How to plan and build a biogas plant?

Sibiu 18.03.2009: How to plan and build a biogas plant?

Content

- Introduction: Evonik New Energies GmbH
- Motivation
  - German Biogas history
  - Sensibility
- Steps of Project Design Process
- Planning Process
  - Legal pre- conditions
  - Economical optimisation
- Biogas Technology
  - Principles for the technological choice: input materials
  - Continuous versus non- continual processes
  - Comparison: dry and wet digestion
  - Process parameters
  - Operation criteria
  - Biogas utilisation Cogeneration
  - Separation
  - Site Necessities

Motivation

- German History with biogas:
  - from small agricultural plants to big industrial sites: step by step
  - from handmade to industrially manufactured components
  - many cost-expensive failures were made

  => use the experiences through know-how exchange

- technology with high automation level but not self-running

  => identification with the plant is crucial

=> Sensibility for the decisive technological aspects to check

Steps of Project Design Process

- Basics:
  - Legal frame conditions define the general utilisation of input materials
  - Gains or costs for the input materials are determined by the legal conditions and technical effort for them
  - Substance prices and further treatment costs have a major influence on the economical affordability

  => the input materials are decisive for the technology
- Decision on an appropriate biogas technology type after feasibility study with economical preview
- Detailed engineering
- Final layout after optimisation of design (depending on contracts closed)

Planning Process

- Clarification of the legal frame conditions
  - EU regulation
  - State law e.g. catalogue of allowed input materials or fermentation residues handling
  - Human security necessities
  - Ensure the so-called "good technical practise"
  - Technical necessities from grid operator

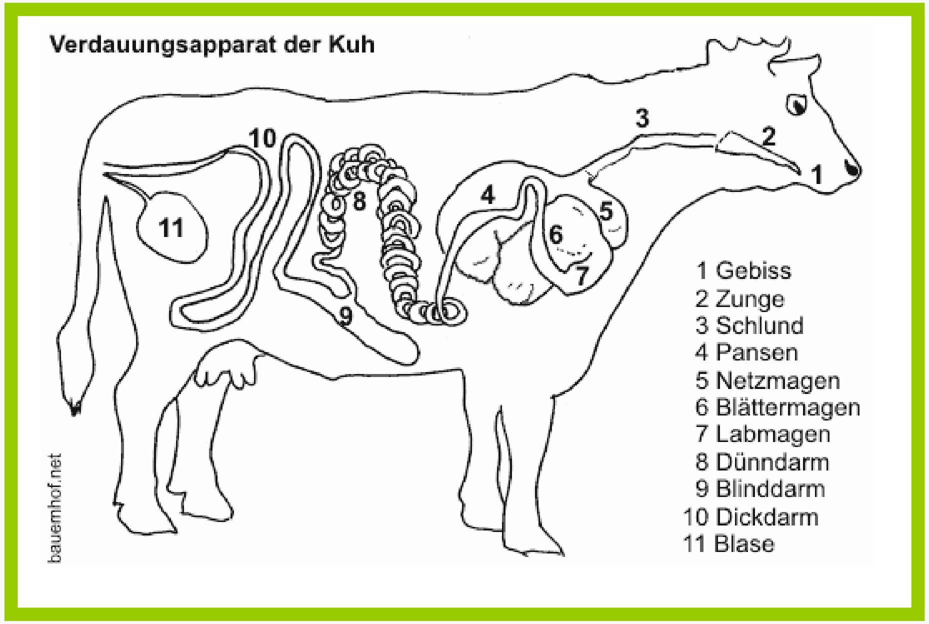
Planning Process

- **Economical optimisation**

- Input materials: contractual definition of quantity and (gas) quality as well as punishment costs
- Delivery construction: small/ big vehicles or sampling systems => consequences for technical solution
- Distance to the next grid connection (gas, electricity)
- Distance to heat consumers
- Type and volume of heat use: Vapour, hot water => choice of cogeneration units
- Enough area for storage of input and output materials on agricultural sites: Fertiliser demand on acres
- Biogas site: transport access, water, distance to sensible neighbours (emissions/ administrative objection?)
- Funds, CO2 certificates
- Waste management: conditions for recycling and non-recyclable substances

