINABLE DEVELOPMENT



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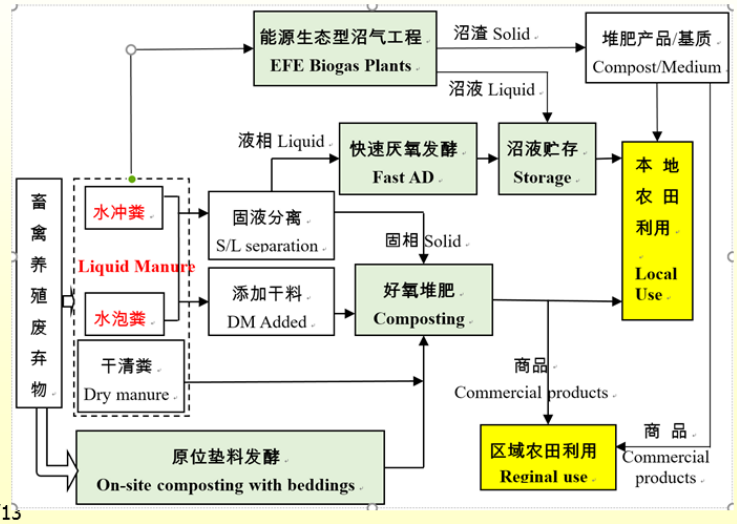
沼气与堆肥是畜禽养殖粪污处理利用的关键
ANAEROBIC DIGESTION AND COMPOSTING ARE KEY TECHNOLOGIES FOR MTR



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堆肥、沼气及贮存中N、P、K养分损失 （%）
NUTRIENTS LOSS (%) DURING COMPOSTING, AD, AND STORAGE

粪肥处理 Manure treatment		全氮损失 N loss	全磷损失 P loss	全钾损失 K loss	参考文献References
堆肥 Composting	平均值Average	**30.7**	11.2	18.7	Eghball et al., 1997; Fukumoto et al., 2011; Larney et al., 2006; Luebbe et al., 2011; Michel Jr et al., 2004; Ogunwande et al., 2008; Parkinson et al., 2004; Tiquia et al., 2000, 2002; Tran et al., 2011; Tubail et al., 2008
	范围 Range	7.0～55.9	2.4～28.2	7.0～35.0	
	样本数 n	44	24	21	
沼气 Anaerobic digestion	平均值Average	9	4.2	4.3	Shievano et al.,2011; 靳红梅等, 2012; 付广青等, 2013
	范围 Range	5.9-12.2	0-9.0	2.0-6.0	
	样本数 n	5	5	3	
储藏 Storage	平均值Average	**37.8**	**48.1**	**43.3**	Dewes 1997; Dong et al., 2011; Hassouna et al, 2008; Külling et al, 2002; Petersen et al, 1998; Rigolot et al, 2010; Shah et al, 2012;Tran et al, 2011; Thomsen, 2000; Tittonel, 2010; Tittonel, 2001; Wolter, 2002; Wolter, 2004;VanderZaag, 2010. 纪术远., 2012;
	范围 Range	10.0-69.0	24.6-67.7	18.0-75.0	
	样本数 n	41	23	23	

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粪水是畜禽养殖粪污处理的瓶颈
LIQUID MANURE TREATMENT: BOTTLE-NECK DIFFICULTY

干粪好利用，污水难处理。

养分含量千分之数量级，不值得长途输送，但COD又足以造成严重环境污染。

养殖种类	清粪方式	COD_{Cr}（mg/L）	NH_3-N（mg/L）	TP（mg/L）	TN（mg/L）	pH
猪	干清粪	2500-2770	230-290	35-50	320-420	6.3-7.5
	水冲粪	15600-46800	130-1780	30-290	140-1970	
牛	干清粪	920-1050	40-60	16-20	57-80	7.1-7.5
	水冲粪	6000-25000	300-1400	35-50	300-500	
鸡	干清粪	2740-10500	70-600	13-60	100-750	6.5-8.5

数据来源：HJ-BAT-10 规模畜禽养殖场污染防治最佳可行技术指南（试行）

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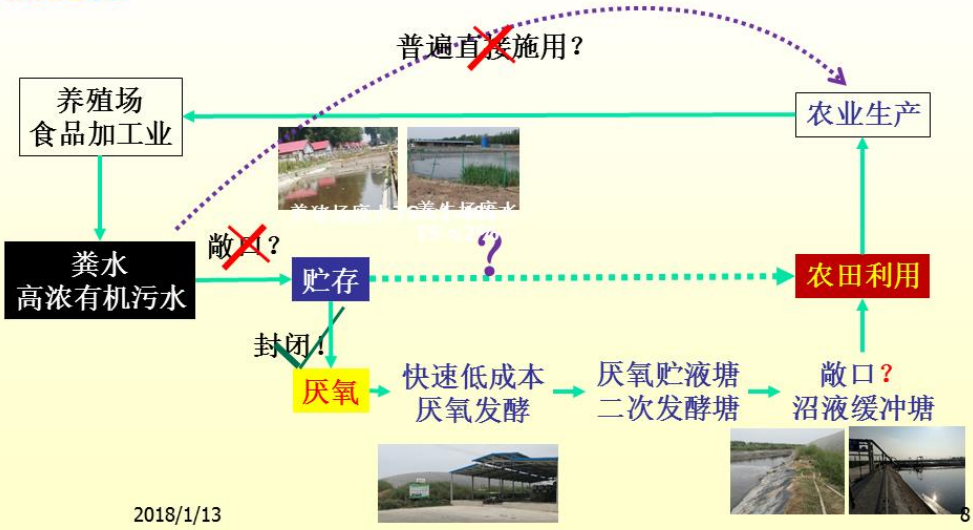
为什么要采用厌氧消化技术处理养殖粪水
WHY AD FOR LIVESTOCK WASTEWATER TREATMENT



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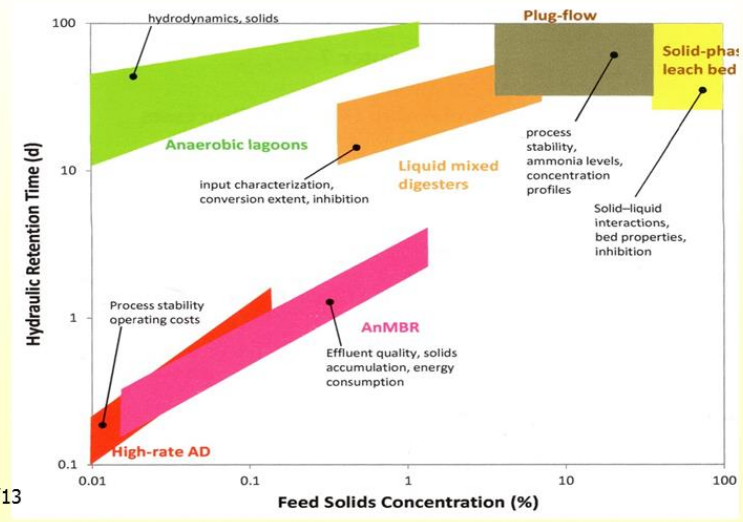
低含固废水的推荐技术
LOW TS WASTEWATER TREATMENT



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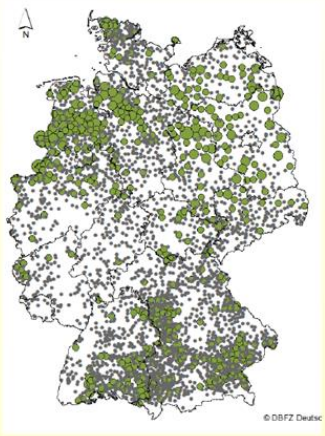
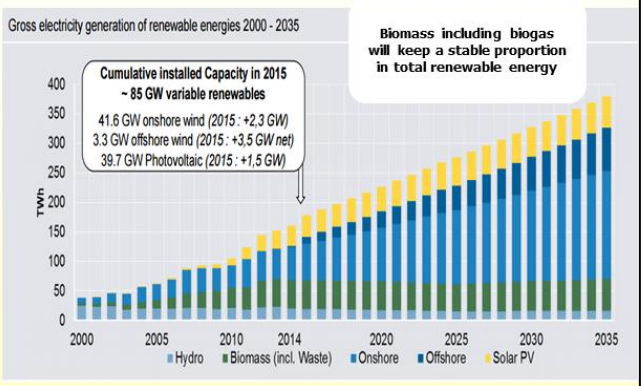
德国沼气能源已经稳定？
GERMANY: BIOGAS ENERGY WILL NOT INCREASE AS IT WAS BEFORE?





Source: Agora 2016

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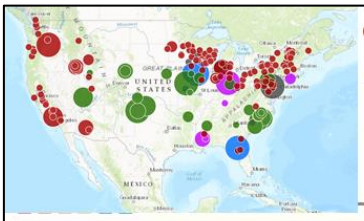


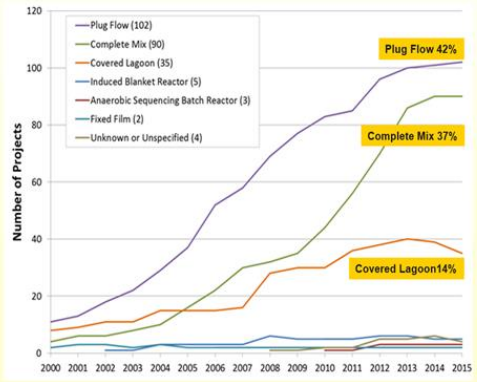
美国的沼气工程
BIOGAS TECHNOLOGY IN US

1. 沼气工程用于处理废物；
2. 提升沼气利用水平，降低沼气利用的成本；
3. 完善市场机制和商业模式，从政策和途径上使沼气工程能够盈利；
4. 成立国家层面的专家组，形成智囊机构。

1. Waste Treatment
2. Enhance efficiency and reduce cost
3. Development mechanism and modules for biogas plants sustainability
4. State expert team to support biogas development and realize the Roadmap

现有2000多沼气工程，将来再建11000多个。到2030年，为300万个美国家庭提供清洁燃气，减排温室气体5400万m^3。

More than 2000 Biogas Plants in US now and there will be 11000 more. By 2030 the bio-natural gas could be supplied for 3 mln households and contribute to 54mln m3 GHGs reduction.



