农业有机污染高效消纳的工程化措

ENGINEERING MEANS FOR EFFECTIVE ORGANIC POLLUTANT CONTROL: SECURING THE FOOD PRODUCTION

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EU-China expert seminar on identifying potential joint priorities for research and innovation in food, agriculture and biotechnology
Brussels, Belgium
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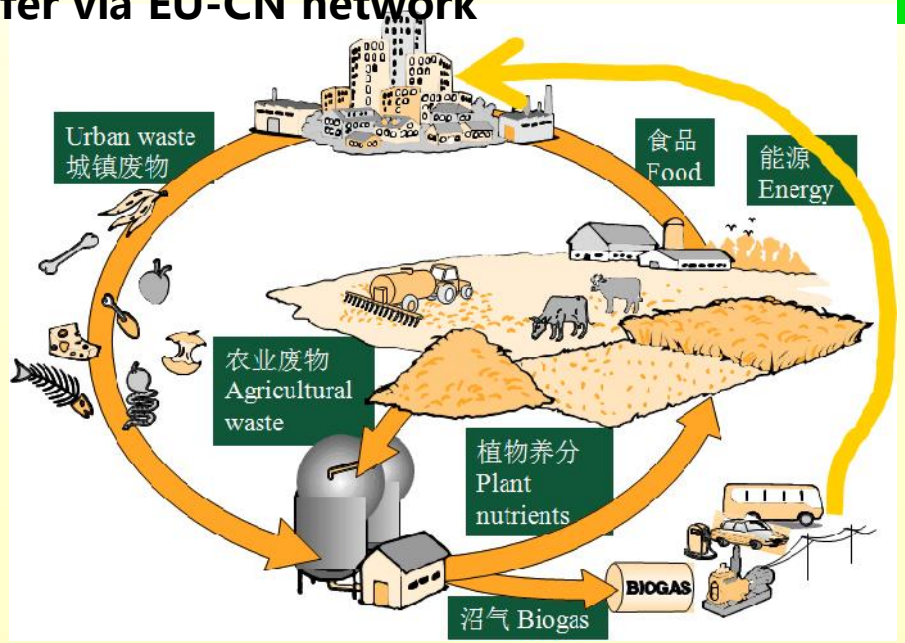
2016/10/27

能源与环保是社会发展的制约因素

ENERGY/ENVIRONMENTAL PROTECTION FOR SUSTAINABLE DEVELOPMENT

- Organic wastes from farming: Pollution, mis-placed biomass resources (fertilizers, energy, materials)
- Green development becomes core indicator
- Booming mega cities require engineering measures
- Knowledge transfer via EU-CN network

N、P、K---Nutrients 肥料
C--- Energy 能源
H-O---Water 水
All are Renewable
ReNEW



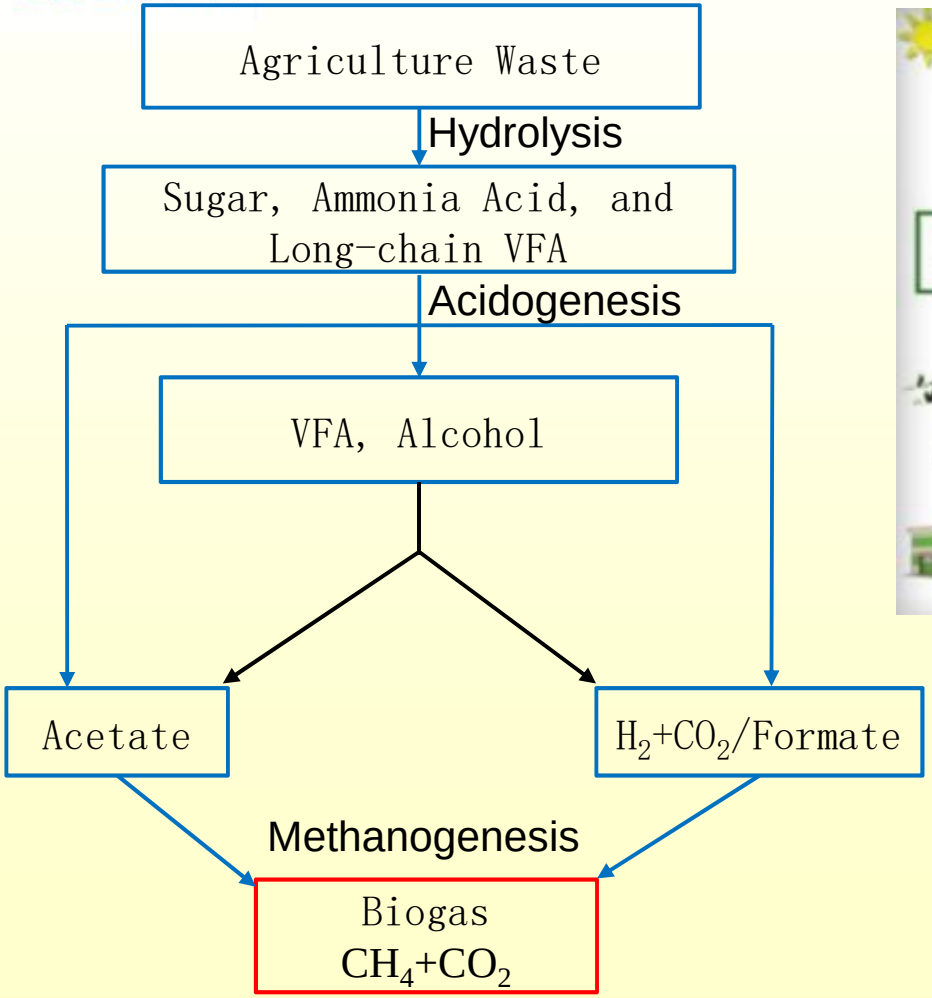
农业源有机废弃物
ORGANIC RESIDUES FROM AGRICULTURE

