

# Experience with biogas plants performance monitoring in Germany 德国沼气工程运行监测经验

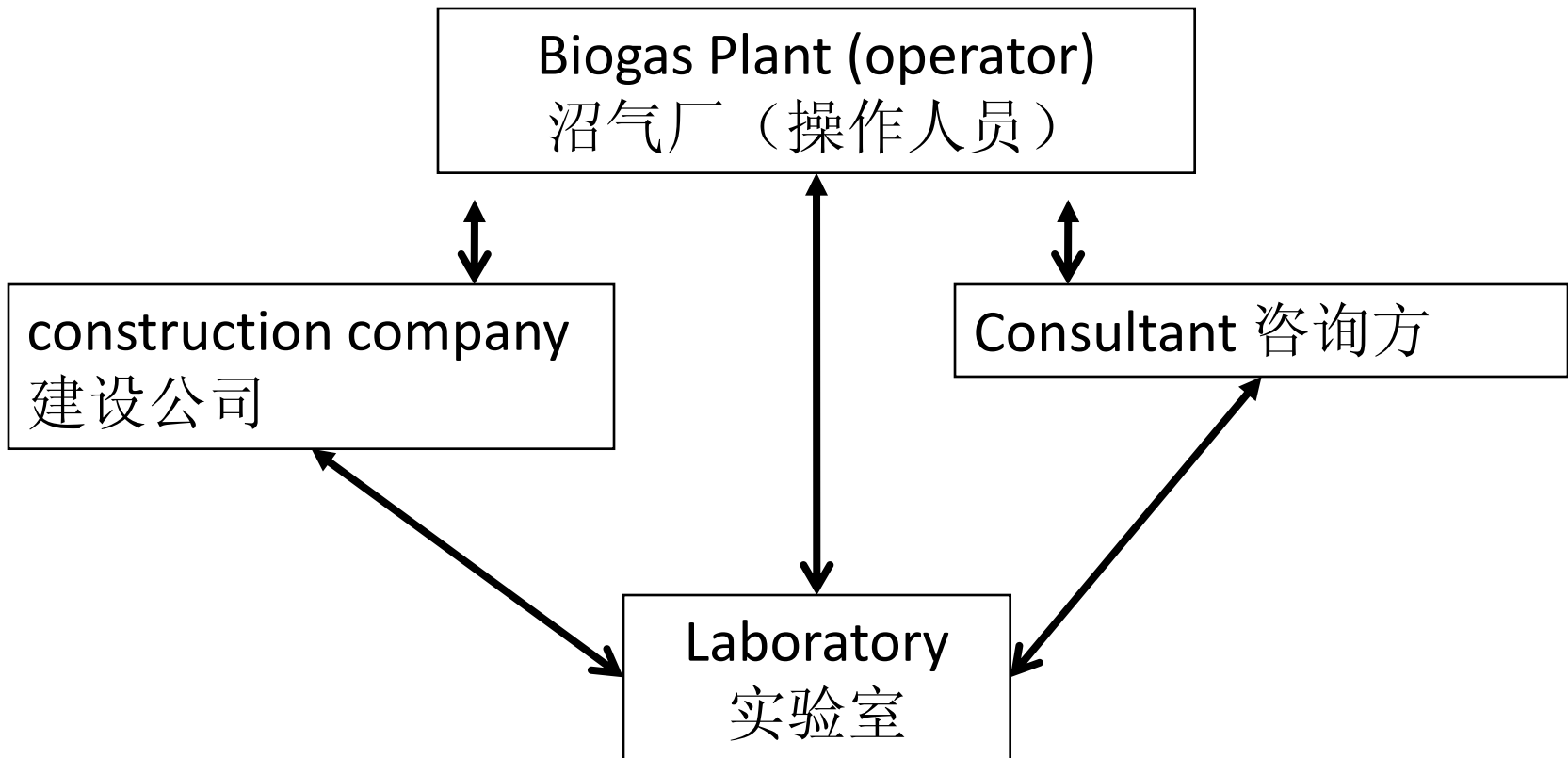
Joachim Clemens

Training for on site measurements for performance  
evaluation of middle and large scale biogas plants in China  
18. – 19. May 2010

# Performance monitoring 运行监测

- Operators 操作人员
- Construction companies 建设公司
- Consultants 咨询方
- Laboratories 实验室

# Flow of Information



# How can a consultant help?

## 咨询方能做什么？

- Check/Calculate biogas efficiency 检测/计算沼气效率
- Advice on operation 运行建议
- Advice on new substrates 新原料建议
- Advice on digestate use 发酵剩余物用途建议

# Aim of a biogas plant

## 沼气工程的目标

- To produce as much biogas as possible 产生尽可能多的沼气
- But how do you know that it performs well? 但是我们怎么知道沼气工程运行的好坏呢?