EPA: https://www.epa.gov/agstar/agstar-data-and-trends#adfacts

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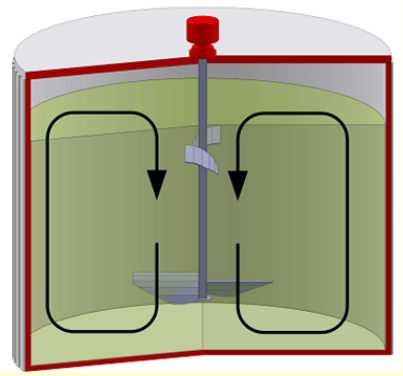
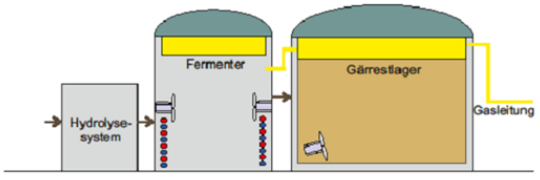
中国沼气工程主要模式
CHINA BIOGAS MODULES





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民和、德清源-处理粪污、气肥联产
MIX MANURE AD TREATMENT 4 BIOGAS AND FERTILIZER

一期——特大型集中式3MW鸡粪沼气发电并网项目

- 采用“原料分散收集——集中沼气处理——沼气发电——沼肥高值化利用”的粪污处理模式，将公司三大区域23个分散鸡场的鸡粪集中处理
- 日均发电6万度，每年向国家电网供电2200万度
- 日产沼气3万立方
- 沼液用于烟台地区20多万亩的苹果、葡萄、樱桃基地
- 年回收机组余热相当于6750吨标煤

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民和二期——沼气提纯生物天然气项目
MINHE PHASE II

日处理鸡粪700吨，日产沼气70000m3，日提纯生物天然气40000m³；总投资1.3亿；发酵采用中温厌氧CSTR工艺，发酵罐12座，单座发酵罐容积3724m³

Chicken manure 700 t/day to produce 70000m3 biogas and then 40000m3 biomethane. Total investment 130mln Yuan for 12 tanks 3724 m3 each.

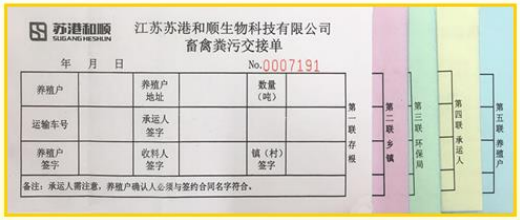
- Feeding TS～10%
  进料浓度约10%
- Ammonium 6000mg/L
  氨氮浓度约6000mg/L
- Biogas production: 1.5m³/m³/d
  容积产气率1.5m³/m³/d

沼气膜提纯系统
Upgrading by membrane filtration
CH_4%>97%; CH_4 loss <0.5%

生物天然气压缩、加气系统
Bio-CNG station

2018/1/13 Source: DONG TL, in GreatCycle meeting, 2017 14

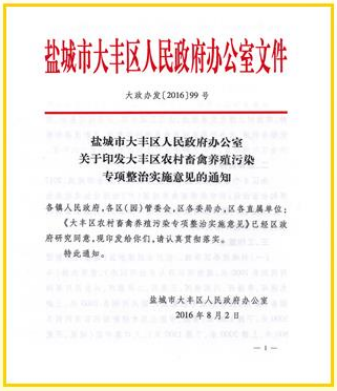
和顺、神州-第三方处置、气肥联产、PPP
MIX MANURE 3RD PARTY AD TREATMENT FOR BIOGAS-FERTILIZER CO-PRODUCTION, WITH PPP ARRANGEMENT


苏港和顺 SUGANG HESHUN 江苏苏港和顺生物科技有限公司
畜禽粪污交接单
年 月 日 No.0007191

养殖户		养殖户地址		数量（吨）	
运输车号		承运人签字			
养殖户签字		收料人签字		镇（村）签字	

备注：承运人需注意，养殖户确认人必须与签约合同名字符合。

第一联 存根 | 第二联 乡镇 | 第三联 环保局 | 第四联 承运人 | 第五联 养殖户


盐城市大丰区人民政府办公室文件

大政办发〔2016〕99 号

盐城市大丰区人民政府办公室
关于印发大丰区农村畜禽养殖污染
专项整治实施意见的通知

各镇人民政府，各区（园）管委会，区各委局办，区各直属单位：
《大丰区农村畜禽养殖污染专项整治实施意见》已经区政府研究同意，现印发给你们，请认真贯彻落实。
特此通知。

盐城市大丰区人民政府办公室
2016 年 8 月 2 日

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江西正和：第三方服务的集中处理沼气工程
3RD PARTY CENTRALIZED BIOGAS PLANTS

All pig manure transported into biogas plant by truck. TS >6%
江西正合两个养猪场工程，粪污车输送，TS>6%

江西罗坊沼气站
供应罗坊镇集镇6000户居民用气
Xinyu Biogas Plant
Biogas for 6000 household cooking

江西南英沼气发电站
年处理养殖废弃物40万吨（粪污、废水和病死猪），彻底解决渝水区的养殖粪污问题
Nanying Biogas Plant, Jiangxi Province
Capacity 400k-tons/a waste (including manure, wastewater and dead pigs)

2018/1/13 Source: Wang LP, in GreatCycle meeting, 2017 16

村沼气站模式
VILLAGE BIOGAS PLANT

北京延庆阜高营村沼气站年产沼气量为99900m³，沼气生产过程产生碳足迹为127.31tCO_2；沼气作为燃料使用每年可避免因使用无烟煤而导致CO_2排放量为379.07t，所以沼气的产生为“零碳”，年净减排CO_2量为251.76t。

Annual production of biogas: 99900m³, the carbon footprint of biogas production in the year is 127.31tCO_2.

Being fuel substitution to ordinary coal (CO_2 emission of 379.07t).

The biogas plant gives annual CO_2 emission reduction of 251.76t.

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高效高浓度有机废水沼气化技术
BIOGAS FROM HIGH ORGANIC LOAD WASTEWATER

湛江农垦三和酒精厂日排放1300m³ COD为10万mg/L的有机废水，日产沼气3万m³。每吨废水的环保处理费5-6元，现每吨产值30-50元，日产值约100万元。
30,000 m3 biogas from 1,300 m3 wastewater (COD 100,000mg/L). The wastewater treatment cost is 5-6RMB/m3, now producing value of 30-50RMB/m3.

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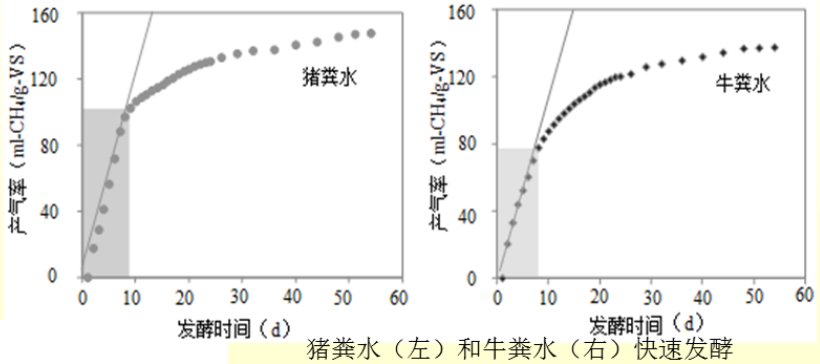
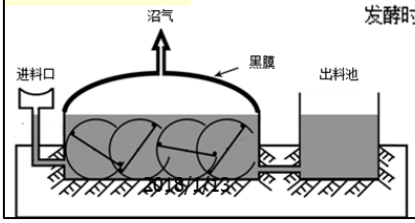
青县秸秆沼气工程
QINGXIAN CORNSTOVER BIOGAS PLANTS