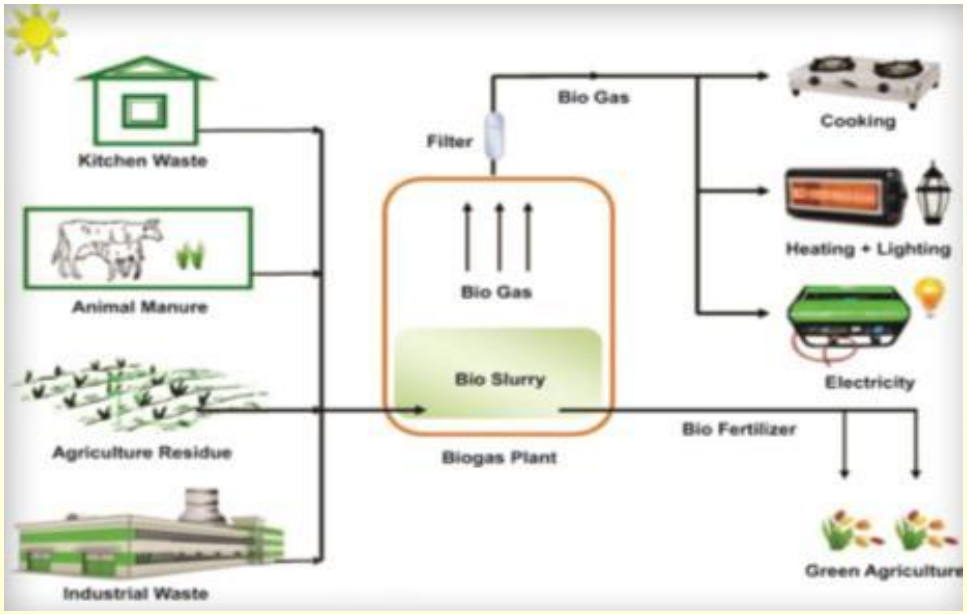
全国有机废物产生量

Annual organic Waste in China

	类别 Waste	数量,亿吨/年, Amount (×10^8 tons/a)	
1	畜禽粪便 Livestock manure	31.6	湿基, wet
2	农作物秸秆 Crops residue	6.89	湿基, wet
3	工业源生物质废物 Industry waste	2.0	湿基, wet
4	家庭厨余垃圾, Household food waste	0.9	湿基, wet
5	城市粪便, Municipal nightsoil	0.25	湿基, wet
6	城市污泥. Municipal sludge	0.26	湿基, wet
7	餐饮业餐厨垃圾, Restaurant waste	0.15	湿基, wet
8	集市果蔬垃圾, Vegetable waste	0.12	湿基, wet
	合计 Total	42.17	湿基, wet

有机废弃物的能源价值
ENERGY VALUE OF ORGANIC RESIDUES





Biogas

CH_4	≈ 60%
CO_2	≈ 40%

Heat Value, ≈ 20MJ/m^3

畜禽粪便的沼气潜力
BIOGAS VALUE OF LIVESTOCK MANURE

	Dry Solid， %	Biogas Yield (m^3/t-Fresh Manure)	CH_4
Cattle Manure	18-20	40-50	≧60
Pig Manure	20-25	55-65	≧60
Chicken Manure	20-32	70-90	≧60

