GIZ/FECC Operation & Maintenance (O&M) Pilot Training for biogas plant technicians

GIZ/FECC小型沼气厂技工运行维护 培训

Beijing 8th - 13th May 2012

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Topics 提纲

- **Introduction – A little about biogas in Denmark & Europe 介绍 – 关于丹麦和欧洲 的沼气厂的一些介绍**
- General O&M philosophy 运行维护理念
- Plant examples from Denmark 丹麦沼气厂示例
- General O&M principles 一般运行维护原则
- Health and Safety 健康安全
- Specific O&M issues 具体的运行维护事项

Introduction … General 介绍…概述

- ***The oil crisis in the 1970'es triggered interest in domestic energy resources, among other Biogas 二十世纪七十年代的石油危机促使人们关注国内能源，其中包括沼气***
- ***Interest has been reinforced by later concern regarding global warming (CO_2 neutral energy) 之后对于全球变暖（无CO_2排放能源）的担忧加强了这一关注***
- ***And for biogas, further reinforced by concerns about ground and surface water N pollution and a wish to utilize and recycle natural nutrients (including recycling of organic waste) 防止地表和地下水的氮污染以及利用自然肥料（包括回收有机废物）的 想法进一步强化了对沼气的关注***
- ***As a result the Danish ministries of Energy, Environment and Agriculture launched a development and demonstration program for biogas in 1985 因此，丹麦能源环境与农业部于1985年启动了沼气示范项目***
- ***Similar initiatives have been launched in other EU countries as well在欧洲其它国家也有类似的项目***

Introduction … Why Biogas
介绍…为什么选择沼气

- Sustainable and domestic energy production 可持续的内部能源
- Reduced Green House Gas (GHC) emission 降低温室气体（GHC）排放
- Recycling of nutrients (N, P, K etc.) 回收肥料（氮磷钾等）
- Reduce pollution of groundwater and marine environment 减少对地下水和海洋环境的污染
- Limit import of commercial fertilizer 控制商业化肥的进口
- Create rural activity and job opportunities 创造农村生产和工作机会
- Reduce odor nuisance of manure handling 减少粪便处理的臭味

Introduction … Biogas in Denmark
介绍 … 沼气在丹麦

- ***In Denmark focus has been to demonstrate the potential of large manure based Biogas plants:*** *丹麦重点一直在示范大型粪便沼气厂在以下方面的潜力*
  - ***as suppliers of renewable energy*** *作为可再生能源来源*
  - ***as a method for better utilization of manure as fertilizer and for a more flexible manure redistribution among farmers*** *作为更好的利用粪便作为肥料且更灵活的农民之间分配*
- ***The Danish programme has since led to the construction of approx. 20 centralized plants:*** *丹麦计划实施以来建设了约20座集中式沼气厂*
  - ***treating an annual amount of manure and other biomass of approx. 2.4 mill. tonnes per year*** *年处理粪便及其他有机质约240万吨*
  - ***producing biogas equivalent to approx. 65 mill. m^3 of methane per year*** *年生产约6,500万方甲烷相当的沼气*
- ***Large centralized manure based biogas plants is a speciality of Denmark due to:*** *大型集中式沼气厂是丹麦特有的*
  - ***intensive agricultural sector and high animal density*** *集中的农业和高动物密度*
  - ***good energy infra-sturcture (district heating in many towns, extensive natural grid for possible nation wide biogas distribution)*** *优良的能源基础设施（许多城镇都有区域供暖，覆盖全国的燃气管道）*

Introduction … Biogas in Denmark

介绍 … 沼气在丹麦

Biogas Plants in Denmark 丹麦的沼气厂

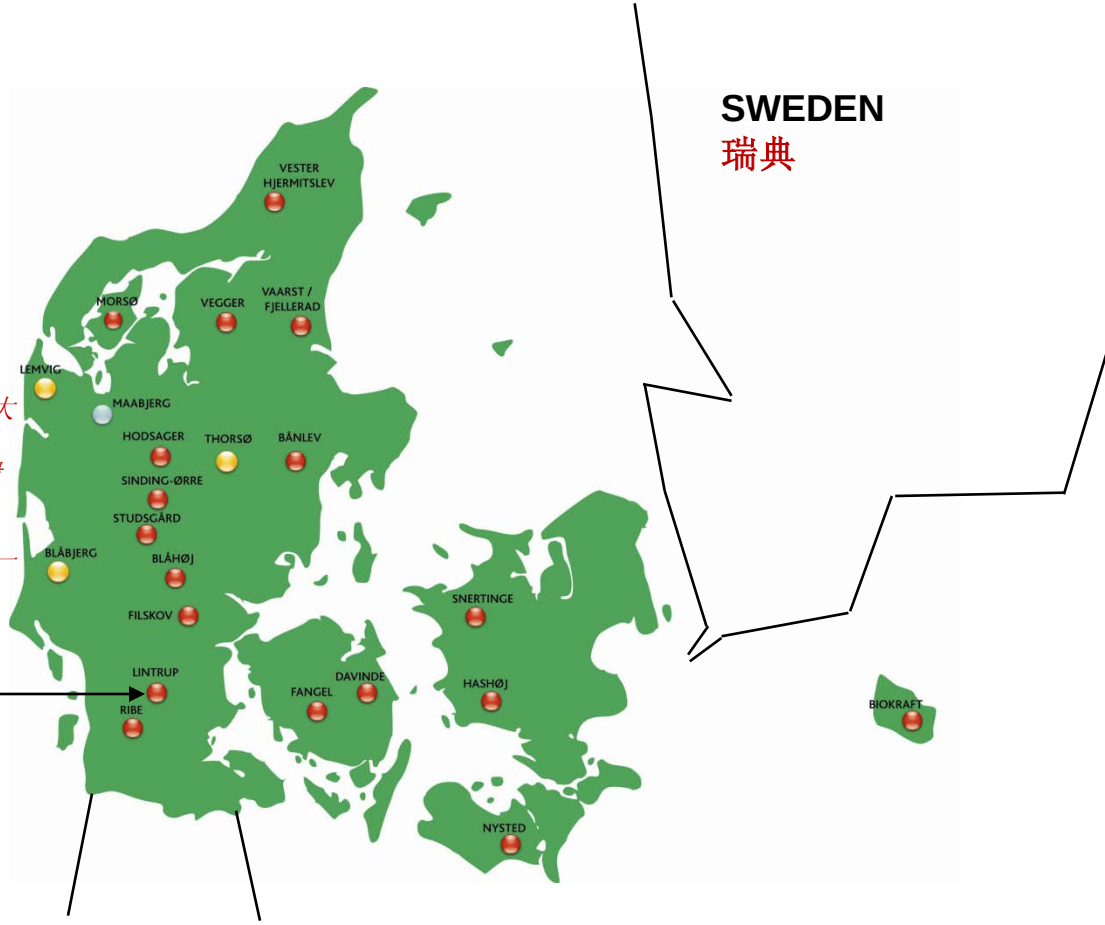
- **22 Centralized manure based plants**
  22个集中式粪污处理沼气厂
- **Total treatment cap.: 2.4 mill. t BM/y**
  总处理能力 240万吨生物质/年
  - **of wich manure: 2.0 mill. t / y)**
    其中粪便200万吨/年
- **BG prod. approx.: 95 mill. Nm³/y**
  沼气产生量约：9500方/年
- **Specific BG yield, all: 38 – 40 Nm³/t**
  单位沼气产量：38～40 方/吨