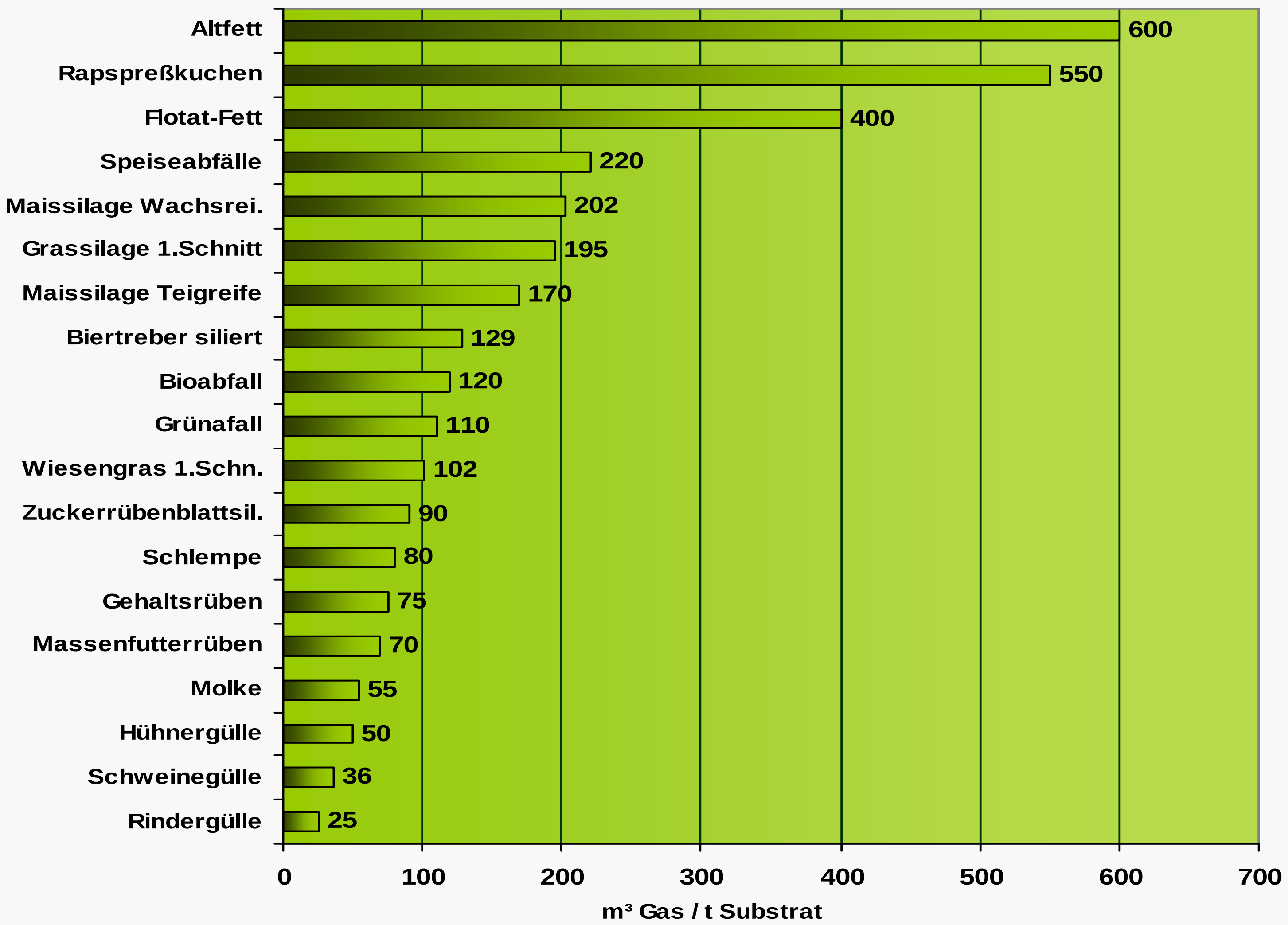
Ensure biogas basics

- Our main workers are bacteria: ensure their wealth!