新模式-以环保为主：快速厌氧发酵
NEW MODEL FOR ENVIRONMENT PROTECTION: FAST AD FERMENTATION



猪粪水（左）和牛粪水（右）快速发酵

Pig liquid manure (left) and Dairy (right) Fast AD



地下/半地下推流式反应器结构示意图

Fast Plug-flow AD

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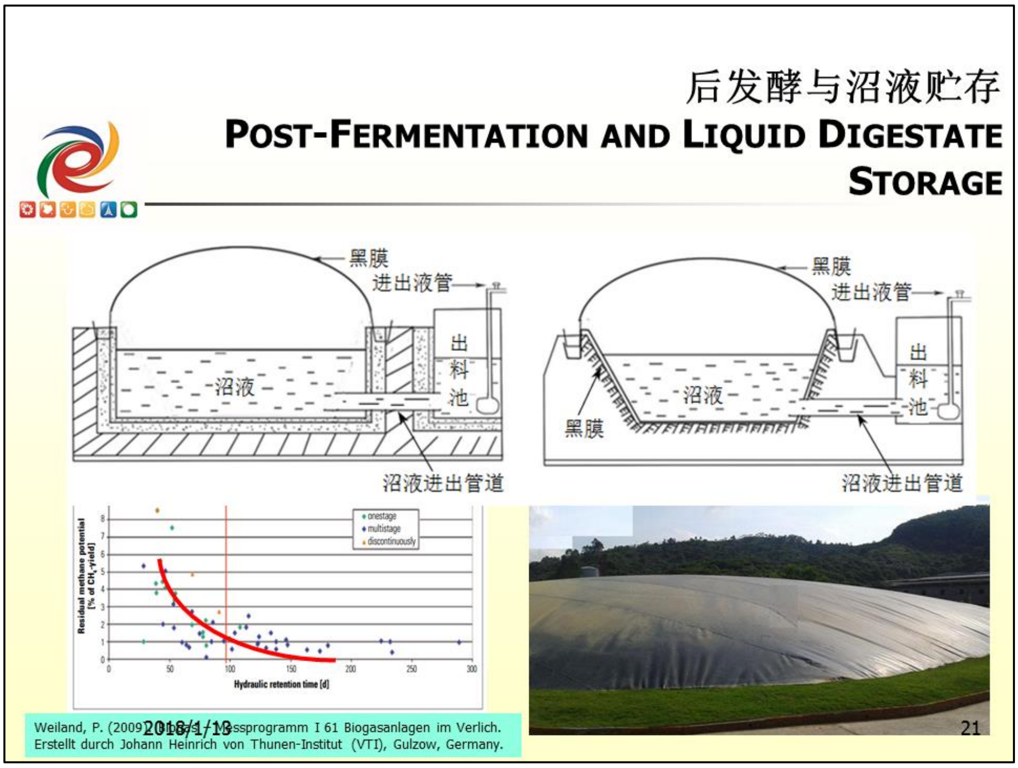
后发酵与沼液贮存
POST-FERMENTATION AND LIQUID DIGESTATE STORAGE
黑膜
进出液管
出
料
池
沼液
沼液进出管道
黑膜
进出液管
出
料
池
沼液
黑膜
沼液进出管道
onestage
multistage
discontinuously
Residual methane potential [% of CH4-yield]
Hydraulic retention time [d]
Erstellt durch Johann Heinrich von Thunen-Institut (VTI), Gulzow, Germany.
2018/1/13
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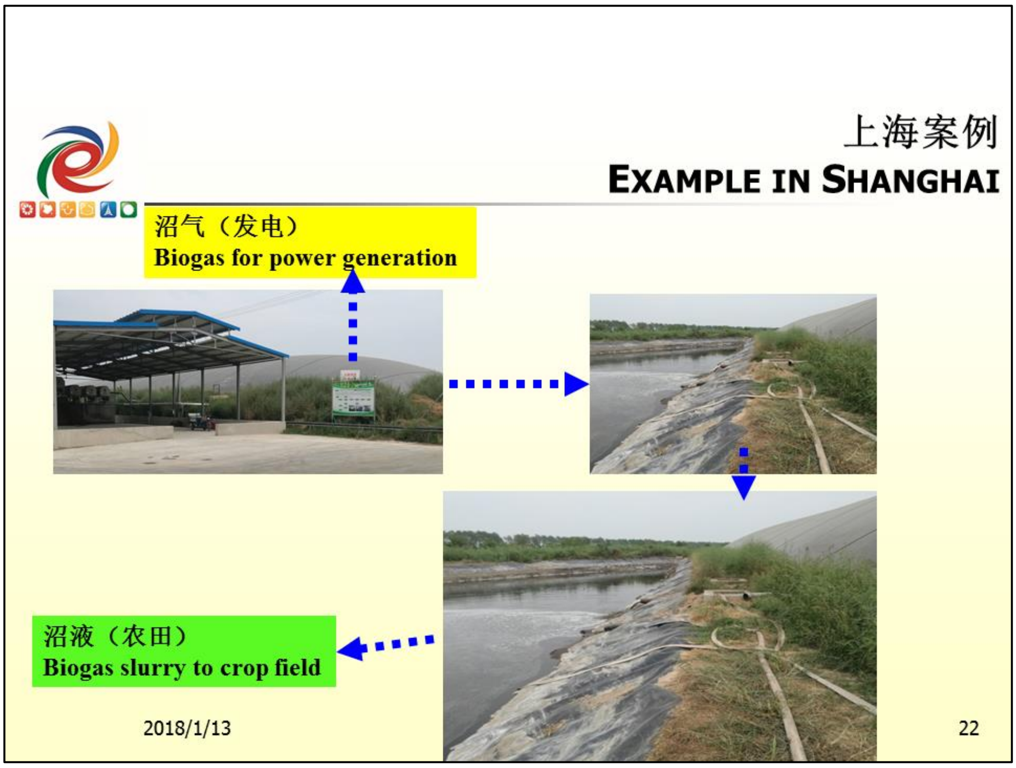
上海案例
EXAMPLE IN SHANGHAI
沼气（发电）
Biogas for power generation
沼液（农田）
Biogas slurry to crop field
2018/1/13
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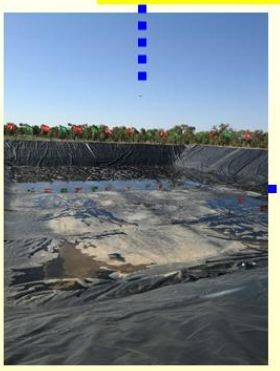
正大案例
EXAMPLE IN ZHENGDA

沼气（进本场燃气管网或者排空火炬）
Biogas leaching into air or collected



沼液（农田）
Biogas slurry to crop field

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沼液沼渣的利用
UTILIZATION OF BIOGAS SLURRY

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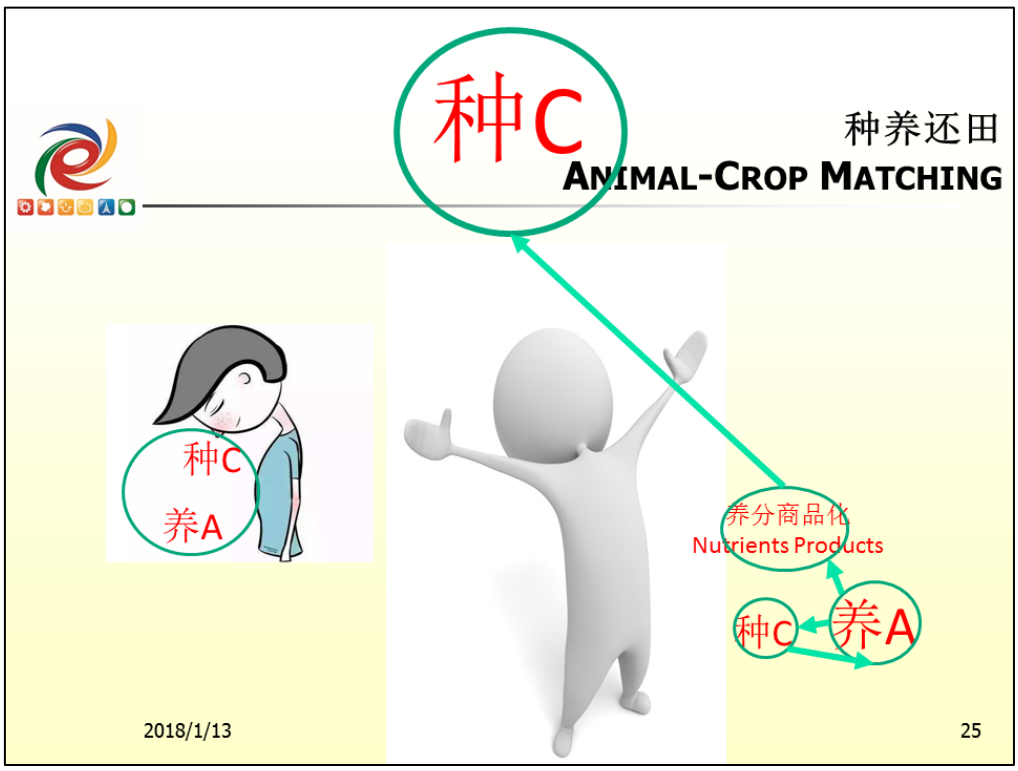
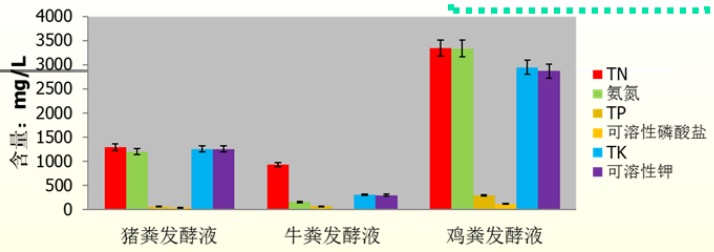