Livestock manure
0.316 billion tons

Biogas Potential From Livestock Manure

0.35m^3/1 kg-COD

Annual Biogas Yield
175 billion m^3

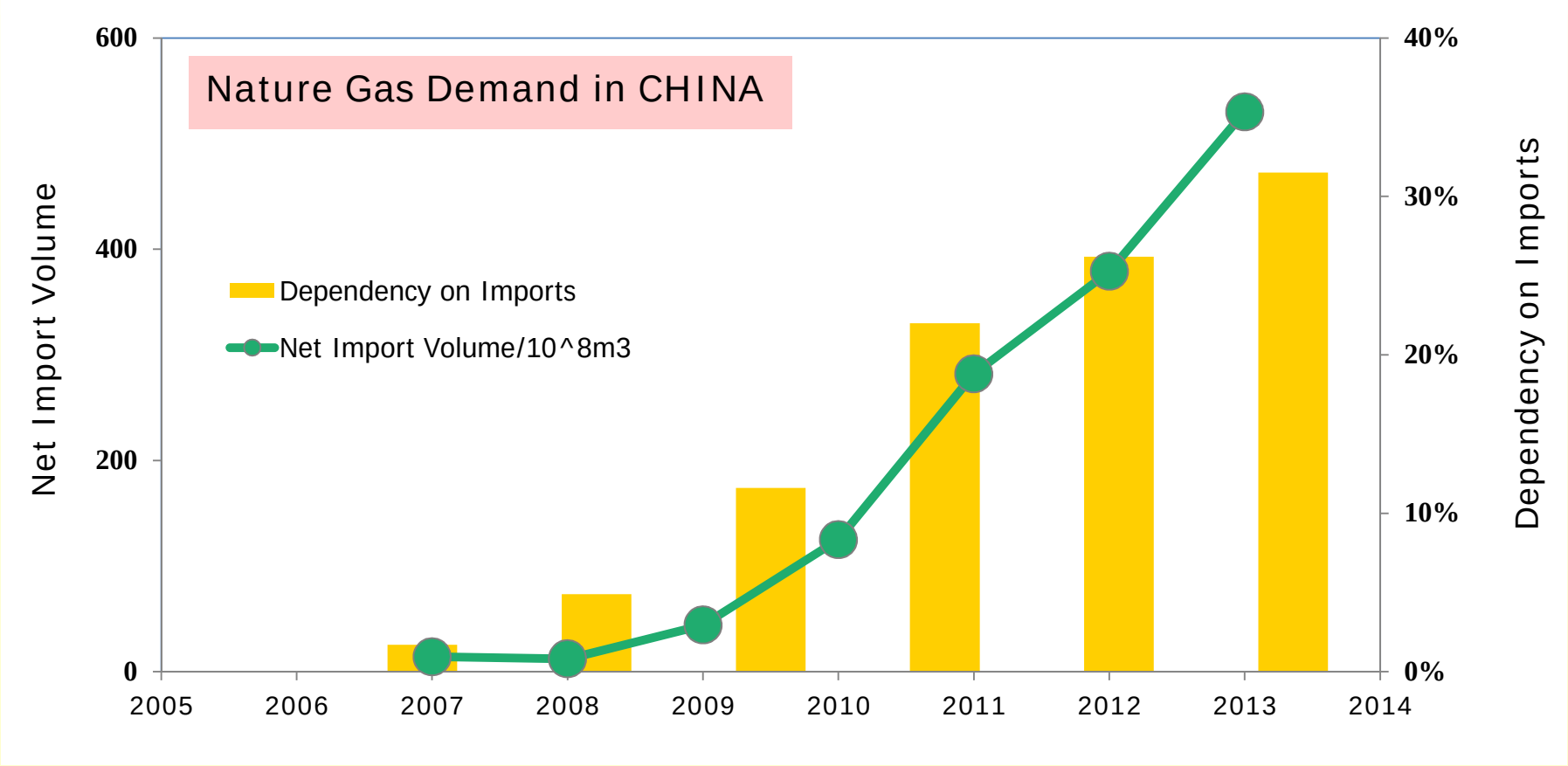
清洁能源发展的需求
DEMAND OF CLEAN ENERGY

Renewable Energy in China

Year	Total Generation	Fossil			Nuclear	Renewable								Total generated by renewables (includes waste, based on table)	Estimated % generated by renewables (based on table)
		Coal	Oil	Gas		Waste	Hydro	Wind	Biofuels	Solar PV	Solar thermal	Geothermal	Tide		
2008	3,481,985	2,743,767	23,791	31,028	68,394	0	585,187	14,800	14,715	152	0	144	7	615,005	17.66%
2009	3,741,961	2,940,751	16,612	50,813	70,134	0	615,640	26,900	20,700	279	0	125	7	663,651	17.74%
2010	4,207,993	3,250,409	13,236	69,027	73,880	9,064	722,172	44,622	24,750	699	2	125	7	801,441	19.05%
2011	4,715,761	3,723,315	7,786	84,022	86,350	10,770	698,945	70,331	31,500	2,604	6	125	7	814,288	17.27%
2012	4,994,038	3,785,022	6,698	85,686	97,394	10,968	872,107	95,978	33,700	6,344	9	125	7	1,019,238	20.41%
2013	5,447,231	4,110,826	6,504	90,602	111,613	12,304	920,291	141,197	38,300	15,451	26	109	8	1,127,686	20.70%
2014	5,678,945	4,115,215	9,517	114,505	132,538	12,956	1,064,337	156,078	44,437	29,195	34	125	8	1,307,170	23.02%