Substrate	m <sup>3</sup> biogas / t oDM
Cattle manure	210 – 300
Cattle slurry	200 – 500
Pig manure	270 – 450
Pig slurry	300 – 700
Chicken manure	250 – 450
Food leftovers	200 - 500

oDM = organic Dry Matter 有机干物质

VS = volatile Solids 挥发性固体

VS = oDM

# Mass balance usually is calculated before a biogas plant is build

## 沼气厂建立前计算物料平衡

- Input of material is known: 进料
  - t/day of substrates 每天多少吨发酵原料
  - m<sup>3</sup>/day 每天多少方
  - Dry matter (DM) and organic dry matter (oDM) of the substrate by laboratory analysis 发酵原料的干物质与有机干物质分析
  - Biogas potential of the substrates by laboratory analysis 发酵原料的产沼气能力
- Gas production is known: 产气
  - m<sup>3</sup>/day
  - CO<sub>2</sub>/CH<sub>4</sub>

# Performance of a biogas plant

$\text{oDM}_{\text{input}} = \text{oDM}_{\text{output}} - \text{biogas}$

1 m<sup>3</sup> of biogas =

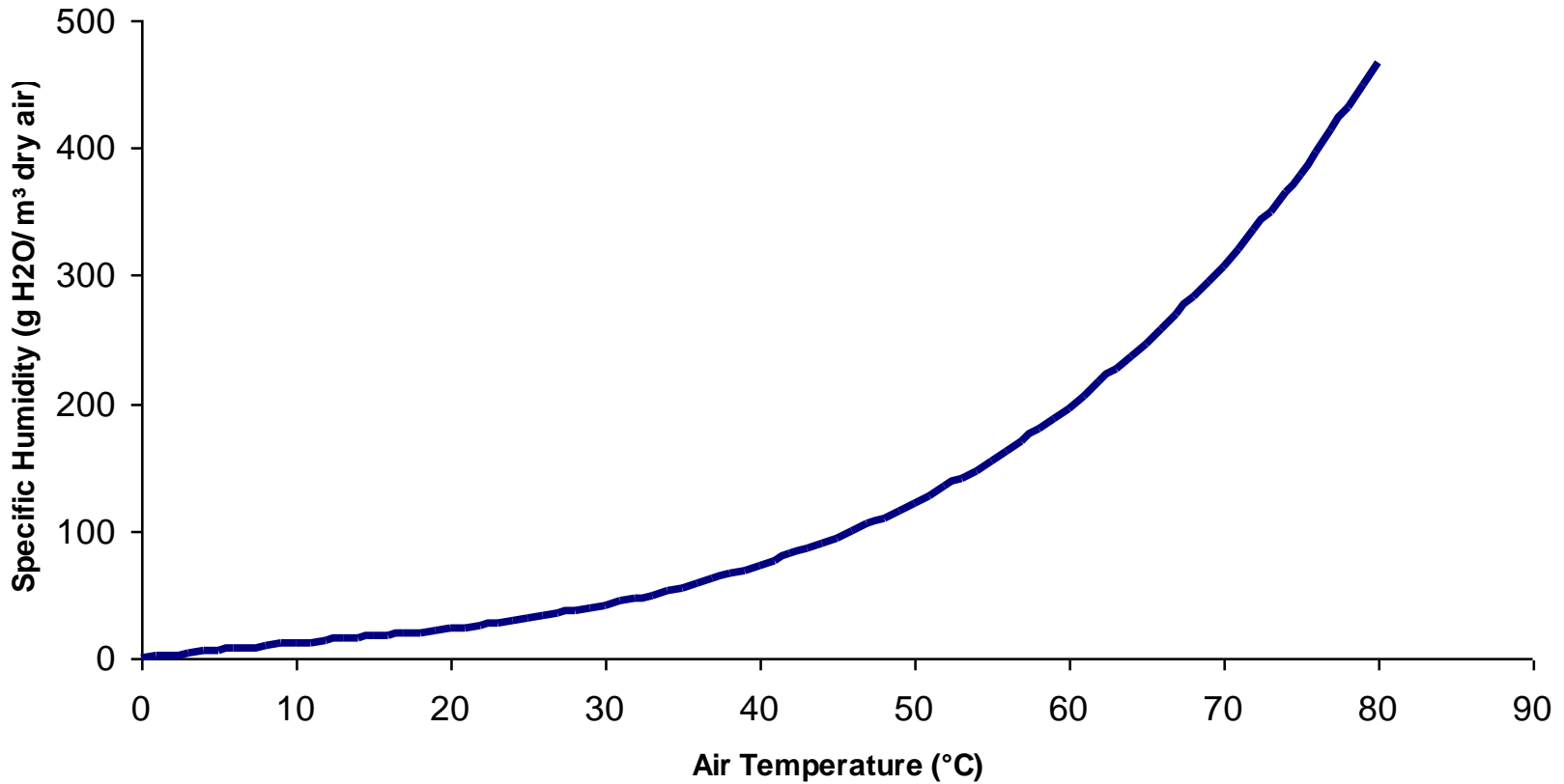
$x\% \text{CO}_2 / 100 * 1000\text{L} / 22.414 \text{ L/mol} * 44 \text{ g/mol} +$