沼液中的养分（N、P、K）
NUTRIENTS IN DIGESTATES

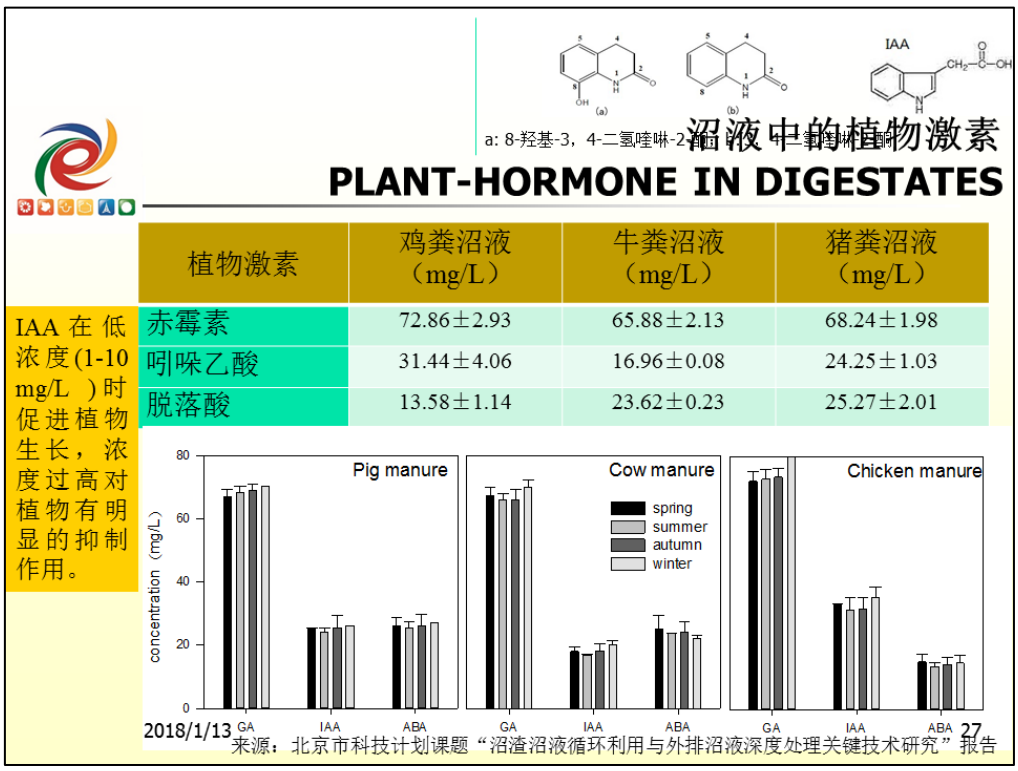
化肥含N最低11%，P44%，K50%以上。但沼液最高也就是N 0.3%。

厌氧发酵沼液中含有大量植物生长所需的氮磷钾等营养成分。



种类(mg/L)	TS（%）	VS（%）	COD	TN	NH_4^+	TP	S-PO_4	TK	S-K
猪粪发酵液 Pig manure based	0.73	0.34	5145	1291.51	1201.83	65.35	45.92	1256.06	1252.81
牛粪发酵液 Cow manure based	0.65	0.38	4050	934.23	157.76	71.67	2.51	312.41	302.08
鸡粪发酵液 Chicken manure based	2.21	1.13	13540	3337.88	3335.31	292.35	121.17	2946.27	2868.7
餐厨发酵液 Kitchen based	2-3.5		8500		400-1500	50-100		20-40	

[1] 沈炳国, 黄安娜, 王能杰, 等. 宁波大型餐厨垃圾厌氧发酵装置简介[J]. 中国沼气, 2011, 29(1): 34-36.
[2] 吴桂菊. 利用小球藻降解餐厨垃圾消化沼液的试验研究[D]. 重庆大学, 2013.
[3] 李祎雯, 曲英华, 徐奕琳, 等. 不同发酵原料沼液的养分含量及变化[J]. 中国沼气, 2012, 30(3): 17-20.
[4] 张佳, 张德励, 王小伟, 等. 餐厨垃圾厌氧消化残余物污染特征分析[J]. 2013 中国环境科学学会学术年会论文集(第五卷), 2013.
[5] 申娅. 餐厨垃圾单相厌氧反应器高负荷运行试验研究[D]. 重庆大学, 2013.


IAA
a: 8-羟基-3，4-二氢喹啉-2-酮
沼液中的植物激素
PLANT-HORMONE IN DIGESTATES
植物激素
鸡粪沼液（mg/L）
牛粪沼液（mg/L）
猪粪沼液（mg/L）
赤霉素
72.86±2.93
65.88±2.13
68.24±1.98
吲哚乙酸
31.44±4.06
16.96±0.08
24.25±1.03
脱落酸
13.58±1.14
23.62±0.23
25.27±2.01
IAA在低浓度(1-10 mg/L)时促进植物生长，浓度过高对植物有明显的抑制作用。
Pig manure
Cow manure
Chicken manure
spring
summer
autumn
winter
concentration (mg/L)
GA
IAA
ABA
2018/1/13
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来源：北京市科技计划课题“沼渣沼液循环利用与外排沼液深度处理关键技术研究”报告


沼液农田利用案例-葡萄
BIOGAS SLURRY APPLICATION FOR GRAPES
省级沼液有机种植
生态园区
蓬莱园艺场
蓬莱市农业局
2018/1/13
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沼液农田利用案例-苹果
BIOGAS SLURRY APPLICATION FOR APPLE



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沼液水肥一体化-江西
FERTIGATION TECHNOLOGY FOR BIOGAS SLURRY APPLICATION-JIANGXI

支持在田间地头配套建设管网和沼液池，解决沼液还田“最后一公里”问题。

Support the construction of pipe and pond in the field for digestate transport and utilization

Source: Wang LP, in GreatCycle meeting, 2017


发布
中国国家标准化管理委员会
中华人民和国国家质量监督检验检疫总局
201x-xx-xx实施
201x-xx-xx发布
沼肥肥效试验及评估方法
Regulations of Anaerobic Digestate Fertilizing Effect Test and Assessment
（送审稿）
沼肥肥效试验及评估办法
REGULATIONS FOR BIOGAS DIGESTATES FERTILIZER TESTING
Great !
GB/T xxxx-201x
中华人民共和国国家标准
ICS 27.200
J73
2018/1/13
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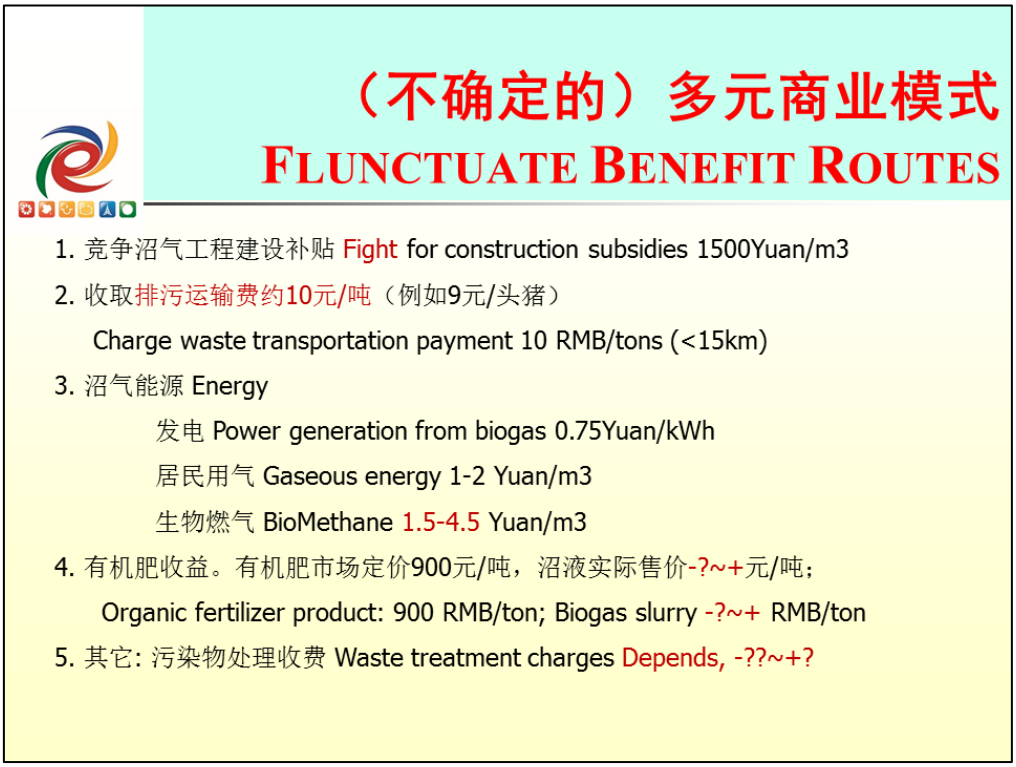
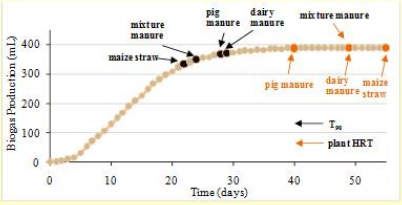

（不确定的）多元商业模式
FLUNCTUATE BENEFIT ROUTES
1. 竞争沼气工程建设补贴 Fight for construction subsidies 1500Yuan/m3
2. 收取排污运输费约10元/吨（例如9元/头猪）
Charge waste transportation payment 10 RMB/tons (<15km)
3. 沼气能源 Energy
发电 Power generation from biogas 0.75Yuan/kWh
居民用气 Gaseous energy 1-2 Yuan/m3
生物燃气 BioMethane 1.5-4.5 Yuan/m3
4. 有机肥收益。有机肥市场定价900元/吨，沼液实际售价-?~+元/吨；
Organic fertilizer product: 900 RMB/ton; Biogas slurry -?~+ RMB/ton
5. 其它: 污染物处理收费 Waste treatment charges Depends, -??~+?

北京市三个粪污一个秸秆沼气工程，问题？
THREE MANURE AND ONE STRAW PLANTS: ?