Note: Only centralized large scale biogas plants 只有集中式大型沼气厂

incl. Maabjerg (running in phase) 包括Maabjera（阶段运行）

In addition there are sewage sludge biogas plants and farm scale biogas plants 另外还有污泥沼气厂和牧场内小型沼气厂

LinkoGas Plant 沼气厂



Introduction … Future perspective

介绍 … 未来展望

- ***The potential amount of manure in Denmark (approx. 30 mill. tonnes per year) could support a large number of new plants, and a growth of this sector is foreseen in the Danish governmental energy planning policy*** *丹麦签字的粪便量（每年约3千万吨）可以支持建设大量新沼气厂，且可以预见丹麦政府能源规划政策里沼气领域的发展*
- ***Ultimately the vision is a fossil energy free Denmark by 2050, with biogas as one of the elements*** *最终丹麦到2050年不再使用化石能源，沼气是其中一个替代能源。*

HOWEVER *但是*

- ***Denmark is only a small country (~ 5 mill. people) with little global impact*** *丹麦只是一个小国家（约5百万人口），对全球影响很小*
- ***China is so much larger, with a significant biogas potential*** *中国要大得多，沼气生产潜力巨大*
- ***Today is an important day for our common globalized future*** *今天对于我们全球共同的未来是重要的一天*

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General O&M Philosophy 一般运行维护理念

- ***The core of a Biogas Plant is a biological process*** *沼气厂的核心是生物过程*
- ***Although the plant contain technical equipment and systems, it should in many respects better be viewed as a living organism*** *尽管沼气厂内有很多设备和系统，但在很多方面，它都更应该被看作活着的生物体*
- ***Living organisms depend on vital "life support systems" to function correctly and continuously*** *活着的生物体依靠"生命保障系统"来正常连续的运作*
- ***A Biogas Plant is NOT like a machine, which can be turned on and off*** *沼气厂不像机器，可以随时开关*
- ***To strive and perform optimal, "life support systems" must work at all times, and "living conditions" shall be kept stable and in harmony with process requirements*** *为了生存得更好，"生命保障系统"必须一直工作，"生活环境"要保持稳定并与工艺要求协调一致。*
- ***Proper biogas O&M is all about stability and harmony, well in line with old Chinese Confucianism principles.*** *合适的运行维护全都是关于稳定和和谐，与传统的中国 儒家思想一致。*

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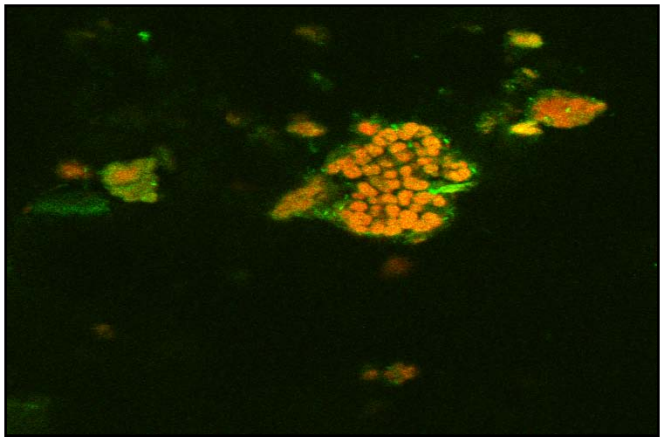
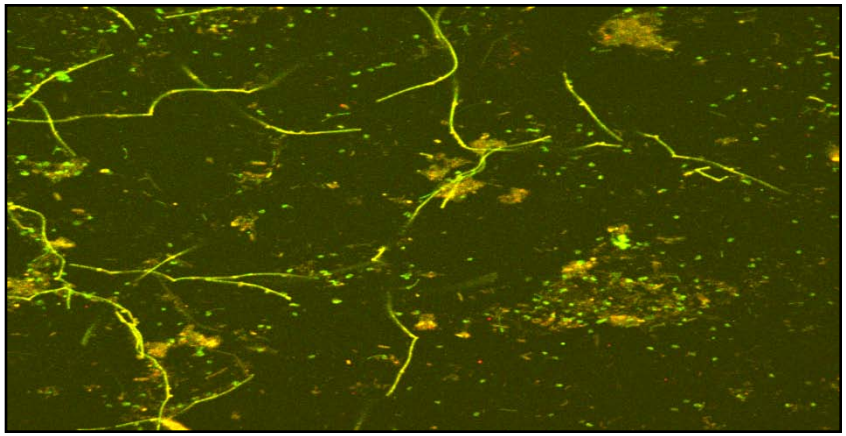
General O&M Philosophy 一般运行维护理念

- ***Like living organisms, Biogas Plants have individual character*** *就像生命体，沼气厂有自己的个性*
- ***The biomass input is never completely identical, and the mixture of micro-organisms are different as a result*** *发酵原料从来都不会完全一样，因此微生物的组成也不一样*
- ***On a technical level plants are also different, adapted to local conditions and evolving over time*** *沼气厂在技术层面上也都不一样，随当地条件和运行时间不同而不同。*
- ***General good practise O&M procedures can be defined, but also a "feeling" for the individual plants requirements is needed by the O&M staff.*** *一般来说可以设定好的运行维护程序，但对单个沼气厂来说，也需要运行维护人员的"感觉"。*