The bacteria are the same as in the fermentation apparatus inside a cow => liquid manure is favourite.

Biogas production from input materials



Choice of input materials

- Organic substances produce differing biogas qualities: cf. wheat for eating and biogas

Type	CH_4	CO_2	NH_4	H_2S
Carbon hydrates	50 %	50 %	0 %	0 %
Grease	71 %	29%	0 %	0 %
Proteins	38 %	38 %	18 %	6 %

Final output: fertiliser liquid and solid

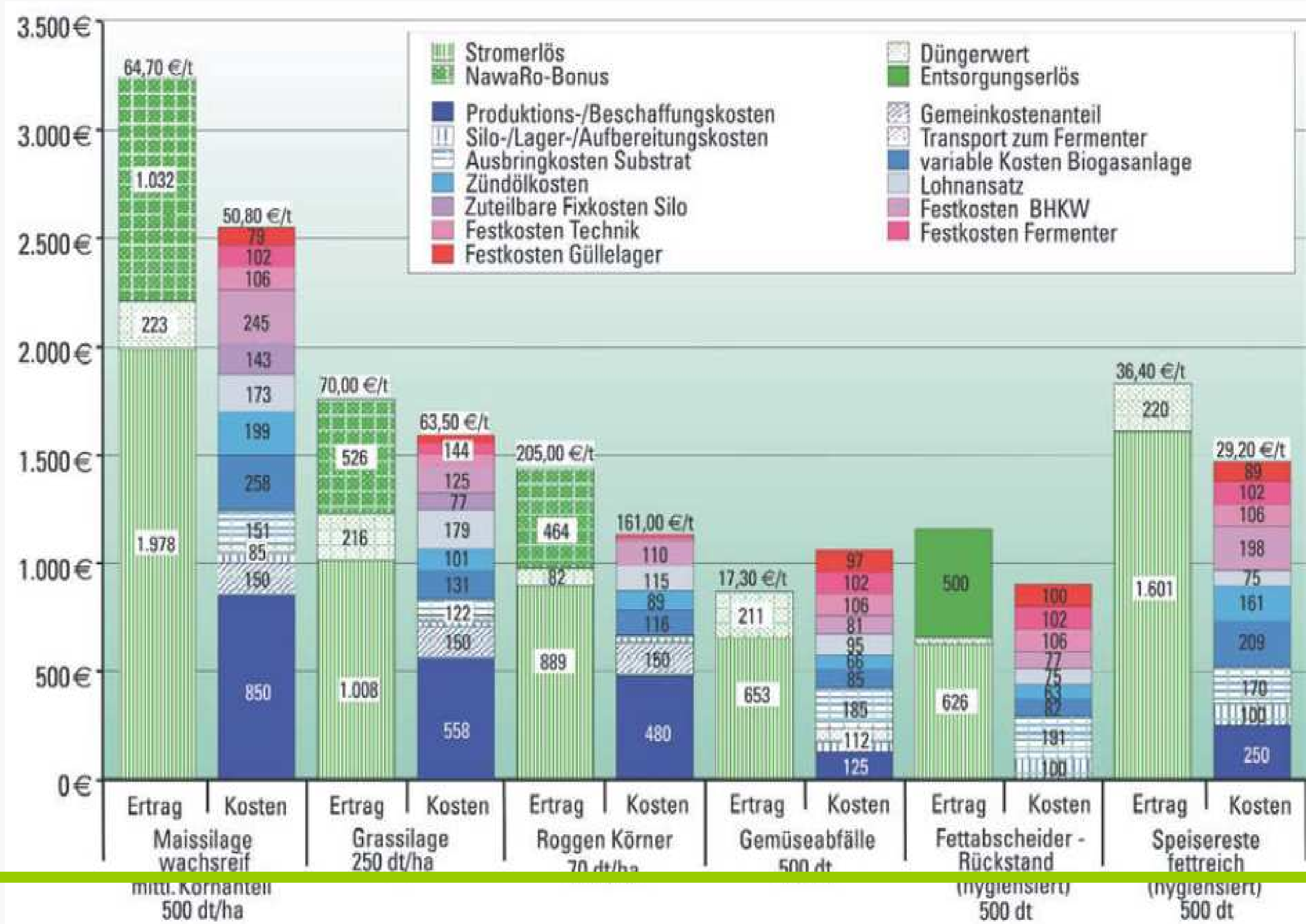
	TS in %	Total substances			Solved substances		
		N total % in TS	P_2O_5 % in TS	K2O % in TS	$(NO_3$-N) mg/l	K_2O mg/l	NH_4N mg/l
Fertiliser before separation	3,50	19,64	5,09	5,11	≤ 0,035 mg/100g	1664	5040
Solid fertiliser	28,00	3,36	4,09	078	≤ 0,035 mg/100g	748	810
Liquid fertiliser	3,25	21,16	3,2	5,13	0,68	1568	4290