$x\% \text{CH}_4 / 100 * 1000\text{L} / 22.414 \text{ L/mol} * 44 \text{ g/mol} +$

Water (at 100% specific humidity)

# Specific Humidity as a Function of Air Temperature

## 气体温度与绝对湿度的函数关系





# How can a laboratory help?

## 实验室能干什么？

- Help to control the process during normal operation (reaction time fast) 在正常运行中协助控制过程（反应时间：快）
- Help to give information about new substrates about biogas (reaction time: fast – slow) 协助获得新的发酵原料的信息（反应时间：快-慢）
- Help when a biological problem occurs (reaction time: very fast) 当生物问题发生时，提供协助（反应时间：很快）

SOME laboratories (otherwise a consultant): 有些实验室（咨询方）

- Give operating advices 提供操作建议
- Give trouble shooting advices 提供解决问题建议

# Services of laboratories in Germany 德国实验室的服务

- DM, oDM 干物质, 有机干物质
- Titration on Volatile fatty acids (VFA) and total inorganic carbon (TIC) 滴定挥发性脂肪酸, 总无机碳
- pH, Electric conductivity EC pH, 电导率测定
- Biogas potential 沼气潜力
- Single component analysis of VFA 挥发性脂肪酸单组分分析
- Trace elements such as Ni, Mo etc. (not all) 微量元素, 例如镍, 钼等(不是所有的)
- Batch test for biogas production: 批式测定沼气产量
- for new substrates (how much biogas is in a new substrate) 对于新原料(沼气产量)
- Digested material (how much energy is still in the substrate) 发酵后原料(剩余多少能量)

Prüfbericht Biogas

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 Ort 53115 Bonn  
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 Tel 0228-2667882  
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Probenehmer:  
 Probenart:  
 Probeentnahmestelle:

Auftraggeber:  
[www.bioreact.de](http://www.bioreact.de)

Prüflabor:  bonalytic GmbH  
 Postfach 1161, 53821 Troisdorf



Datum der Prüfung BASIS: 12.05.2010 TS/oTS: GC: 12.05. - 14.05.2010

Prüfberichtsnummer: 100512-034-BG-2 ersetzt Prüfbericht: 100512-034-BG-1

Hinweis: Alle Angaben beziehen sich auf die Probe mit dem jüngsten Probeneingangsdatum!

Probenpaket		BASIS						TS/oTS		GC							Daten- ausgang	
Proben- eingang	Probe- nahme	pH EN 12176	EC [mS/cm] EN 27888	FOS [g HAc <sub>eq</sub> /l] NT	TAC [g CaCO <sub>3</sub> /l] NT	FOS/ TAC	NH <sub>4</sub> <sup>+</sup> -N [g/l] KHL	TS [g/kg] EN 12880	oTS [g/kg] EN 12879	ES [g/l] GHM	PS [g/l] GHM	BS [g/l] GHM	iBS [g/l] GHM	VS [g/l] GHM	iVS [g/l] GHM	CS [g/l] GHM		HAc-ÄQ [g HAc <sub>eq</sub> /l]
16.04.2010	13.04.2010	8,7	24,0	2,64	13,30	0,20	1,72	372	124	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03	0,00	17.04.2010
29.04.2010	27.04.2010	8,5	31,7	5,92	22,40	0,26	2,18	381	135	1,73	0,95	<0,03	<0,03	<0,03	0,11	<0,03	2,57	07.05.2010
05.05.2010	04.05.2010	8,6	26,3	5,33	19,80	0,27	4,94	395	136	1,82	2,22	0,08	0,08	0,08	0,16	<0,03	3,86	07.05.2010
12.05.2010	k.A.	8,6	39,7	7,90	33,60	0,24				0,55	2,53	<0,03	0,04	<0,03	0,04	<0,03	2,66	14.05.2010

Anmerkungen:

Die ausstehenden Analysen-Ergebnisse werden nachgeliefert. Unser Labor ist von montags bis samstags für Sie geöffnet!