Methanosarcina
Vegger plant

Methanosaeta
Grindsted plant



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Plant examples from Denmark 丹麦沼气厂示例

LinkoGas Plant – Established 1990/91 and continuously evolving/expanded

LinkoGas 沼气厂，建于1990/91，之后不断改进扩建

LinkoGas Main data
LinkoGas的主要数据

Built 建设 : 1990/91

Owned by 45 farmers as a cooperative

由45个农民组成的合作社拥有

Biomass processing处理生物质:		300.000ton/year
Biogas production产生沼气	:	10 mill. Nm^3/year
Fermentor capacity发酵罐体积:		14.600 m^3
Process temperature发酵温度	:	52 °C (Thermophilic 高温)
Gas storage capacity储气罐容积:		5000 m^3
Utilization of Biogas沼气用途	:	CHP-generation
Electricity production发电量	:	20 mill. kWh / year + heat

More plant examples from Denmark

更多的丹麦沼气厂示例

LEMVIG BIOGAS PLANT (1991/92)
LEMVIG沼气厂（1991/92）

THORSØ BIOGAS PLANT (1993/94)
THORSØ 沼气厂(1993/94)

BLAABJERG BIOGAS PLANT (1995/96)
BLAABJERG 沼气厂 (1995/96)

All with similar elements – but individual character

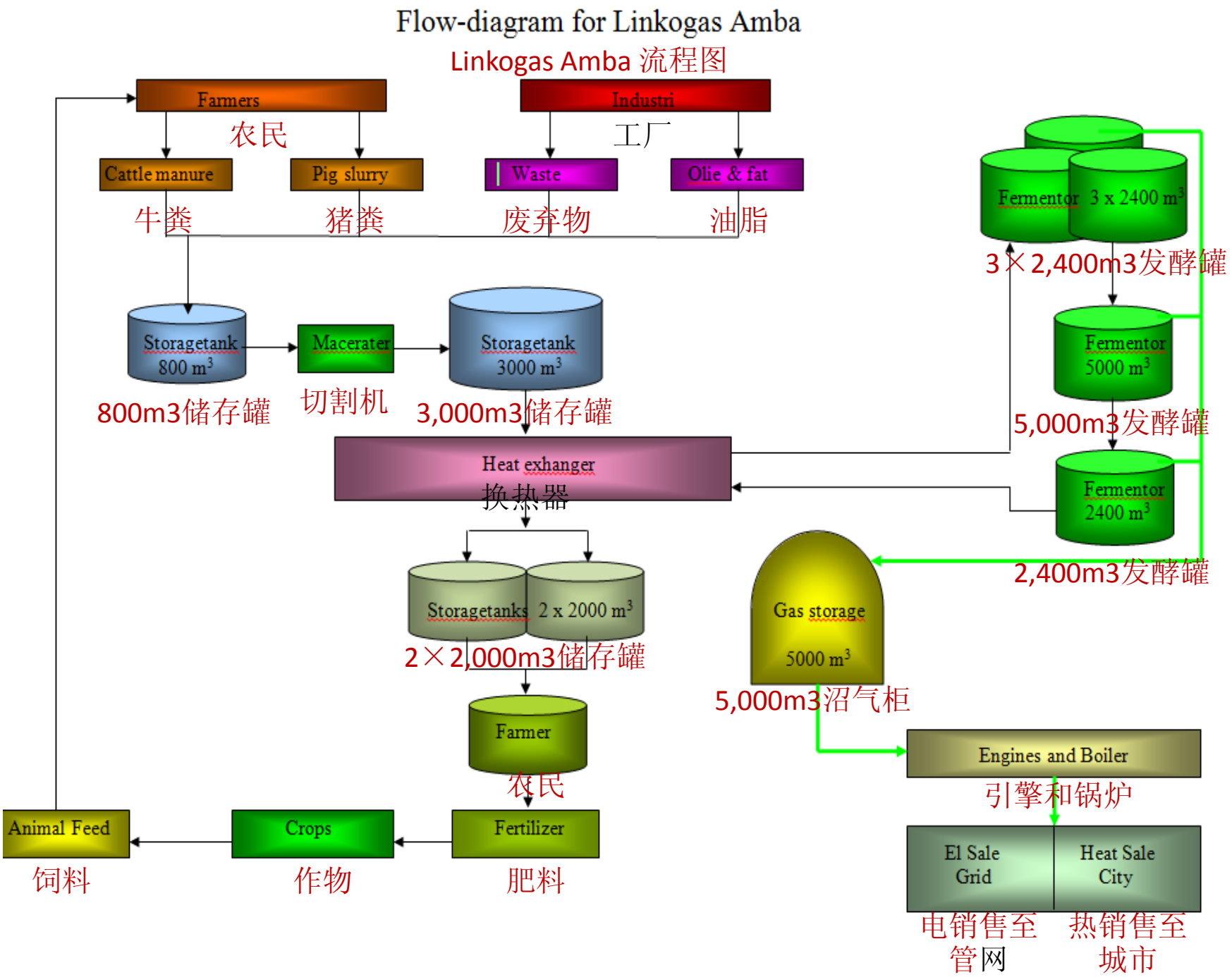
都有类似组成，但也各有特点

All plants “still going strong” and continuously evolving

都“运行很给力”并不断改进

Significant exchange of operational experience between plants O&M staff (publications, statistics, seminars etc.)