Separation

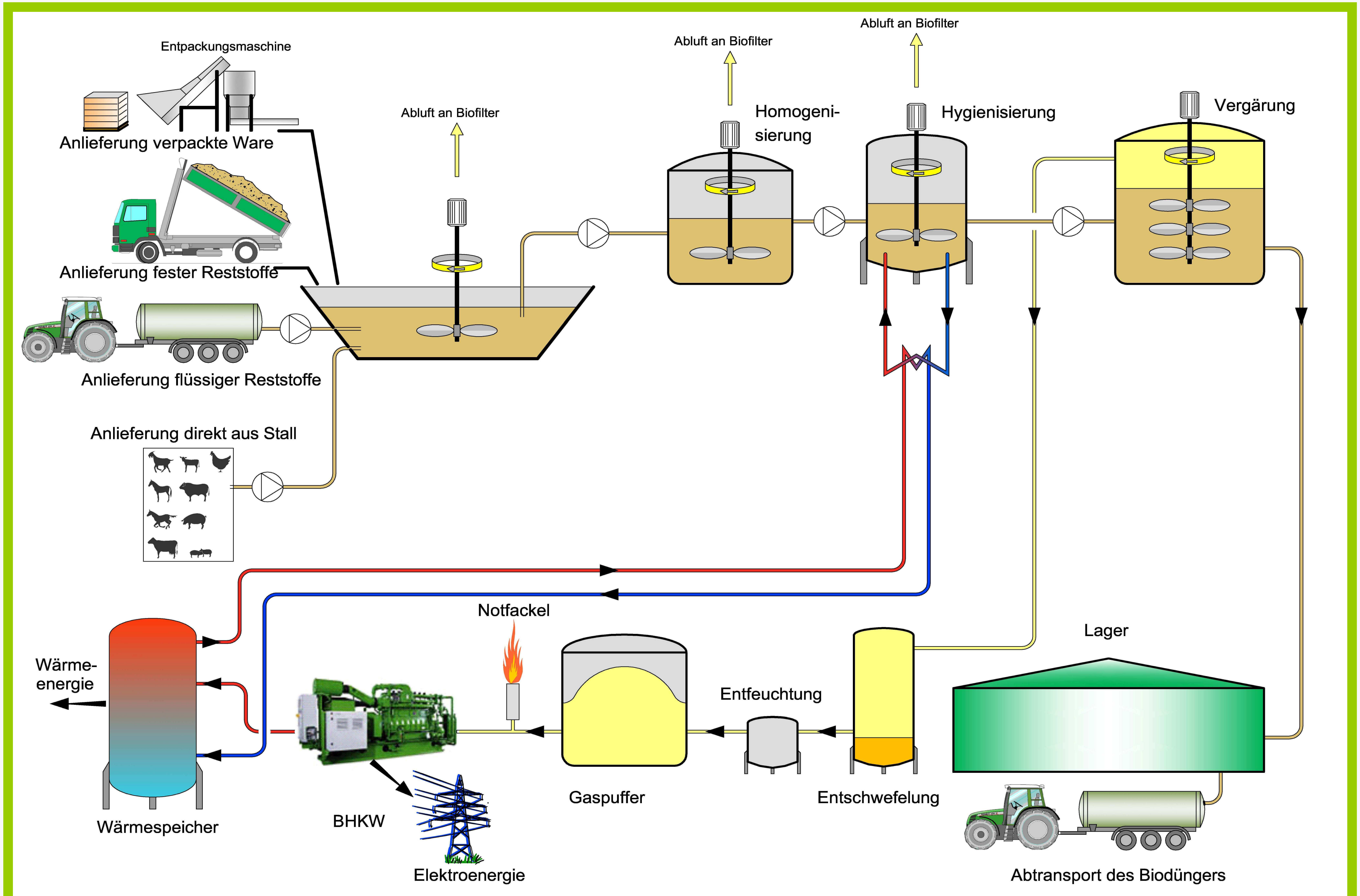

liquid fertiliser in lagoon


solid fertiliser in container

Calculation of costs and gains (example)