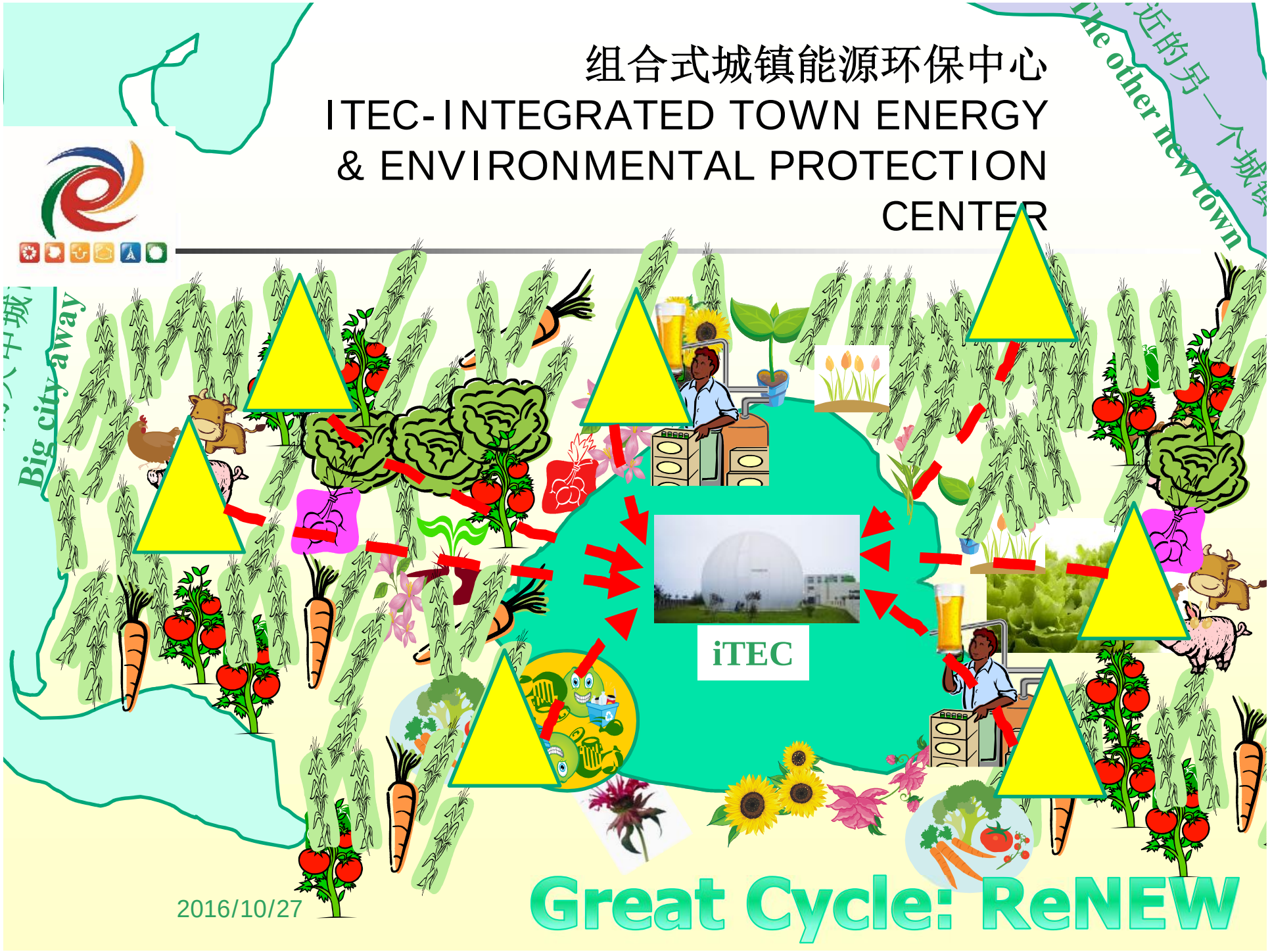
https://en.wikipedia.org/wiki/Renewable_energy_in_China