沼气厂的运行维护人员之间大量交换运行经


Flow-diagram for Linkogas Amba
Linkogas Amba 流程图
Farmers
农民
Industri
工厂
Cattle manure
牛粪
Pig slurry
猪粪
Waste
废弃物
Olie & fat
油脂
Fermentor 3 x 2400 m3
3×2,400m3发酵罐
Storagetank 800 m3
800m3储存罐
Macerater
切割机
Storagetank 3000 m3
3,000m3储存罐
Fermentor 5000 m3
5,000m3发酵罐
Heat exhanger
换热器
Fermentor 2400 m3
2,400m3发酵罐
Storagetanks 2 x 2000 m3
2×2,000m3储存罐
Gas storage 5000 m3
5,000m3沼气柜
Farmer
农民
Engines and Boiler
引擎和锅炉
Animal Feed
饲料
Crops
作物
Fertilizer
肥料
El Sale Grid
电销售至管网
Heat Sale City
热销售至城市

Note : Many similarities => Similar “good practise” O&M guide lines

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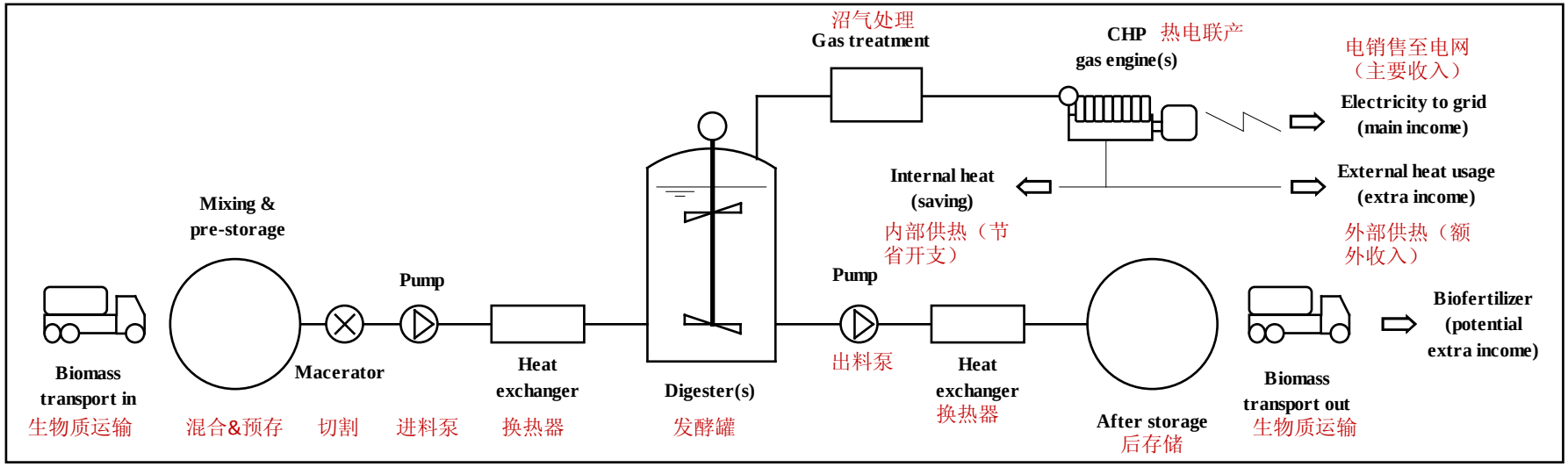
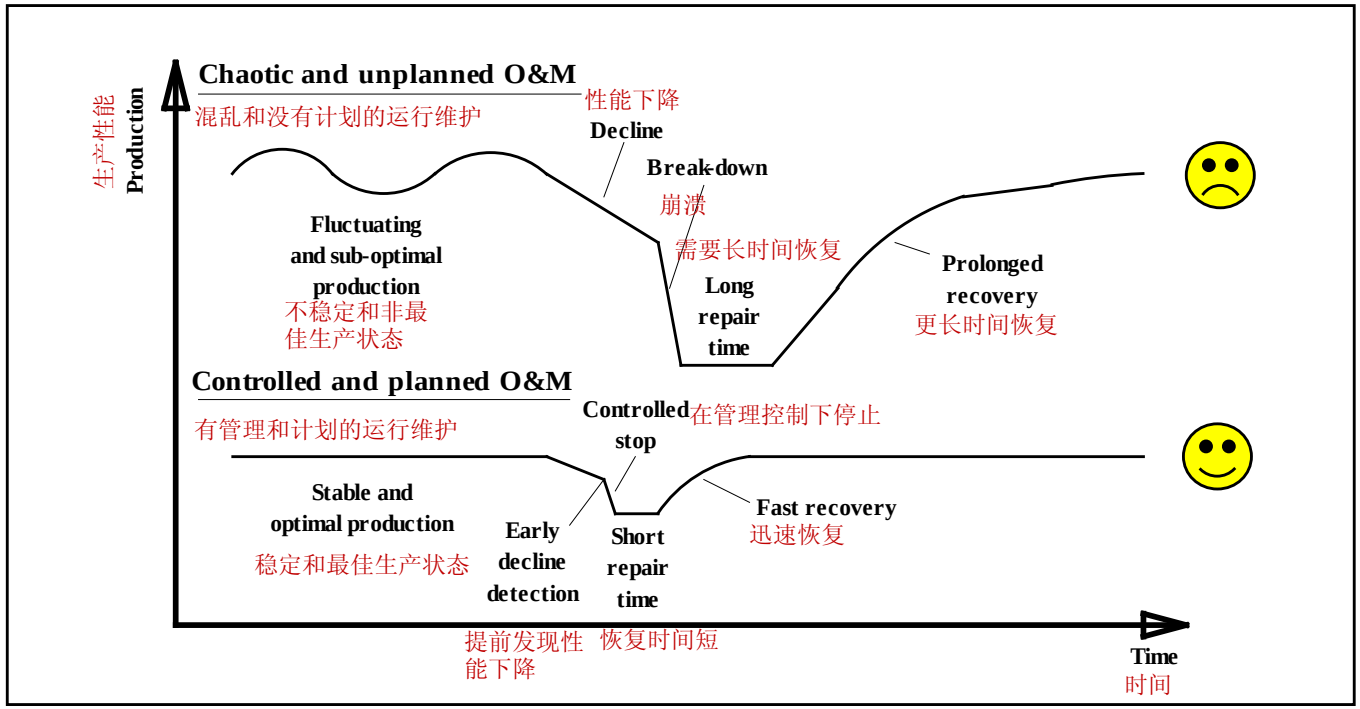
General O&M principles一般运行维护原则