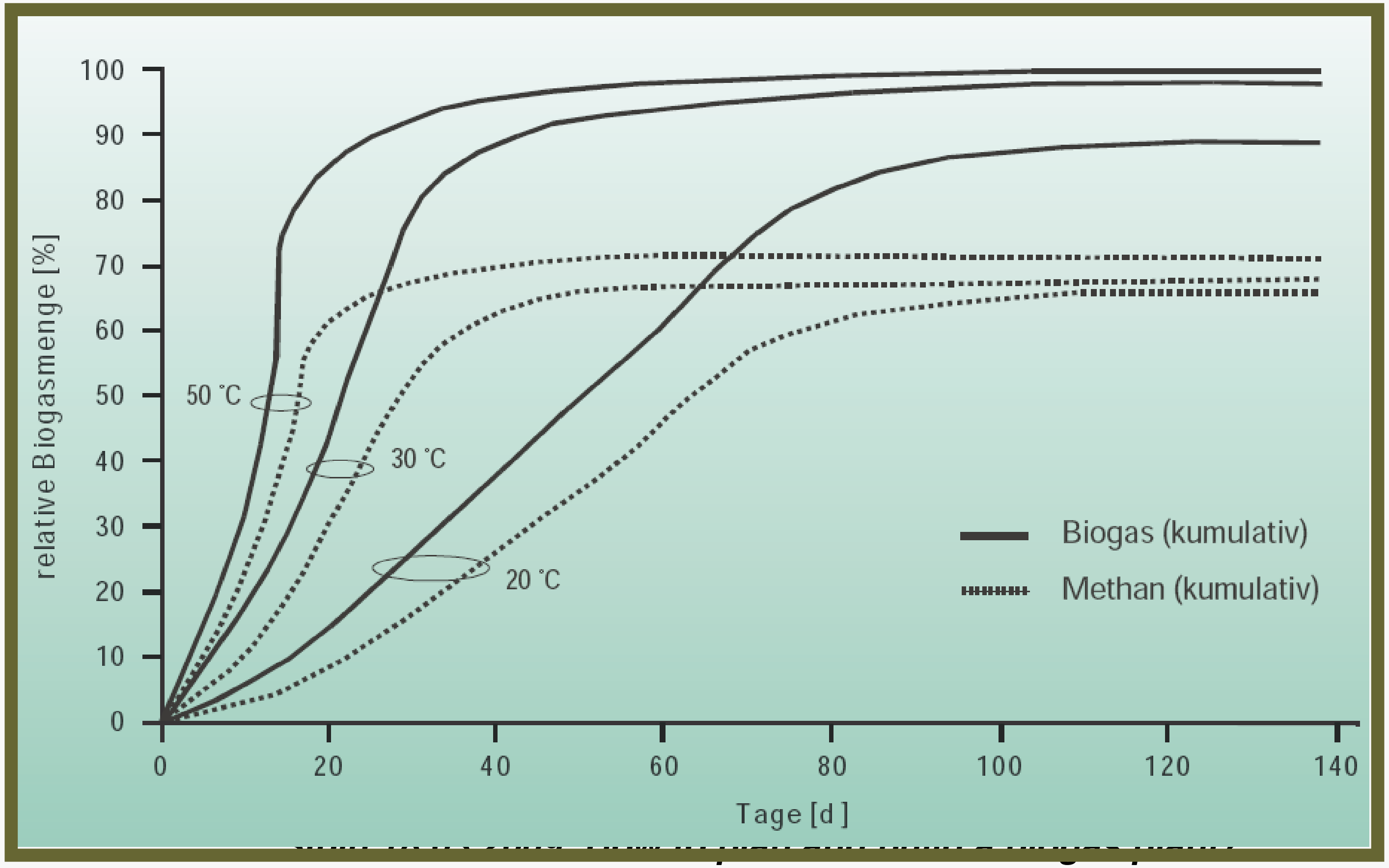


- # Biogas Process steps



Basic decision between thermo- and mesophilous systems

The process to convert organic substances is depending on temperature and duration.



Choice of technology depending on risks

Co- substrat / RISK	Without risk	Hygienically risky	With problematic particels	chemical waste, risky
Residues from agriculture	Liquid and solid manure, residues from plants	Liquid and solid manure, residues from plants		Manure spoiled with Cu and Sn
Energy crops	Silage, Wheat, whole plants			
Substances from EU1774/2002 list		Arbatory waste		Grease separator
Industrial organic waste	Vegetable waste, residues from nutrition industry	Old vegetable, spoiled by transport	Old vegetable, spoiled by transport	residues from bio-oil production
Organic residues from communities	grass		Bio- waste, green from street	Bio- waste, green from street

Biogas technology

- Site dependency: agricultural area

- In the case of liquid manure use, the plant site should be as nearest as possible to the stables. Reason: high water volumes with small biogas output.
- The liquid manure should be transferred by controlled pumps from these stables to the plant through closed pipes avoiding smell development.
- Analogous the fertiliser output shall be directly pumped back to the agricultural storages
- Suggestion: strict site separation between farm and biogas plant => no crossing streets, ensure hygienic regulation and find an appropriate solution for delivery ⇔ risks for the feedstock!
- Cheap area for large silage storages or can farmers deliver just in time?
- Obey the normal rules for fertiliser displacement on agricultural areas (mass, fertiliser and heavy metal contents, near to the soil technologies)

=> Up to 10 (15) km circle distances can be profitable

Biogas technology

- Site dependency: industrial area

  - Avoid smell, emissions and other influences for the neighboured industrial enterprises especially when introducing bio-waste and disposal to be transported to landfill stations

  - Reduce noise from transport, cogeneration, cutting machines

  - Only those substrates with high biogas outputs can be transported on long distances: collecting systems from experienced companies could be ideal and cheap partners (optimising the logistic handling)