天然气缺口对生物燃气的需求
NATURAL GAS DEMAND



Source: Zhang Kang. Natural Gas Industry, 2014

组合式城镇能源环保中心
ITEC-INTEGRATED TOWN ENERGY & ENVIRONMENTAL PROTECTION CENTER



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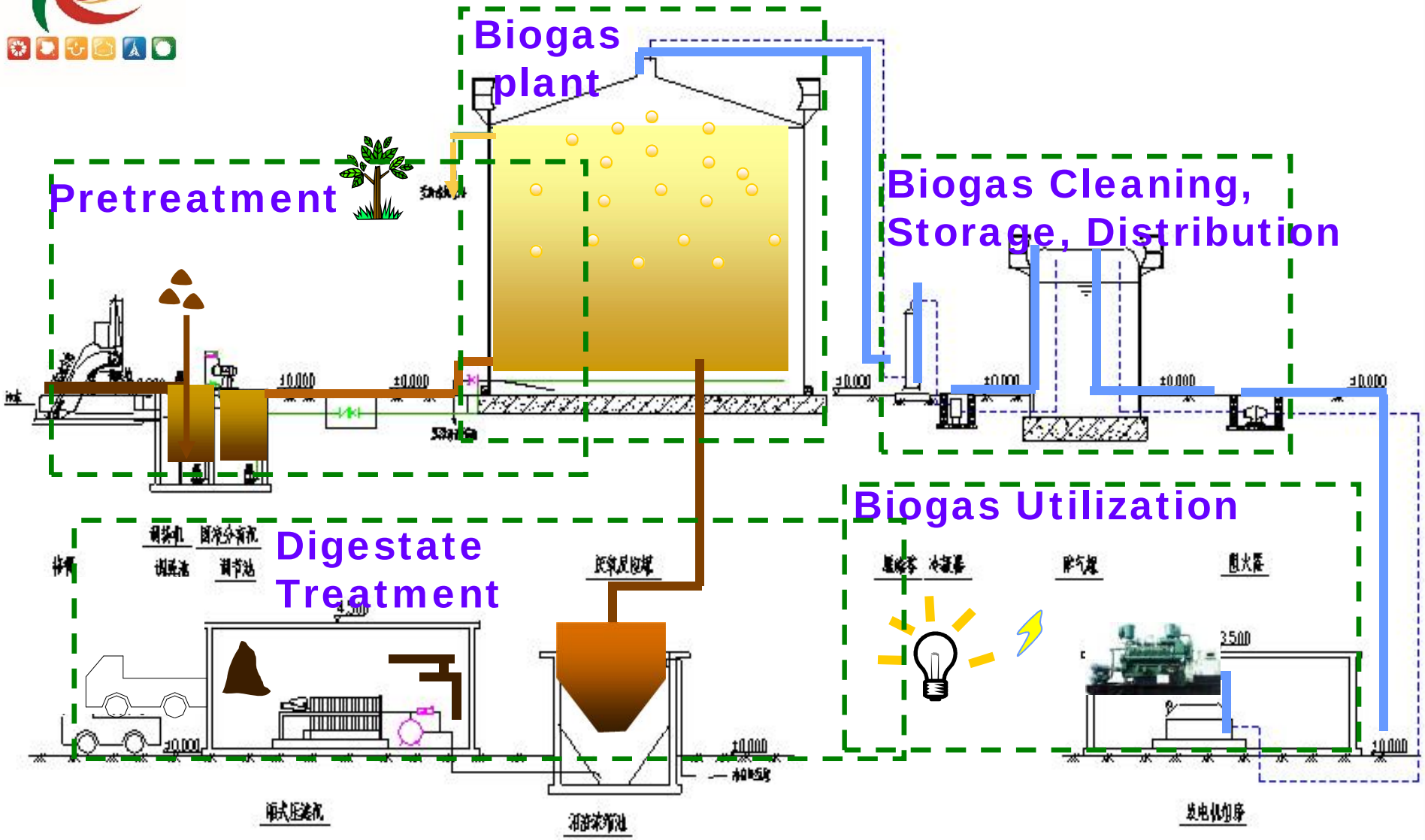
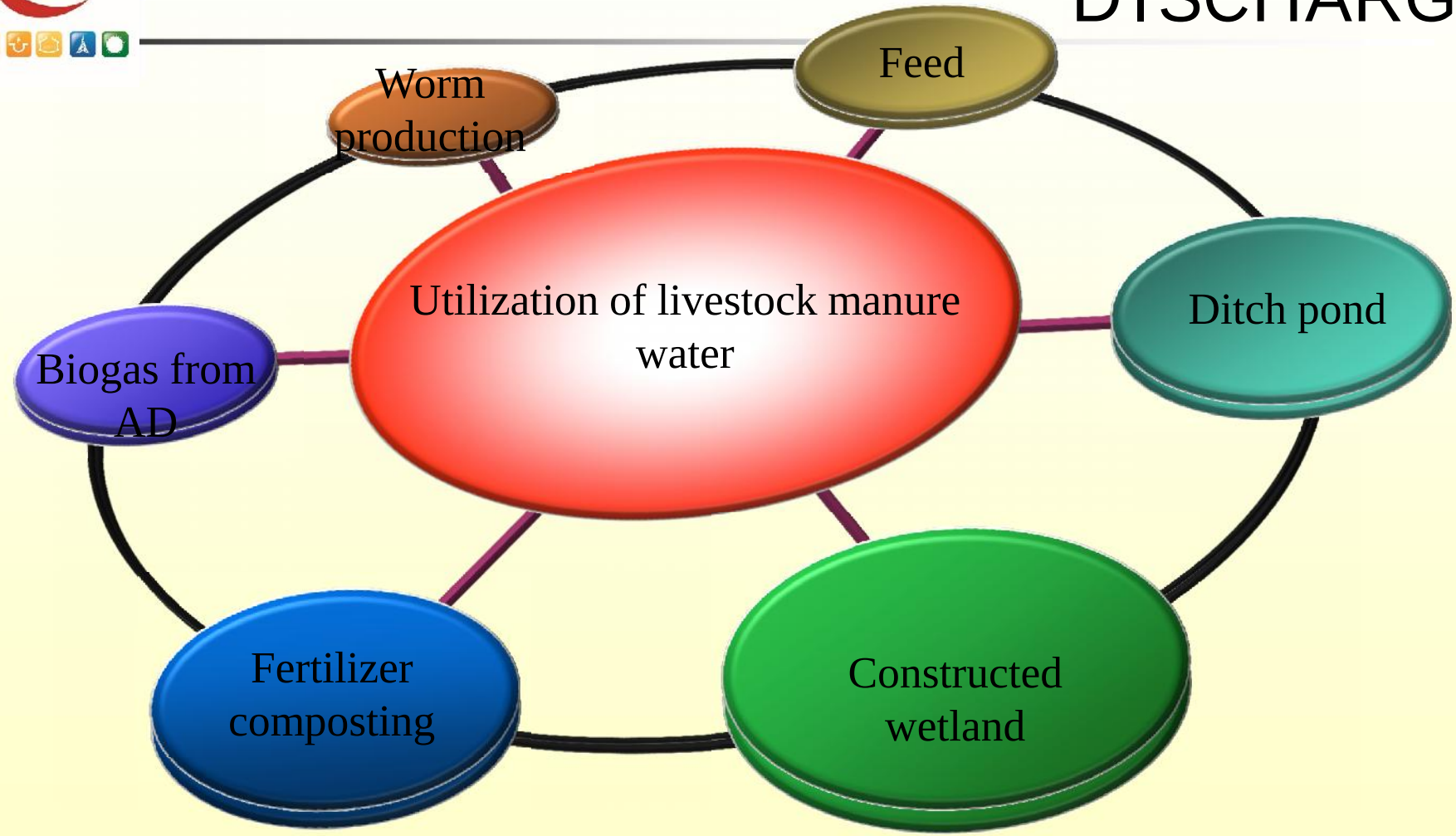
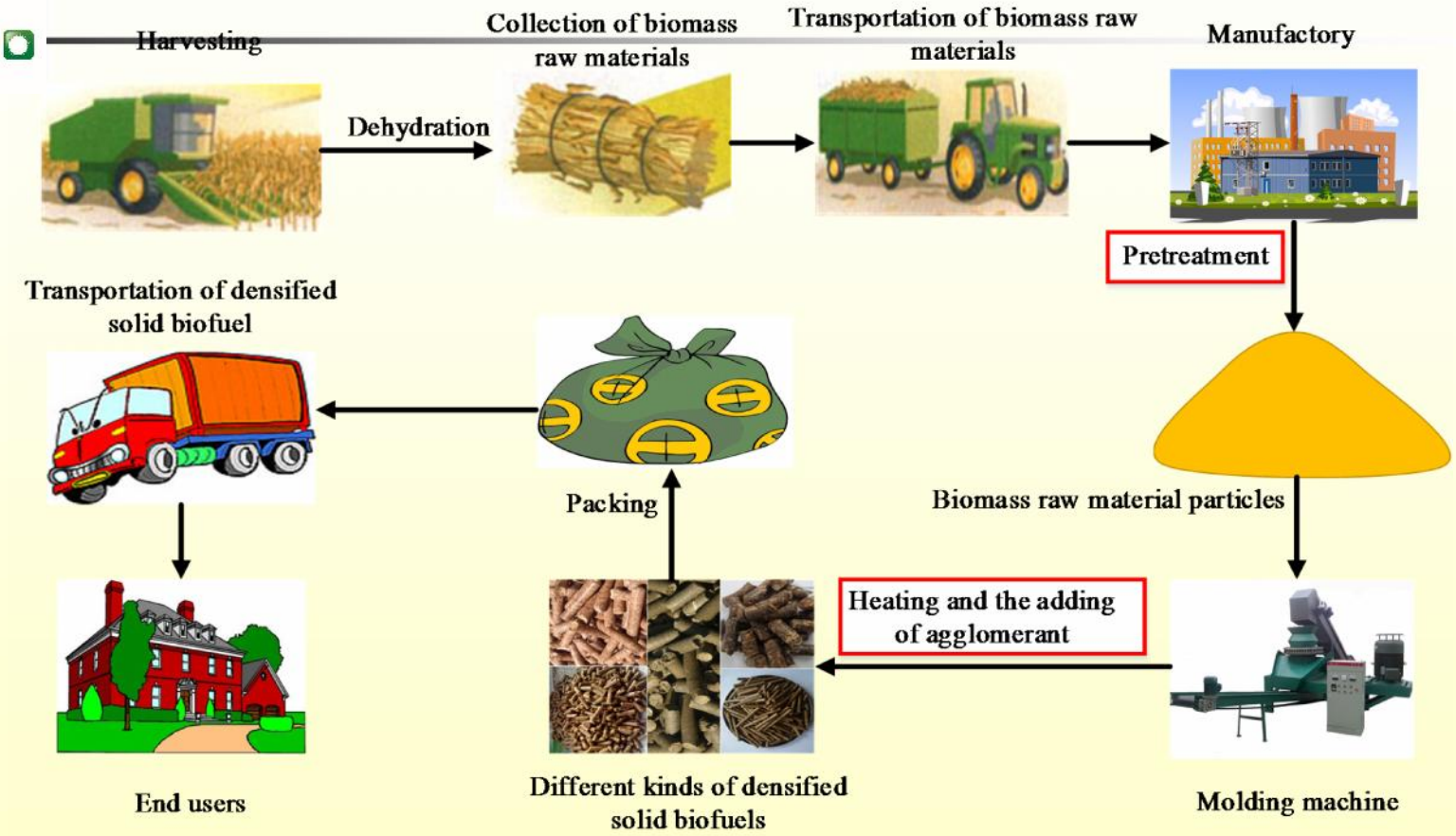
EXAMPLE: M/L BIOGAS PLANT