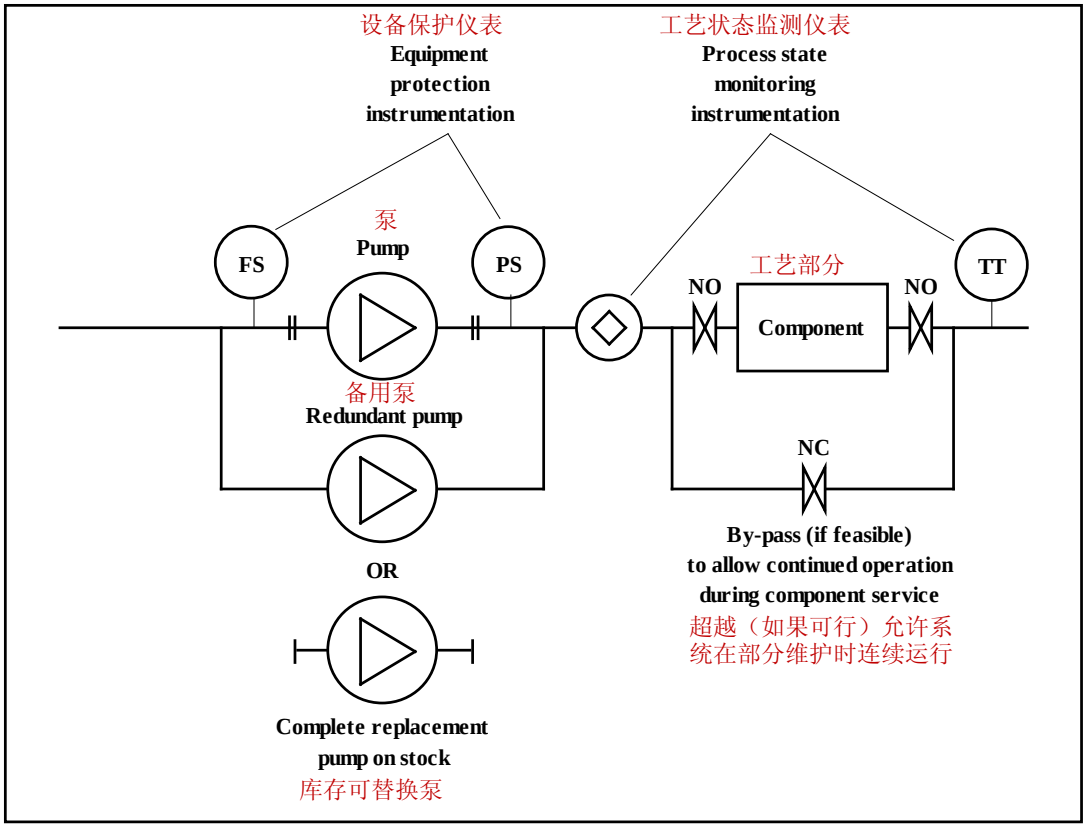
- Principal diagram showing vital biogas plant production steps 主要流程图显示了沼气厂生产的核心步骤
- It is a chain of steps, where each link can spoil production 各个步骤构成一个链，每一步都有可能损害整个沼气厂的生产
- All systems need to be cared for to maintain a stable and optimal production 整个系统都需要注意保持稳定和最佳的生产状态

General O&M principles一般运行维护原则



- Illustration of value of controlled operation and pro-active planned maintenance 表明了管理和积极有计划维护工作的价值
- Disturbances are minimized, resulting in more efficient production and better economy (and less panic) 干扰被最小化，运行就能更有效率，系统经济性更好（更少紧张）
- BUT : It may not be easy ! 但：这并不容易

General O&M principles … Design interaction
一般运行维护原则 … 与设计相关



Redundant pump installation
冗余泵系统

- Illustration showing Design – O&M interaction 表明了设计和运行维护的关系
- Proper equipment and system design is important for effective O&M work正确的设备和系统设计对于有效的运行维护至关重要

General O&M principles … Design interaction
一般运行维护原则 … 与设计相关

Design related O&M issues: 与设计相关的运行维护

- Suitable and sturdy equipment 合适且可靠的设备
- Automatic protection and safety instrumentation to avoid serious break downs 自动保护和安全仪表，以避免严重的事故损害
- Redundant installation on key functions, or quickly replaceable complete components on stock重要功能部分的冗余设计，或者仓库备有可迅速替换的部件
  - Operation quickly restored 运行迅速恢复
  - Proper service off-line 合适的线下维护
- Shut off possibilities and easy access where relevant 可以关闭并必要时可以进入
- Drain and flushing connections where service is foreseen 需要维护的地方备有排水和清洗接口
- Process indication instruments and logging to be able to follow equipment state and trends, in order to react in time 工艺显示仪表和数据记录，可以跟踪设备的状态和趋势，从而可以及时响应

General O&M principles … Spare part management
一般运行维护原则 … 备件管理

- Keep ***Strategical pare parts*** and ***Wear parts*** on stock 库存保有**战略备件**和**耗件**
  - Strategical spare parts : Parts which can be foreseen to be needed to keep vital functions running and/or parts with long delivery time 战略备件：可以预见到的保持关键工艺运行所需的和/或供货时间厂的备件
  - Wear parts : Parts which can be foreseen to wear out periodically, to be able to schedule service without need to wait for parts 耗件：可以预见到需要定期更换的部件，可以按计划维护而不需等待
- Update relevant spare and wear parts to have on stock according to experience 更新相关的备件和耗件，根据经验保留库存
- Remember to replenish stock as soon as spare parts are used 记得备件使用之后立即补充
- Consider to refurbish replaced equipment to keep as emergency spare units 考虑重新修复替换下来的设备作为紧急备件

General O&M principles ... Spare part storage facility
一般运行维护原则 … 备件仓库

- Keep storage facility Dry, Clean and Ventilated. 保持备件仓库干燥、干净并通风良好
- Keep spare parts organized so you know where to find the parts for different equipment. 保持备件存放条理，这样可以知道在哪里找到不同设备的部件
- Keep parts according to manufacturers recommendation. 根据制造商推荐储存备件
- Upon receiving of parts: Check that it is the right parts and quantity. 收到备件时：检查型号和数量是否正确
- Put them in place. 备件应随时可以取出使用
- Spare parts are normally preserved for shipment and storage when delivered, so keep in original packing. 备件通常在供货时储存于可运输包装，可保留在原始包装内

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General O&M principles … Health and safety
一般运行维护原则 … 健康安全