=> Up to 100 km circle distances can be profitable

Technology choice

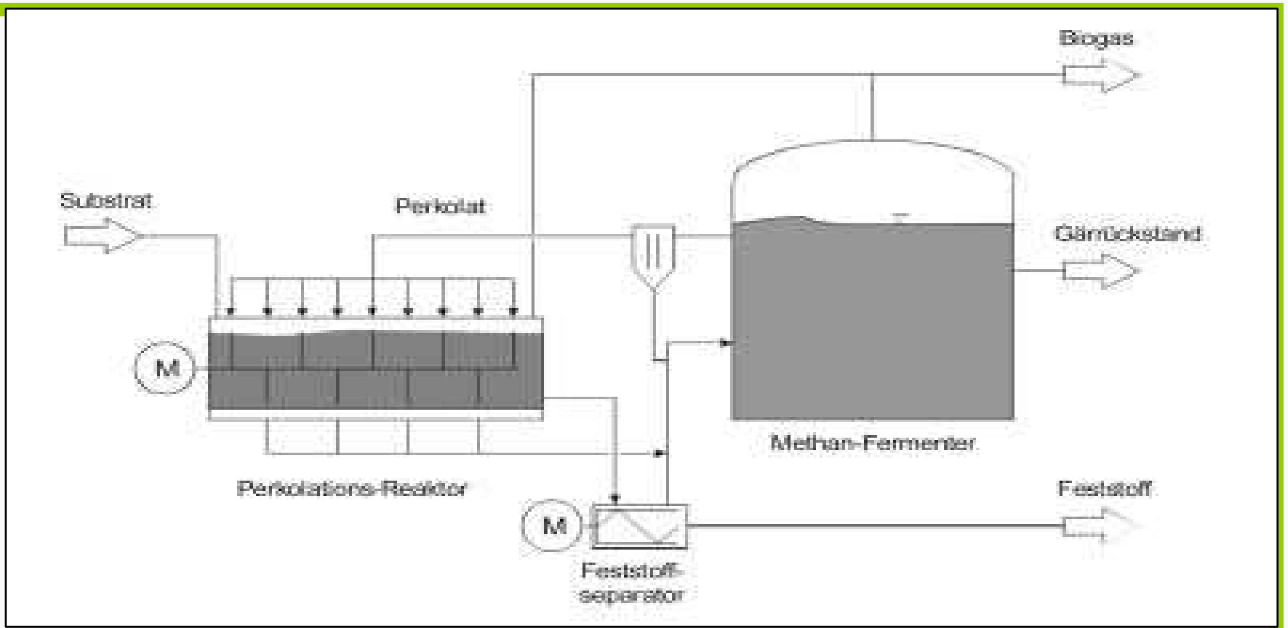
- Continuous versus non-continuous processes

  - Only dry fermentation processes can work under non-continuous conditions
  - Non- continuous (batch) approaches are rare in praxis as:
    Smell emissions occur during feeding
    - Huge amounts of methane were left into atmosphere which is a strong economic disadvantage and ecologically dangerous
    - Biogas quality and quantity are moving strongly ⬄ continuous use in cogeneration units
  - The majority of plants are running with wet fermentation processes.
  - Continuous approaches are preferred in praxis, as:
    - Some input substances can only be cracked through wet fermentation
    - Biogas production can better be planned
    - Operation is easier as process control can steadily be influenced.