氮磷回收与达标排放
EXAMPLE: N/P RECYCLE AND SAFETY DISCHARGE



秸秆固体燃料化
EXAMPLE: FARM RESIDUES FOR COMBUSTION



Yuguang Zhou, Zongxi Zhang, Yixiang Zhang, Riaz Ahmad, Renjie Dong. A comprehensive review on densified solid biofuel industry in China. Renewable and Sustainable Energy Reviews, 2016. 54: p. 1412-1428.

农业有机废弃物利用面临的挑战
CHALLENGES FOR FARMING ORGANIC WASTE UTILIZATION IN CHINA

- Feedstock property database should be established.
- Feedstock collection equipment development should be enhanced.
- Pretreatment for mixed culture feedstock is critical – biomass/enzyme interactions.
- Centralized large-scale biogas plants are welcome but lacking of automation. Household biogas digesters are scattered.
- Heat and mass transfer models for AD – intelligent biogas plants.
- Safety discharge of digestates should be concerned and standardized.
- Crop field load limits for digestates application.
- Efficient cellulase for SSCF ethanol production.
- Household clean combustion for crop residues must be improved.
- Technical support are not sufficient.
- New commercialization model relies on technology improvement.

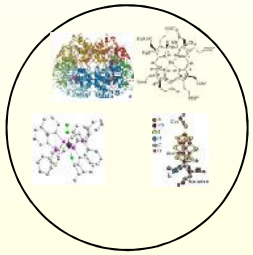
先进厌氧发酵技术集成
ADVANCED AD TECH INTEGRAT

2013年董仁杰教授获得国家科技进步二等奖

原料归一化预处理
Pretreatment for unique feedstock

郭建斌副教授
Dr. GUO Jianbin

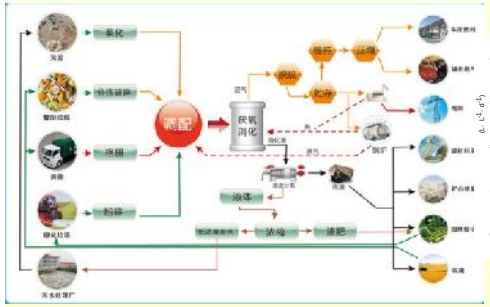
- 禽粪 Poultry manure
- 畜粪 Livestock manure
- 秸秆 Straw
- 餐厨 Kitchen waste
- 污泥 Activated slurry