Don't forget Health & Safety: 别忘了健康安全

- Use proper work clothe and safety equipment according to work: 根据工作岗位使用合适的工作服和安全设备
  - Safety shoes (general when handling heavy equipment) 安全鞋（通常当操作重量大的设备时）
  - Helmet (general when venturing outside general access areas) 头盔（通常在公共区域以外）
  - Gloves (when in contact with biomass etc.)手套（当接触生物质时）
  - Safety goggles (when risk of sparks etc.) 护目镜（当有火花等）
  - Ear defenders (in noisy areas, >85 dB(A)) 护耳器（噪声大区域, >85 dB(A)）
  - Personal gas and EX alarm when in risky areas where explosive gas or poisonous gas (H_2S) may occur 个人气体和防爆报警（当位于可能有爆炸性气体和有毒气体(H_2S)的危险区域）
- Use the proper tool for each task (it is not only safer, but also more efficient) 每项工作使用正确的工具（不仅更安全，而且更有效率）
- A "Work Permit" procedure is recommended to ensure all know what is going on and when 建议采用许可证制度，确保都知道何时在发生什么事情
- Always ensure local service breaker is switched off and locked or blocked on electrical equipment before service 在电气设备维护时，始终确保现场开关是关闭并锁死的
- Shut off, drain and vent work area/equipment to be serviced 维护关闭，排水和排气区域和设备
- Clean up work area after job is done 工作完成后清洁工作区域

General O&M principles … Health and safety
一般运行维护原则 … 健康安全

Special Health & Safety issues related to Biogas Plants: 特别针对沼气厂的特殊健康安全事项

- Be aware that biomass contain millions of microorganisms, some of which may be unhealthy to humans: 注意生物质包含成百上千万微生物，其中一些可能对人体健康有害
  - Avoid direct contact with biomass (gloves etc.) 避免直接接触生物质（手套等）
  - Frequently wash hands and take bath after dirty work 经常洗手，从事不卫生工作后洗澡
  - Keep work clothe clean (and separate from private clothe) 保持工作服清洁（和私人衣服分开）
  - Keep plant clean 保持工厂清洁
  - Vaccination against Tetanus is recommend for plant staff 操作人员建议打破伤风疫苗

General O&M principles … Health and safety
一般运行维护原则 … 健康安全

Special Health & Safety issues related to Biogas Plants:特别针对沼气厂的特殊健康安全事项

- Be aware of explosion risk where biogas may leak and mix with air: 了解沼气可能泄漏并与空气混合区域的爆炸危险
  - Periodically check for leaks, and in particular if smelling gas 定期检查泄漏，特别是有异味的气体
  - Ventilate areas with gas equipment 有沼气设备的房间内保持通风
  - Never work on operational gas systems 绝不在运行的沼气系统上工作
  - Isolate and vent work area before initiating work 开始工作之前隔离工作区域并通风
  - Avoid spark igniting tools on gas systems避免在沼气系统使用产生火花等工具
  - Work permit mandatory on gas systems 沼气系统强制采用许可证系统
- Be aware that H_2S is a very poisonous gas 注意H_2S是毒性非常强的气体
  - It smells like rotten eggs, but if concentration is high you can't smell it any longer and is in danger being of poisoned without sensing it 闻起来有臭鸡蛋味道，但浓度高时闻不到，可能在没有感觉到时就有中毒危险
  - If You smell "rotten eggs" be alert. 如果闻到臭鸡蛋味道，要保持警惕
  - If smell suddenly "disappear", get away immediately to fresh air area 如果味道突然消失，立即离开到有新鲜空气的区域

Topics 提纲

- Introduction – A little about biogas in Denmark & Europe 介绍 – 关于丹麦和欧洲 的沼气厂的一些介绍
- General O&M philosophy 运行维护理念
- Plant examples from Denmark 丹麦沼气厂示例
- General O&M principles 一般运行维护原则
- Health and Safety 健康安全
- **Specific O&M issues 具体的运行维护事项**

O&M equipment specifics ... pumps

设备运行维护...泵

Note :

Special centrifugal pumps may be suitable for high flow/low pressure Transfer

须知：

特殊的离心水泵可能适用于大流量/低水头输送

Typical eccentric worm (positive displ. pump) for biomass pumping (low flow/high pressure) 典型的用于生物质泵送（小流量/大水头）的偏心螺杆泵（容积式泵）

O&M equipment specifics … pumps
运行维护设备…泵

- Generally select relatively large pumps compared to flow requirement根据流量要求选择相对较大的水泵:
  - Larger pumps are less prone to clocking and more tolerant reg. hard foreign items较大的水泵不容易堵塞，不受坚硬异物影响
  - Pump speed is lower (for a given flow) with reduced wear rates 水泵转速较小（在流速不变情况下），磨损率较低
  - Usually give longer service intervals (fewer operational interruptions) 通常维护间隔时间更长（ 少一些运行中断）
- Avoid suction vacuum if at all possible如果可能尽量避免空吸
- All through hardened rotor (tool steel) when abrasive wear is severe 当磨料磨损严重时使用硬化的转子（工具钢）
- Proper protection against excessive pump pressure (pressostats) 适当保护防止过高的泵压（稳压器）
- Avoid dry running by level switch or (more reliable) thermal flow sensor/switch 用液位开关避免干运行或（更可靠的）热式流量传感器/开关
- Flow measurement compared to pump speed is useful to determine wear condition. When flow reduces relative to speed, pump is worn and may deteriorate fast 对比流速和泵速以判断磨损情况。当流速相对于泵速减小，就说明水泵已经用磨损并且损耗很快。

O&M equipment specifics ... other pumps

设备运行和维护...其它泵

Centrifugal pump.
High flow transfer with low pressure demand.
离心泵
高流量低水头

Rotor pump.
Medium to high flow with Moderate pressure demand.
转子泵
中到高流量/中等压力要求。

O&M equipment specifics … pump utilities

设备运行和维护…泵

Liquid flow meters
液体流量计

- Typical electromagnetic type flow meter shown below
  如下图典型的电磁流量计
- Useful to check pump condition, but also for process control purposes (to know how much is pumped)
  用于检查泵情况，同时也用于过程控制（了解已抽到多少物料）

Variable Frequency Drives (VFD)
变频驱动

- Example shown above如上图
- Useful to maintain stability when demand varies (compared to on/off operation)用于在需要变化流速时（相对于开和关）保持稳定性
- Saves energy in many applications
  在很多情况下能节省能耗
- May extend useful lifetime of components可以延长零部件使用寿命

O&M equipment specifics ... Heat exchangers

设备运行和维护...换热器

Note :

Various other biomass heat exchangers are also in use

须知：

其它各种生物质换热器也都有使用。

Typical spiral heat exchanger for direct digested biomass to fresh biomass heat recovery.