Feed stock	Temp (°C)	Digester Volume (m^3)	Biogas (m^3/d)	HRT (d)	Process	Gas application
Pig manure	35	1x320	100	40	CSTR	Household
Chicken and pig manure	35	2x1,000	600	50	CSTR	Household
Dairy manure	35	4x550	2.000	50	USR	Household
Maize straw	55-60	1x400	120	50	CSTR	Household



2018/1/13

Source: Wandera SM, Renewable Energy, 2018

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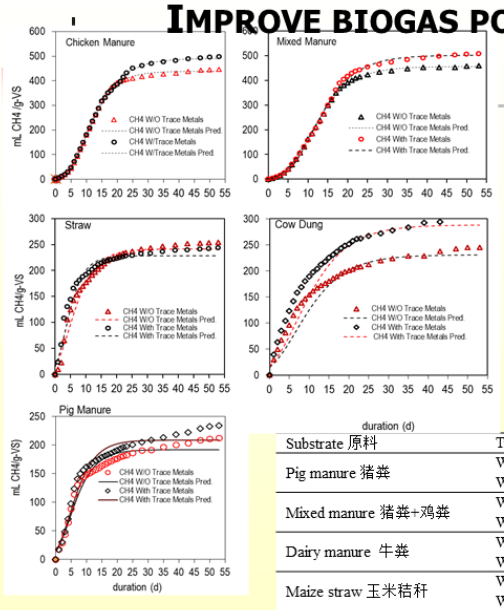
添加微量元素提高原料产气潜能
IMPROVE BIOGAS POTENTIAL BY ADDING TRACE METALS



Trace Metals	Con.(mg/L)
$FeCl_2 \cdot 4H_2O$	20
$CoCl_2 \cdot H_2O$	1
$ZnCl2$	1
H_3BO_3	1
$MnCl_2 \cdot 2H_2O$	1
$NiCl_2 \cdot 6H_2O$	1
$CuCl_2 \cdot 2H_2O$	0.625
$NaMoO_4 \cdot 2H_2O$	0.625

Substrate 原料	Trace metals (with / without)	P_o (mL CH_4/g-VS)	Increment
Pig manure 猪粪	Without 添加	79	22%
	With 不添加	96	
Mixed manure 猪粪+鸡粪	Without 添加	288	10%
	With 不添加	316	
Dairy manure 牛粪	Without 添加	78	26%
	With 不添加	98	
Maize straw 玉米秸秆	Without 添加	169	-5%
	With 不添加	160	

2018/1/13

Source: Wandera SM, Renewable Energy, 2018

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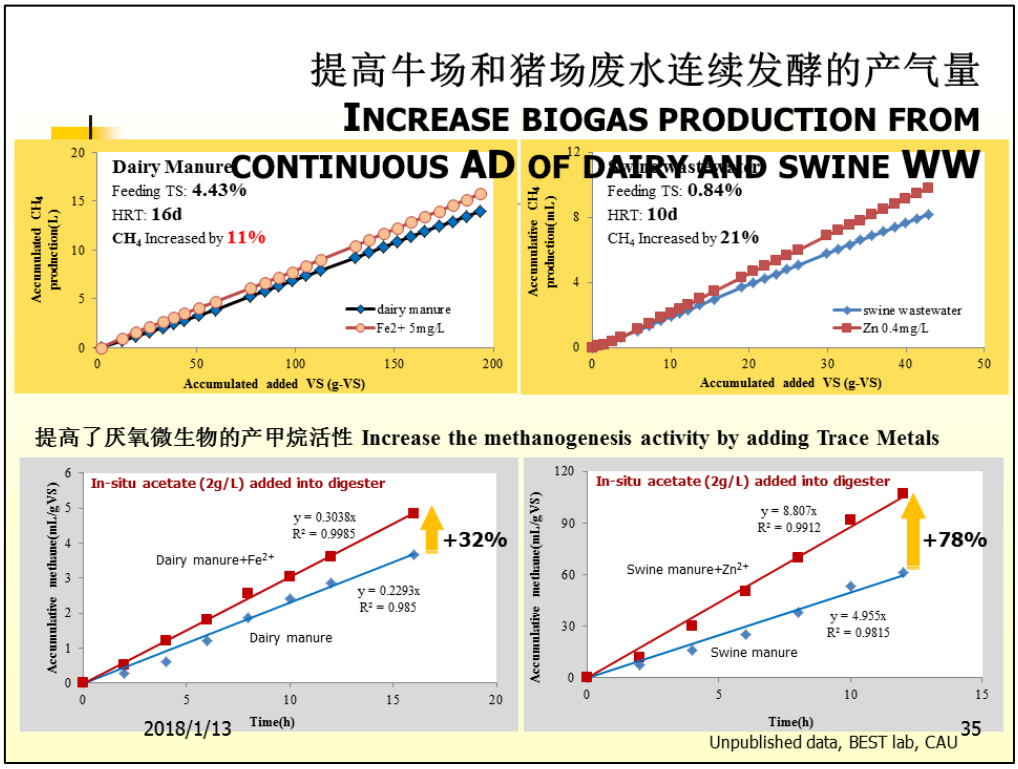
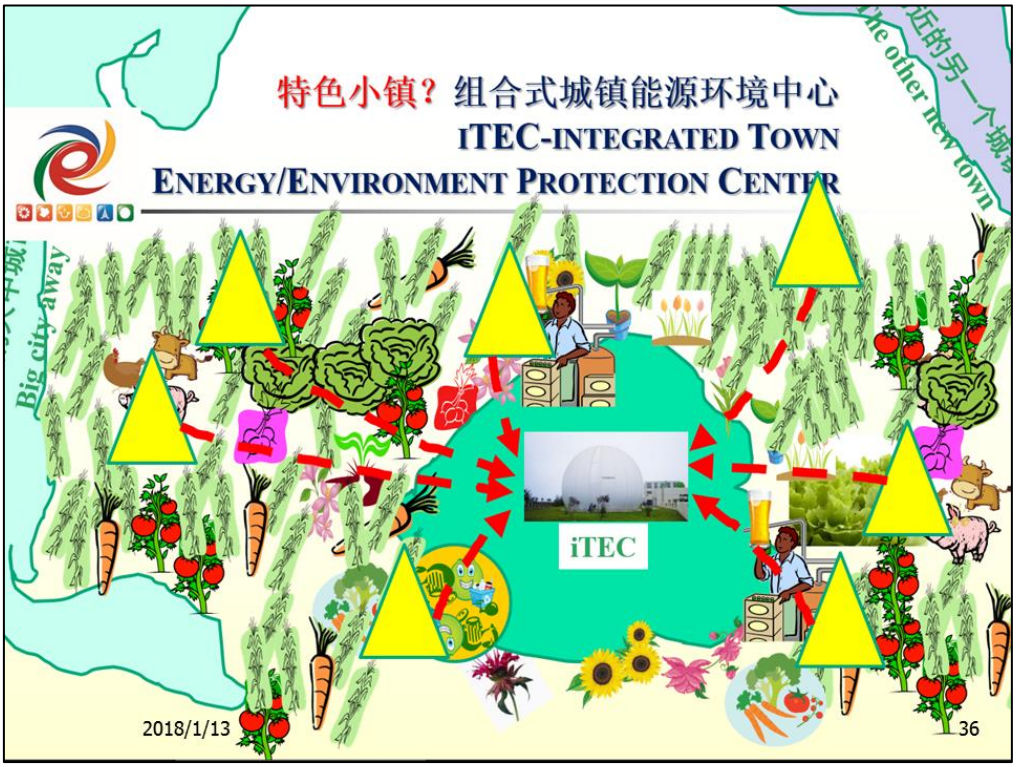

提高牛场和猪场废水连续发酵的产气量
INCREASE BIOGAS PRODUCTION FROM
CONTINUOUS AD OF DAIRY AND SWINE WW
Dairy Manure
Feeding TS: 4.43%
HRT: 16d
CH4 Increased by 11%
dairy manure
Fe2+ 5mg/L
Accumulated added VS (g-VS)
Swine Wastewater
Feeding TS: 0.84%
HRT: 10d
CH4 Increased by 21%
swine wastewater
Zn 0.4mg/L
提高了厌氧微生物的产甲烷活性 Increase the methanogenesis activity by adding Trace Metals
In-situ acetate (2g/L) added into digester
y = 0.3038x
R² = 0.9985
Dairy manure+Fe2+
y = 0.2293x
R² = 0.985
Dairy manure
+32%
Time(h)
In-situ acetate (2g/L) added into digester
y = 8.807x
R² = 0.9912
Swine manure+Zn2+
y = 4.955x
R² = 0.9815
Swine manure
+78%
Time(h)
2018/1/13
35
Unpublished data, BEST lab, CAU