Die Daten sind Eigentum der bonalytic GmbH und dürfen daher nur mit deren Zustimmung an Dritte weitergegeben werden.

Verwendete Prüfverfahren: EC nach EN 27888:1993, GHM = gaschromatographische Bestimmung (Hausmethode), KHL = Küvettestest LCK 303(Hach Lange), NT = Potentiometrische Titration nach Nordmann, oTS = EN 12879:2000, pH nach EN 12176:1998, TS = EN 12880:2000,

Legende: <0,03 = Analysenwert kleiner als die Bestimmungsgrenze, BS = Buttersäure, CS = Capronsäure, EC = Leitfähigkeit, ES = Essigsäure, FOS/TAC = FOS-TAC-Quotient, FOS = Flüchtige Organische Säuren, HAc-ÄQ = Essigsäureäquivalente berechnet aus den Konzentrationen der Gärnsäuren (ES bis CS), iBS = iso-Buttersäure, iVS = iso-Valeriansäure, k.A. = keine Angabe, NH<sub>4</sub><sup>+</sup>-N = Ammoniumstickstoff, oTS = organische

Trockenmasse, pH = pH-Wert, PS = Propionsäure, TAC = Pufferkapazität, TS = Trockenmasse, VS = Valeriansäure

Dieser Prüfbericht wurde elektronisch erstellt und ist daher ohne Unterschrift gültig.

erstellt durch: Christina Günther  
 BTA

# Types of laboratories 实验室类型

Type of laboratory	Remarks
Independent laboratories 独立实验室	<ul style="list-style-type: none"><li>• Receive samples from every customer从每个消费者手里获得样品</li><li>• Usually no contact to the „end“ customer because most of the samples come from biogas companies or consultants不与”终端“的消费者联系，因为大部分样品来自沼气公司和咨询方</li><li>• Routine analysis常规分析</li></ul>
Laboratories that are operated by biogas construction companies 沼气建设公司的实验室	<ul style="list-style-type: none"><li>• Usually restricted to customers who have bought a plant from the company通常只为从公司购买了沼气厂的客户服务</li><li>• Some companies offer process control for some time after the start up of plants在启动阶段后，一些公司有时会提供过程控制服务。</li><li>• Good way to keep in contact with the customer与消费者保持联系</li><li>• Plant specific analysis possible可能进行针对工厂的具体分析</li><li>• Reputation of the lab. Is related to the company实验室的声誉与公司有关。</li></ul>
Laboratories that are operated by biogas consultants 沼气顾问的实验室	<ul style="list-style-type: none"><li>• Usually restricted to customers who have bought a plant from the company通常只为从公司购买了沼气厂的客户服务</li><li>• Good way to keep in contact with the customer与消费者保持联系</li><li>• Plant specific analysis possible可能进行针对工厂的具体分析</li><li>• Reputation of the lab. Is related to the company实验室的声誉与公司有关</li></ul>

# Laboratory/On site analysis

## 实验室/现场分析

### Laboratory 实验室

- pH, EC
- VFA
- TIC
- DM, oDM
- Single component VFA
- Trace elements

### Operator 操作员

- pH, EC
- VFA
- TIC

# Experiences from Germany

## 德国的经验

- Samples can reach a laboratory within 24 hours. Samples are analysed within 48 hours to 10 days. 24小时内，样品送达实验室，48小时至10天内，样品分析完成。
- Concentration process. There are less and less laboratories. Reasons: 集中处理，实验室越来越少，这是因为
  - quality standards 质量标准
  - Pricing 价格
- Not all laboratories have all analysis. Especially small labs tend to subcontract other laboratories (VFA single components analysis, trace elements)
- 不是所有实验室可以分析所有指标。尤其小的实验室倾向于将样品分包给其他实验室（挥发性脂肪酸单组分分析，微量元素）

# Goal of the training

## 培训目标

- Learn how and where to take samples 学习怎样，在哪取样
- Learn what samples should be taken 学习应该取什么样品
- Learn which samples should be taken 学习应该取哪种样品
- Learn methods 学习方法