典型的螺旋式换热器，用于沼液直接给新生物质供热。

O&M equipm. specifics ... heat exch.
设备运行和维护...换热器

- Biomass heat exchanging can dramatically lower own energy consumption, typically 60-80% 生物质换热能大幅降低自身能量消耗，通常在60%-80%
- Very important when heat can be sold or utilized elsewhere
  当热量能够在其他地方出售或利用时非常重要的
- However, biomass heat exchangers are expensive, also to operate and must be selected carefully according to need/value
  然而生物质换热费用高，而且还需要根据需求和价值进行谨慎的选择
- When heat exchangers are employed macerating become extra important (less clocking, better heat transfer)
  当采用换热器时，切割变得特别重要（更少的堵塞，更好的换热）
- For P-rich biomasses Struvite scaling on digested side shall be expected
  对富含磷的生物质在沼液一侧很容易形成鸟粪石结垢
- Struvite can be dissolved/flushed out by weak acid, eg. Chloric Acid (however, beware of acid strength and exchanger material)
  鸟粪石可以在弱酸下溶解/消散，如盐酸（然而要注意酸的强度和换热器的材料）
- Possibility to open up and manually clean heat exchanger is valuable in case of blocking 保留打开换热器进行手动清理的可能性，在发生堵塞是很重要

O&M equipment specifics … Macerator

设备运行和维护…切割机

Note :

Other installation configurations also in use

须知：

其他规格也有使用

Typical macerator on biomass feed line (before heat exhanging)

在生物质进料管线上的典型切割机（在换热前）

O&M equipm. specifics … Macerator
设备运行和维护…切割机

- Macerating fresh biomass is useful to avoid problems elsewhere in the plant 切割新鲜的生物质有利于避免在沼气厂的其它地方产生问题
- However, the macerator itself then become a high wear important piece of equipment, requiring special attention 然后切割机本身也因此变成一种高磨损的重要设备，需要特别注意。
- Easy service access to internals is therefore important, as are relatively cheap spare parts
  因此方便地进入设备内部维护是很重要的，因为备件相对便宜
- Installation to avoid heavy objects entering the cutting part, either by pre-sedimentation in tanks and/or stone trap on suction line 通过设置预沉淀池和/或在进料口设置石块过滤等预处理，避免让大物体进入到切割部分。
- Keep (plenty) of spare parts on stock, and order new as soon as used 库存（足够的）备件，一旦有使用立即订购新备件
- A complete replacement drive unit on stock or redundant installation is recommendable to minimize shut downs 建议备用完整的可替换驱动单元或备用设备可最小化降低故障导致系统停机的概率
- The Vogelsang type of macerator (as shown on picture) dominates in Denmark now现在在丹麦主要使用Vogelsang切割机（如图）。

O&M equipment specifics … Gas Engines

设备运行和维护…沼气引擎

Note :

Similar Jenbacher units also common

须知：

类似的Jenbacher设备也很普遍。

Typical gas engine installation for biogas utilization
CHP with heat for district heating or plant own consumption

典型的沼气引擎以利用沼气。
热电联产单元为集中供暖和沼气厂自身供热。

O&M equipm. specifics … Gas Engines
设备运行和维护…沼气引擎

- Usually sale of electricity is the main income for a biogas plant 通常电的销售是一个沼气厂的主要收入。
- Selecting modern high efficiency, turbo charged gas engines are therefore important, rather than elder and cheaper lower efficiency gas engines 因此选择现代的高效率的，涡旋增压的沼气引擎而不是过时的相对低效的气体引擎是很重要的
- For example : 42 % electrical efficiency compared to 35% efficiency mean 20% higher income ! 比方说：42%相对于35%的电力效率意味着20%更高的收入。
- Large units are preferred due to efficiency and operating cost 由于效率和运行成本，大设备比较受人喜欢。
- However, minimum 2 or n+1 units are preferred for reliability reasons 然而，考虑到可靠性，最低2台或者N+1台更受人欢迎。
- Full load operation is more economical than part load operation (efficiency and specific service cost). Therefore consider on/off full load operation with heat storage if needed 满负荷运行比部分负荷运行更经济（效率和单位维护费用），因此必要时采用热储罐，发电机采用开/关满负荷运行
- Watch lubr. oil quality and secure low H_2S level in biogas 观察润滑油质量并确保低H_2S浓度
- Monitor good engine operation, including kWh produced relative to gas consumption to determine when service is needed. 监测引擎运转，包括相对于沼气消耗量的发电量，以确定何时需要维护
- Consider to perform routine service, such as spark plug replacement yourselves, but leave major service to experts考虑日常维护，比如自行更换火花塞，但主要的维护交给专业人员。
- High efficiency lean burn spark ignited (Otto) engines dominate in Denmark, needing no pilot oil. Dual-fuel capability is not considered necessary. Reliability is high and pure oil operation too expensive. Better have a biogas fired back up hot water boiler for emergencies. 丹麦主要使用火花点燃高效稀薄燃烧（奥托）引擎，不需要预燃燃油。双燃料系统并不需要。需要高可靠性。靠燃油来运行太贵，最好有一个沼气热水锅炉可用于紧急情况

O&M equipment specifics … Gas cleaning

设备运行维护… 沼气净化

Note 须知:

After early 1990'es experimentation with various H_2S reduction techniques, biological H_2S reduction has become the standard. 在1990年代以后实验了各种去除H_2S的技术，生物脱硫成为了标准技术。

Biogas cooling and condensate Removal equipm.