特色小镇？组合式城镇能源环境中心
iTEC-INTEGRATED TOWN
ENERGY/ENVIRONMENT PROTECTION CENTER
Big city away
the other new town
iTEC
2018/1/13
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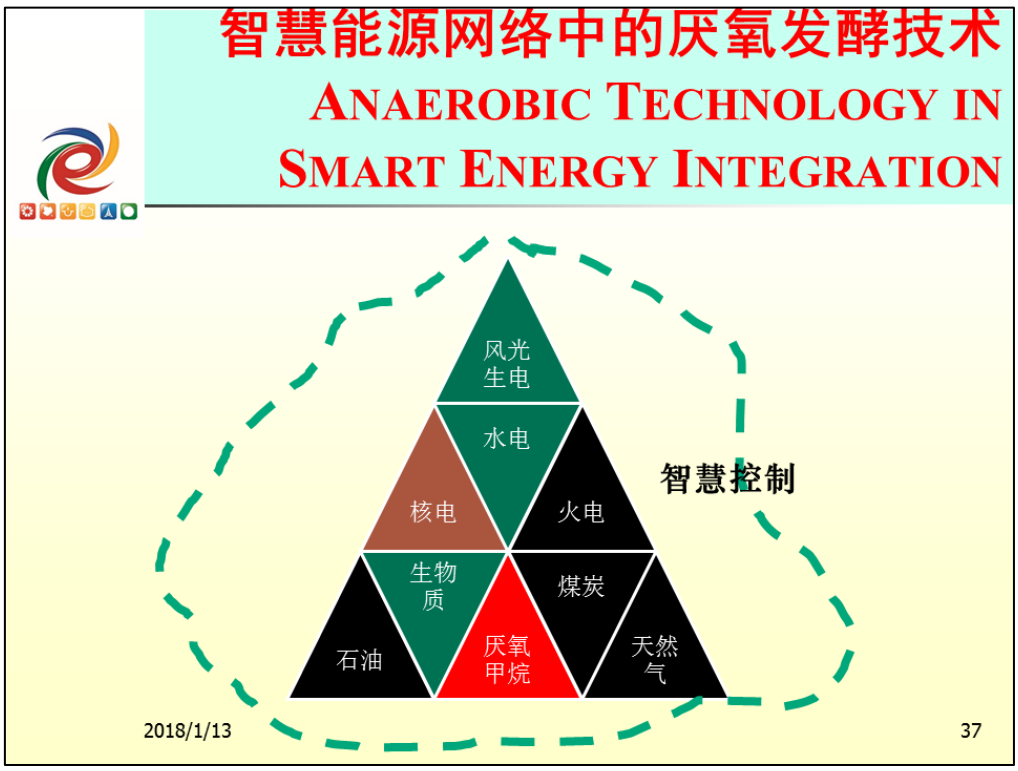
智慧能源网络中的厌氧发酵技术
ANAEROBIC TECHNOLOGY IN SMART ENERGY INTEGRATION
风光生电
水电
核电
火电
生物质
煤炭
石油
厌氧甲烷
天然气
智慧控制
2018/1/13
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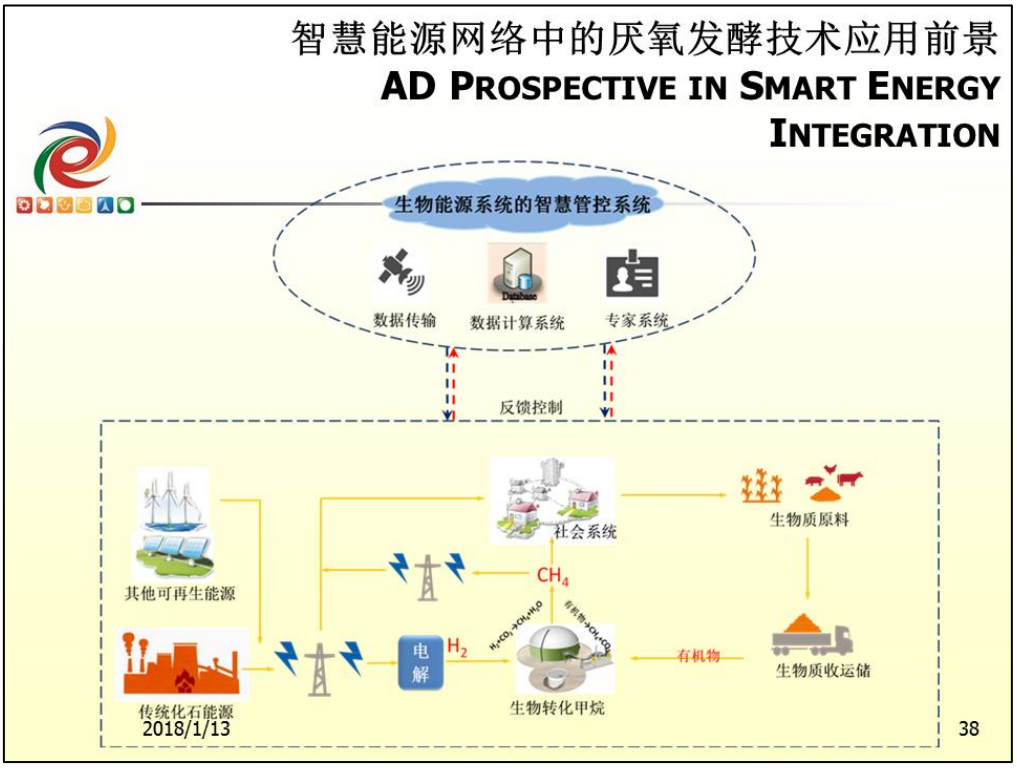
智慧能源网络中的厌氧发酵技术应用前景
AD PROSPECTIVE IN SMART ENERGY INTEGRATION
生物能源系统的智慧管控系统
数据传输
数据计算系统
专家系统
反馈控制
社会系统
生物质原料
其他可再生能源
CH4
电解
H2
有机物
生物质收运储
传统化石能源
生物转化甲烷
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BEST团队的研发工作
RESEARCHES AT BEST
原料归一化预处理
Pretreatment for unique feedstock
郭建斌
Dr. GUO Jianbin
乔玮 副教授
Dr. QIAO Wei
禽粪
Poultry manure
畜粪
Livestock manure
秸秆
Straw
餐厨
Kitchen waste
污泥
Activated slurry
厌氧发酵过程
Anaerobic Process
微量元素
Trace element
微生物菌剂
Microbial additive
预警
Monitor prewarning
远程监控
Remote monitoring
膜反应器
Membrane reactor
吴树彪
Dr. WU Shubiao
沼液沼渣后处理
Digestates post-treatment
农田利用
Field application
氮磷回收
N/P recovery
沼液回流
Liquid recycling
人工湿地
Constructed wetlands
气体减排
GHGs reduction
周宇光
Dr. ZHOU Yuguang
工程装备
Equipment
2018/1/13
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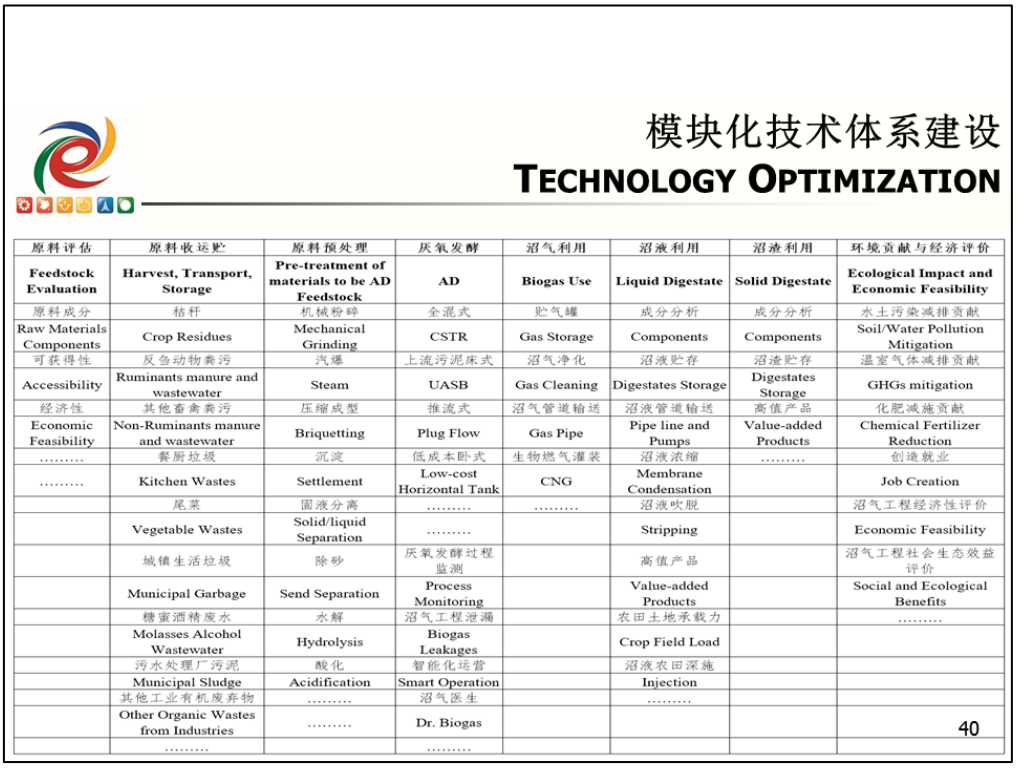
模块化技术体系建设
TECHNOLOGY OPTIMIZATION
原料评估 | 原料收运贮 | 原料预处理 | 厌氧发酵 | 沼气利用 | 沼液利用 | 沼渣利用 | 环境贡献与经济评价
Feedstock Evaluation | Harvest, Transport, Storage | Pre-treatment of materials to be AD Feedstock | AD | Biogas Use | Liquid Digestate | Solid Digestate | Ecological Impact and Economic Feasibility
原料成分 | 秸秆 | 机械粉碎 | 全混式 | 贮气罐 | 成分分析 | 成分分析 | 水土污染减排贡献
Raw Materials Components | Crop Residues | Mechanical Grinding | CSTR | Gas Storage | Components | Components | Soil/Water Pollution Mitigation
可获得性 | 反刍动物粪污 | 汽爆 | 上流污泥床式 | 沼气净化 | 沼液贮存 | 沼渣贮存 | 温室气体减排贡献
Accessibility | Ruminants manure and wastewater | Steam | UASB | Gas Cleaning | Digestates Storage | Digestates Storage | GHGs mitigation
经济性 | 其他畜禽粪污 | 压缩成型 | 推流式 | 沼气管道输送 | 沼液管道输送 | 高值产品 | 化肥减施贡献
Economic Feasibility | Non-Ruminants manure and wastewater | Briquetting | Plug Flow | Gas Pipe | Pipe line and Pumps | Value-added Products | Chemical Fertilizer Reduction
…… | 餐厨垃圾 | 沉淀 | 低成本卧式 | 生物燃气灌装 | 沼液浓缩 | …… | 创造就业
…… | Kitchen Wastes | Settlement | Low-cost Horizontal Tank | CNG | Membrane Condensation | | Job Creation
 | 尾菜 | 固液分离 | …… | …… | 沼液吹脱 | | 沼气工程经济性评价
 | Vegetable Wastes | Solid/liquid Separation | …… | | Stripping | | Economic Feasibility
 | 城镇生活垃圾 | 除砂 | 厌氧发酵过程监测 | | 高值产品 | | 沼气工程社会生态效益评价
 | Municipal Garbage | Send Separation | Process Monitoring | | Value-added Products | | Social and Ecological Benefits
 | 糖蜜酒精废水 | 水解 | 沼气工程泄漏 | | 农田土地承载力 | | ……
Molasses Alcohol Wastewater	Hydrolysis	Biogas Leakages		Crop Field Load	
污水处理厂污泥	酸化	智能化运营		沼液农田深施	
Municipal Sludge	Acidification	Smart Operation		Injection	
其他工业有机废弃物	……	沼气医生		……	
Other Organic Wastes from Industries	……	Dr. Biogas			
……		……			
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测定畜禽粪污的成分
MANURE CONTENTS MONITORING