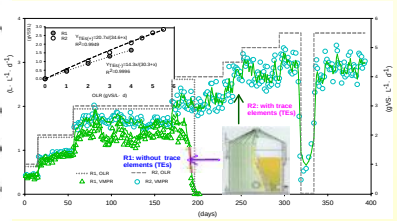


乔玮 副教授
Dr. QIAO Wei

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





- 国家外专局高端外专项目1：村镇分散污水人工湿地生态处理（中丹）
- 国家外专局高端外专项目2：先进厌氧发酵核心技术攻关及系统集成 （中德）

吴树彪副教授
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

周宇光副教授
Dr. ZHOU Yuguang

沼气工程装备与户用生物质炉灶
Biogas Equipment/ Cookstoves

户用生物质清洁燃烧与减排
HOUSEHOLD COOKSTOVES

室内燃烧对室内空气质量的影响及减排策略

- 通风情况
- 不同时段
- 炉灶类型
- 燃料类型
- 推广调研

户用生物质炉具测试国际标准研究

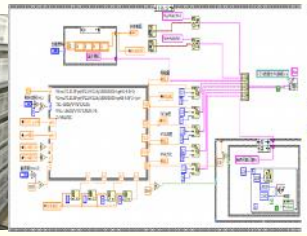
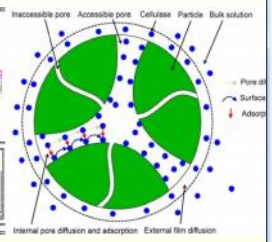
- 测试需求
- 测试指标
- 测试流程
- 数据处理
- 标准制定

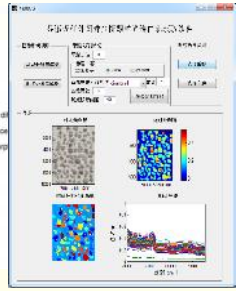
清洁炉具设计与对非培训

- 气化炉具设计改良
- 区域知识中心建设
- 炉具培训项目

中国-荷兰国际合作项目：中国西部农村地区室内空气质量监测
中国-南非国际合作项目：适用于发展中国家的清洁炉具性能测试方法研究

技术研究进展
RESEARCH PROGRESS



- 有机废弃物特性数据库 **Database for physico-chemical properties of biomass feedstock**
- 复杂原料预处理 **Complex materials pretreatment**
- 沼液回流改善发酵效果 **Effluent recirculation for hydrolysis and AD improvement**
- 秸秆发酵产沼气 **SS-AD from crop residues**
- 沼气工程过程控制 **Biogas process monitoring and control**
- 沼液中微量元素和吲哚乙酸 **Trace elements and Indole Acetic Acid in effluent**
- 沼液沼渣多级处理与循环利用 **Multiple treatment and recycle utilization of biogas digestates**

国际合作成果
INT'L COLLABORATIONS FOR RESEARCH

- CN-NL University of Groningen-Yantai; Diary Sustainable Development PhD; Indoor air quality monitoring in Western China
- CN-GE Advanced AD technology integration; Composting of organic waste from animal farm in Qinghai-Tibet Plateau
- CN-DE Distributed artificial wetland for village wastewater treatment
- CN-BE Spectra detection method for biomass
- CN-EU Feasibility study on cassava straw to energy; Great Cycle Workshop
- CN-US Doctor in Environment and Energy Program
- CN-SA Testing method for clean stoves in developing countries
- CN-WB Emission baseline of space heating stoves in Hebei Province; China stove standardization roadmap
- CN-UNDP Renewable Energy Tech Transfer Center
- CN-GACC Regional Testing and Knowledge Center for clean stoves
- CN-AFRICA 20+20 ISAF/V Talent Program; Forum of Renewable Energy Promotion in Developing Countries

研究团队
R&D TEAM

Name	Title	Focus	Name	Title	Focus
Wang Tao	VP of CAU, Director of MoA Key Lab, Prof.	Energy Crops	Dong Renjie	Executive Director of MoA Key Lab, Prof.	Biogas Engineering
Xie Guanghui	Executive Director of NECB, Prof.	Energy Crops	Han Lujia	Dean of College of Engineering, Prof.	Biomass Property
Chen Longjian	Prof.	Biomass Property	Yang Zengling	Prof.	Biomass Detection
Qiao Wei	Associate Prof.	Anaerobic Diegestion	Wu Shubiao	Associate Prof.	AD digestate management
Huang Guangqun	Associate Prof.	Composting	Xiao Weihua	Associate Prof.	Biomass Degradation
Liu Xian	Associate Prof.	Biomass Pretreatment	Zhou Yuguang	Associate Prof.	Biogas Equipment and Biomass Clean Combustion
Yuan Xufeng	Assistant Prof.	Biogas Engineering	Yang Xiaolin	Associate Prof.	Energy Crops

生物能源环境科学与技术研究室

Bioenergy and Environment Science & Technology Laboratory

谢 谢！

Thanks a lot