沼气冷却和冷凝水去除设备

Typical biological H_2S reduction reactor and other treatment equipment 典型的生物脱硫反应器和其他处理设备

O&M equipm. specifics … Gas Cleaning
设备运行维护… 沼气净化

- H_2S content from pure manure can easily reach 2000 ppm, or even higher if also utilizing (Sulfur) rich organic waste 纯粪便产生的沼气H_2S浓度很容易达到2000 ppm，如果采用含硫量高的底物，其浓度会更高
- A low H_2S content is very important for good engine performance, the lower the better. H_2S浓度对引擎的运行很重要， H_2S浓度越低越好。
- H_2S is also poisonous with a very strong odour. H_2S有臭味且有毒
- Biological reduction is very simple, but: 生物脱硫很简单，但：
  - Seed the process with some rotten or digested organic material to provide the necessary S reducing bacteria采用腐烂或者已经消化的有机物接种，提供必要的脱硫细菌
  - Secure a relatively stable temperature in the range 30-40 ºC 确保在30-40 ºC 之间内一个稳定的温度
  - Dose enough, but not too much air, by monitoring performance periodically (H_2S inlet, O_2 excess etc.)通过定期监测性能（入口H_2S，出口氧气等），加入足够但不过量的空气。
  - Maintain sump pH above approx. 6. Process tend to run sour by oxidised products. Use neutralization agent if necessary (biogas condensate, screened digested manure or commercial alkaline products) 保持反应器内pH值大于6. 反应氧化H_2S呈酸性，必要时加入中和药剂（沼气冷凝液，过滤后的消化粪便或者商品碱）
  - Keep filling moist by showering and add NPK nutrients periodically 通过喷淋保持湿度，定期添加NPK
  - Avoid un-necessary fouling and watch pressure drop to determine when to clean/wash filling 避免不必要的结垢，观察压力损失以确定何时清洁/冲洗填料
  - Easy access to filling is recommendable for extraction and manual cleaning if necessary 建议设计时便于取出填料，手动清洁。

O&M equipment specifics … Digesters
设备运行维护… 发酵罐

Note须知:
Many sizes up to 8000 m^3 in use. 许多容积达到800m3的发酵罐在使用
Tanks are either welded on site (as these) or of prefabricated bolted type
发酵罐要么是现场焊接（如图），要么是工厂预制，现场螺栓固定

Typical digesters at LinkoGas : 2400 m^3 low type (foreground) 5000 m^3 high type (background) 典型的发酵罐（LinkoGas）：2400m^3 低型（前）5000m^3高型（后）

O&M equipm. specifics … Digesters
设备运行维护… 发酵罐

- Simple, proven and sturdy design is essential 关键是采用简单、可靠且牢固的设计
- This is the “heart” of the process, and any disturbance is costly 是工艺的“心脏”，任何干扰都很昂贵
- Sufficient, reliable and maintenance free mixing is very important (see mixer slide later) 充分、可靠且免维护的搅拌非常重要（见后续的搅拌器部分）
- Ensure possibility to observe liquid surface through sight glasses, to catch floating layer in time (in can be very problematic to discover a massive floating level too late) 确保可以通过观察窗看到液体表面，以及时去除浮渣层（如果发现得太晚可能会有大问题）
- Periodic removal of a batch from the bottom area is useful to limit sediment accumulation (but also to ensure sedimentation in pre-storages, where access is easier). 定期从底部排出一部分淤泥以避免沉积（还需确保淤泥在便于清理的预储存池中沉积）
- Proper insulation is very important to be able to maintain a stable process temperature. 合适的隔热对于保持温度非常重要
- Necessary heating capacity likewise, either internal, external or both. 必要的加热能力，可以是内部和/或外部换热器

Sight glass to be able inspect surface is important.

可以通过观察窗看到液体表面很重要

Otherwise floating layer may accumulate undetected.

否则浮渣层可能在没有注意到的时候沉积

O&M equipment specifics … Mixers

设备运行维护 … 搅拌器

Note须知:

Early plants were with submerged mixers, but service and production interruption were problematic. 早期沼气厂采用潜流搅拌器，但其维护和对生产的影响产生问题

Now sturdy top mounted mixers prevail in digesters. 现在可靠的顶部安装搅拌器是主流

Special features of the type shown这种搅拌器的特殊在于:

- Feeder screw to suppress floating layer 进料螺旋能抑制浮渣层的形成
- Rotating water lock shaft seal without wear parts 全密封防水转轴，无需耗件

Typical top mounted digester mixer

典型的顶式安装发酵罐搅拌器

O&M equipment specifics … Mixers

设备运行维护 … 搅拌器

Note 须知:

Heavy duty submerged mixers still common for pre- and after storage slurry tanks. 发酵罐前后储存罐内使用大功率潜水搅拌器还很普遍。

Wear is significant, requiring periodic maintenance and/or replacement. 磨损很严重，需要定期的维护和/或更换

Shaft seal leak detection and ampere monitoring is recommendable to avoid serious break down or loss of impeller. 建议安装轴密封泄漏检测和电流监测 以避免严重的损坏和叶轮磨损。

Typical submerged type storage tank mixer

典型的潜水搅拌器

O&M equipment specifics … CHP generation
设备运行维护 … CHP热回收

Note须知:
Approx. 20% waste heat directly available from engine cooling circuits, but additionally app. 20% from exhaust gas. 约20%的废热可以直接从引擎的冷却系统中获得，但还能从尾气中获得额外约20%的热量
If relevant also steam can be generated from exh. gas. 必要时还可以利用烟气余热生产蒸汽

Typical gas engine exhaust gas heat exchanger for CHP heat production. 典型的用于CHP产热的沼气引擎烟气热交换器

O&M equipm. specifics … CHP
设备运行维护 … CHP

- Be aware that gas engine exhaust gasses are potentially corrosive due to residual H_2S content in biogas (unlike operation on natural gas). 注意由于沼气内含有H_2S，引擎的烟气可能是腐蚀性的（与天然气引擎不同）
- Avoid material temperatures on exhaust gas side below approx. 130-140 °C by not cooling too far and by keeping water side at elevated temperature. 保持冷却水的温度，不要将烟气过分冷却以避免烟气侧的温度下降到低于约130-140 °C 。
- If cooling below 160-180 °C consider a separate corrosion resistant LT section. 如果冷却温度低于160-180 °C ，考虑单独的防腐低温段

THANK YOU
FOR YOUR TIME
AND YOUR ATTENTION

谢谢您的时间和精力

Questions are welcome

欢迎提问