- 干物质
- 有机质
- 电导率
- pH
- 总氮、有机氮、无机氮、氨
- 总磷P2O5、磷酸盐
- 总钾K2O等
- 金属（钙、铜、镁、纳、锌）

- 重金属（镍、铅、铬、镉、砷、汞）
- 抗生素
- 蛔虫卵
- 腐熟度

表 5：荷兰的牛粪浆、牛粪浆的固体部分、固体牛粪、育肥猪粪浆、猪粪浆的固体部分以及蛋鸡固体粪便的一般成分和氮/磷比例

	干物质 (g/kg)	有机物质 (g/kg)	N-tot* (g/kg)	N-min* (g/kg)	N-org* (g/kg)	P_2O_5* (g/kg)	K_2O* (g/kg)	N/P_2O_5
牛粪浆	85	64	4.1	2.0	2.1	1.5	5.8	**2.7**
牛粪浆的固体部分	250	188	7.8	1.6	6.2	4.4	5.8	**1.8**
固态牛粪便	194	152	5.3	0.9	4.4	2.8	6.1	**1.9**
育肥猪粪浆	93	43	7.1	4.6	2.5	4.6	5.8	**1.5**
猪粪浆的固体部分	250	116	10.5	3.8	6.7	12.4	5.8	**0.9**
固态鸡粪（蛋鸡）	573	416	25.6	2.5	23.1	19.6	15.5	**1.3**

*: N-tot = 总氮，N-min = 氨态氮，N-org = 有机氮，P_2O_5 = 磷酸盐，K_2O = 碳酸钾，N/P_2O_5= 总氮/磷酸盐

粪污取样检测

Parameter		Interm ref. nr.	Eenheid	1	2	3	4
Droge stof	干物质		% (m/m)	7,9	7,0	3,5	5,5
Ruwe as	粗物质		% van ds	28,9	29,4	33,6	46,5
Geleidbaarheid (20°C)	导电性		µS/cm	19000	20000	17000	18000
pH-H2O	PH			7,8	7,8	7,9	7,8
Stikstof	氮		g/kg	4,06	4,02	2,52	3,06
Fosfaat (als P2O5)	磷		g/kg	1,78	1,79	1,33	3,81
Metalen	金属						
Destructie	破坏性			+	+	+	+
Calcium	钙		mg/kg ds	16000	17000	24000	22000
Koper	铜		mg/kg ds	41	43	69	49
Magnesium	镁		mg/kg ds	10000	10000	22000	13000
Natrium	钠		mg/kg ds	5900	6000	11000	12000
Zink	锌		mg/kg ds	140	150	210	150
Nutriënten	营养物						
Tot. Kalium (als K2O)	总钾		g/kg	5,6	6,0	3,1	3,1
ortho-Fosfaat (als P)	磷酸盐		mg/kg ds	7300	7400	10000	7600
Ammonium (als N)	氨		g/kg	1,6	1,7	1,4	1,4

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秸秆湿储存技术
WET STORAGE OF CROP RESIDUES WITH DIFFERENT PROPERTIES

- Storage for the year-round substrate supply
- Complex characteristics (cellulose, lignin, water content et al.)
- High Dry matter loss (could be as high as 30%)

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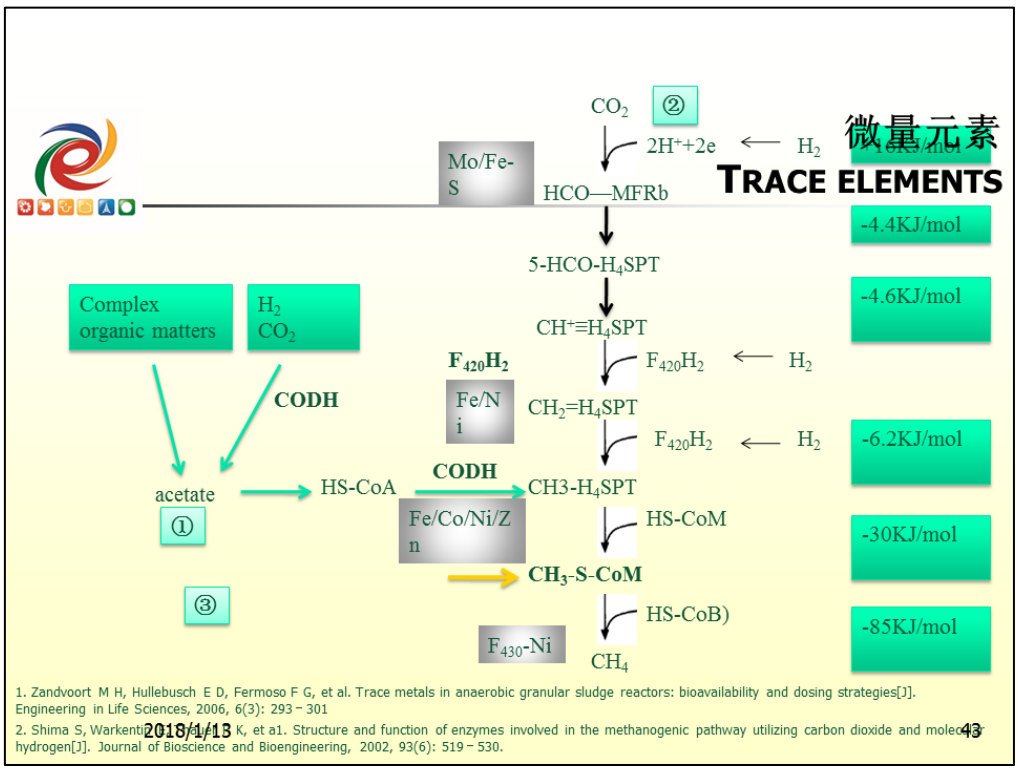
微量元素
TRACE ELEMENTS
CO2
②
2H+ +2e
H2
Mo/Fe-S
HCO—MFRb
-4.4KJ/mol
5-HCO-H4SPT
-4.6KJ/mol
CH+≡H4SPT
F420H2
F420H2
H2
Fe/Ni
CH2=H4SPT
F420H2
H2
-6.2KJ/mol
Complex organic matters
H2
CO2
CODH
CODH
acetate
①
HS-CoA
CH3-H4SPT
Fe/Co/Ni/Zn
HS-CoM
-30KJ/mol
CH3-S-CoM
③
HS-CoB)
-85KJ/mol
F430-Ni
CH4
1. Zandvoort M H, Hullebusch E D, Fermoso F G, et al. Trace metals in anaerobic granular sludge reactors: bioavailability and dosing strategies[J]. Engineering in Life Sciences, 2006, 6(3): 293－301
2. Shima S, Warkentin E, Thauer R K, et a1. Structure and function of enzymes involved in the methanogenic pathway utilizing carbon dioxide and molecular hydrogen[J]. Journal of Bioscience and Bioengineering, 2002, 93(6): 519－530.
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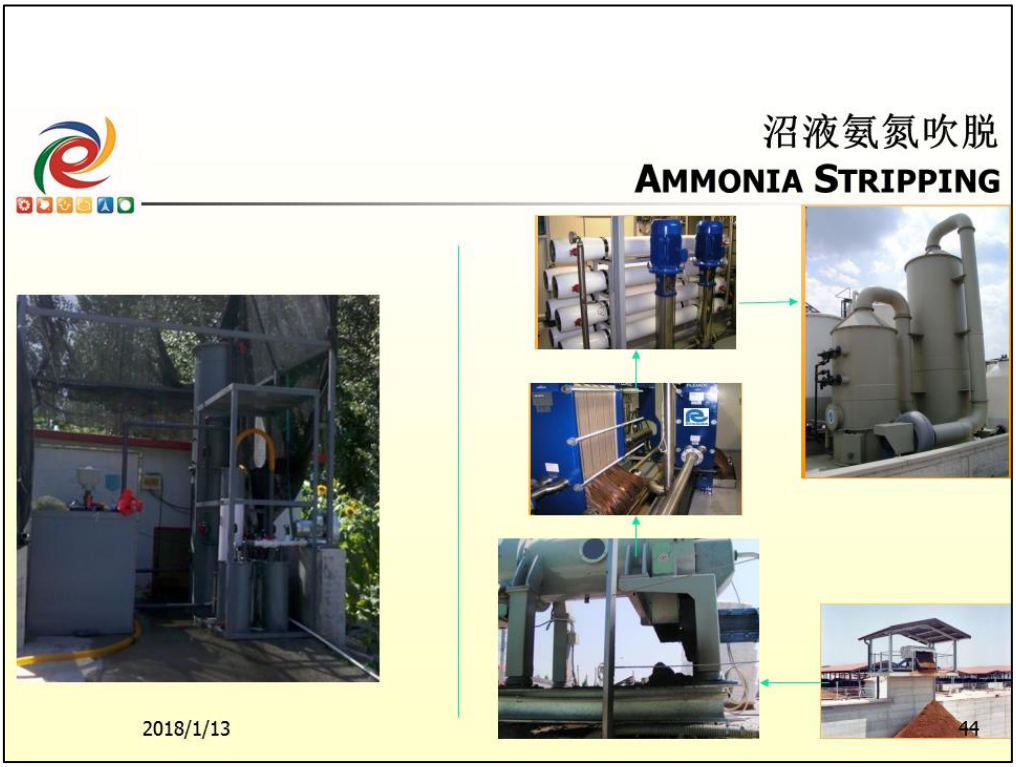
沼液氨氮吹脱
AMMONIA STRIPPING
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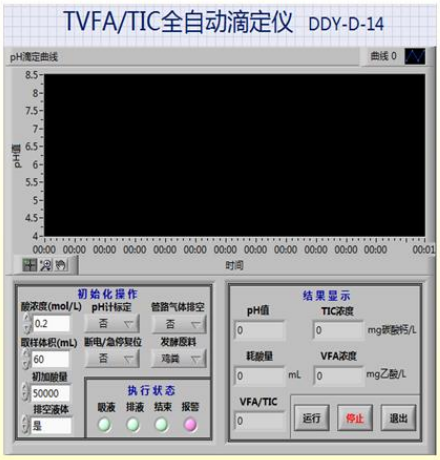
厌氧发酵过程监测与反馈控制
PROCESS MONITORING AND FEED-BACK CONTROL



吴树彪, 陈新颖, 刘良, 郭建斌*, 董仁杰. 规模化沼气工程总挥发酸与碳酸氢盐碱度自动滴定装置[J]. 农业机械学报, 2015,（接收）

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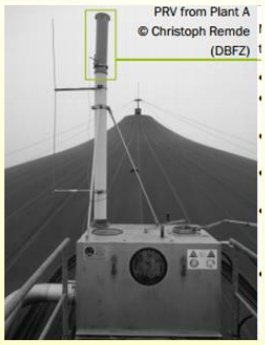
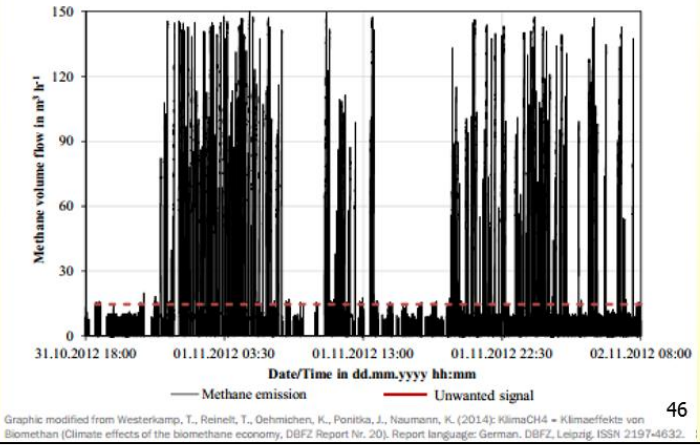
沼气工程泄漏-来自DBFZ的启发
MONITOR BPS LEAKAGE- DBFZ KNOWLEDGE

Results and Discussion
PRV – Plant A

Introduction
Methods
Results and Discussion
Outlook
DBFZ





Graphic modified from Westerkamp, T., Reinelt, T., Oehmichen, K., Ponitka, J., Naumann, K. (2014): KlimaCH4 – Klimaeffekte von Biomethan (Climate effects of the biomethane economy, DBFZ Report Nr. 20). Report language: German. DBFZ, Leipzig. ISSN 2197-4632.

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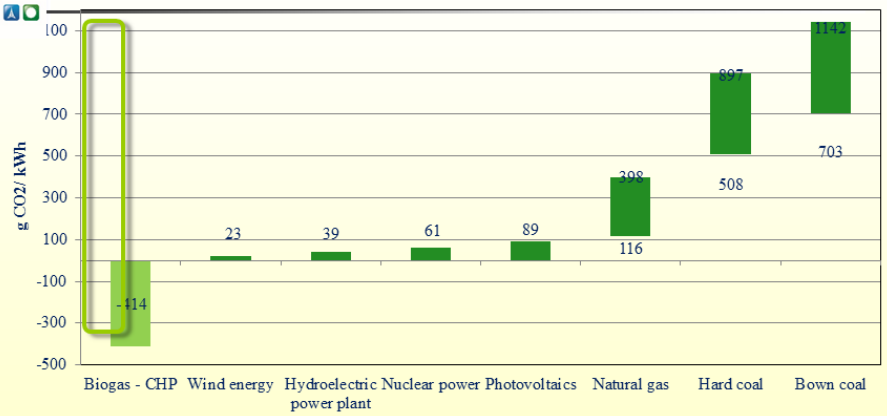
沼气工程的减排贡献
BIOGAS FOR CLIMATE CHANGE MITIGATION



Specific CO_2 Emission Associated with Energy Generation

Resource: Poeschl M, S Ward & P Owende. 2010. Prospects for expanded biogas utilization in Germany. *Renewable & Sustainable Energy Reviews*: In Review

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沼气工程服务：诊断、恢复、高效运行
BIOGAS CARE: ACTIVATE EXISTING BIOGAS PLANTS

J3 沼气医生 Dr. Biogas

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烟台格罗宁根大学-合作的新机遇
NEW COOPERATION OPPORTUNITY

烟台格罗宁根大学的八大研究中心
RESEARCH CENTERS IN UGY


生物能源环境科学与技术研究室
Bioenergy and Environment Science & Technology Laboratory
工学院
COLLEGE OF ENGINEERING
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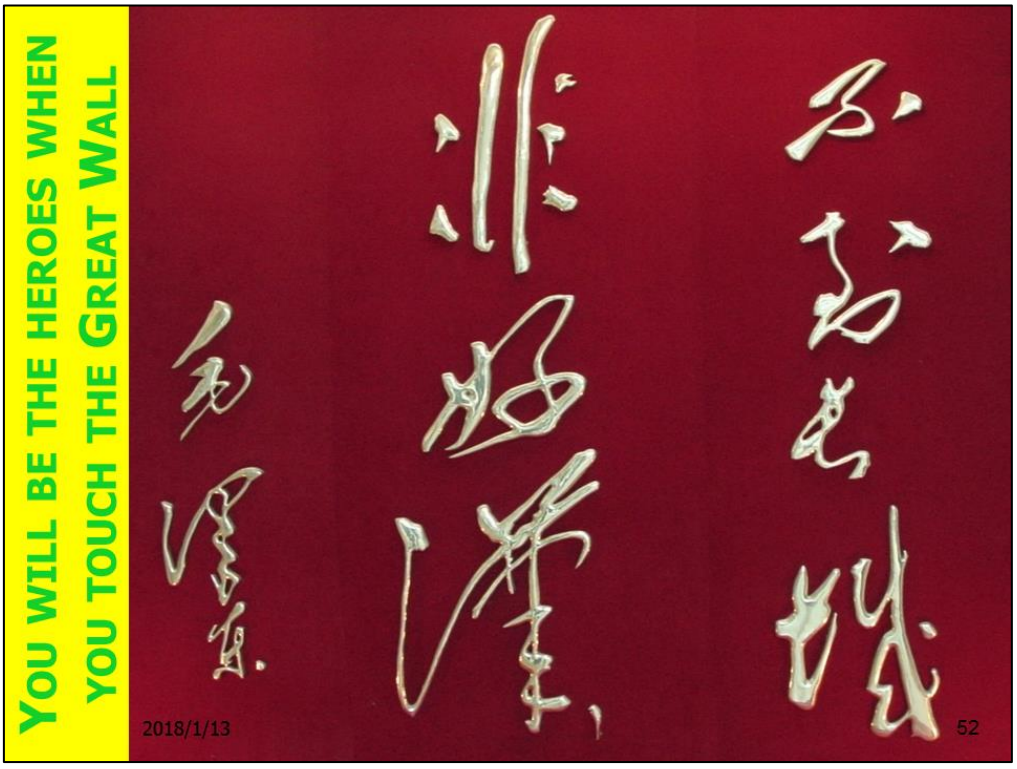
YOU WILL BE THE HEROES WHEN
YOU TOUCH THE GREAT WALL
2018/1/13
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IMPRINT

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DISCLAIMER

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