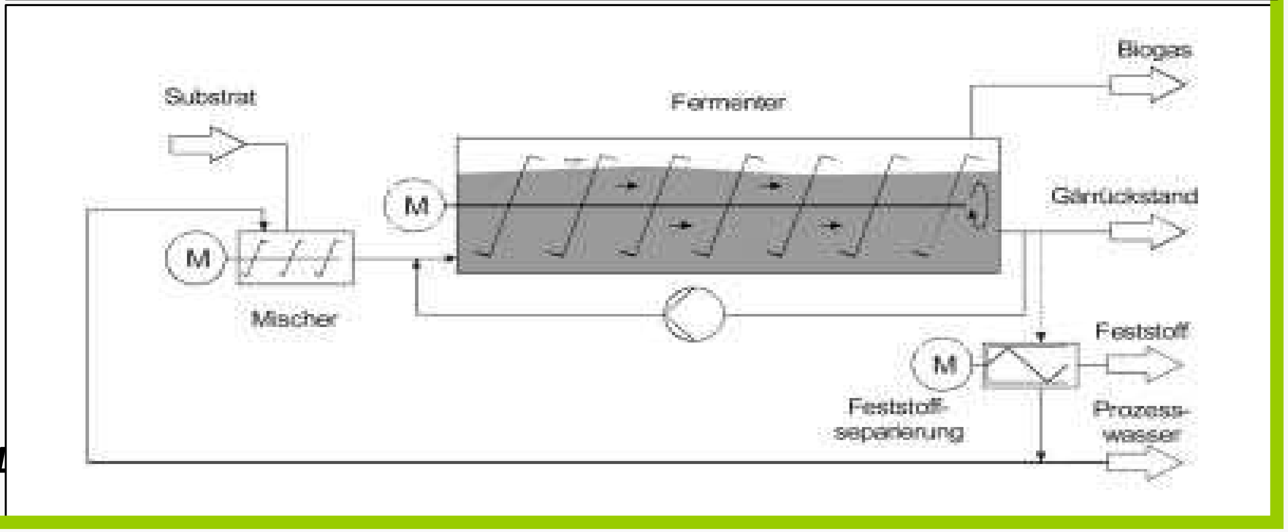
Technology choice

- Types of dry fermentation:

Perculation e.g. Dranco system



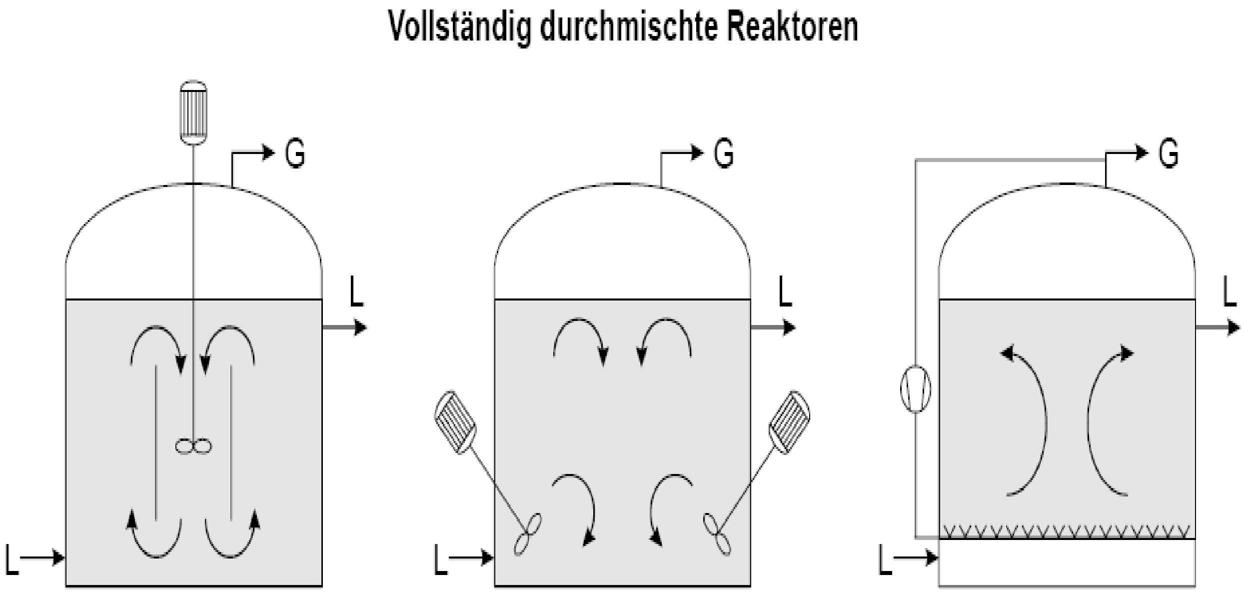
Streaming approach e.g. Linde/ LARAN, SIUS



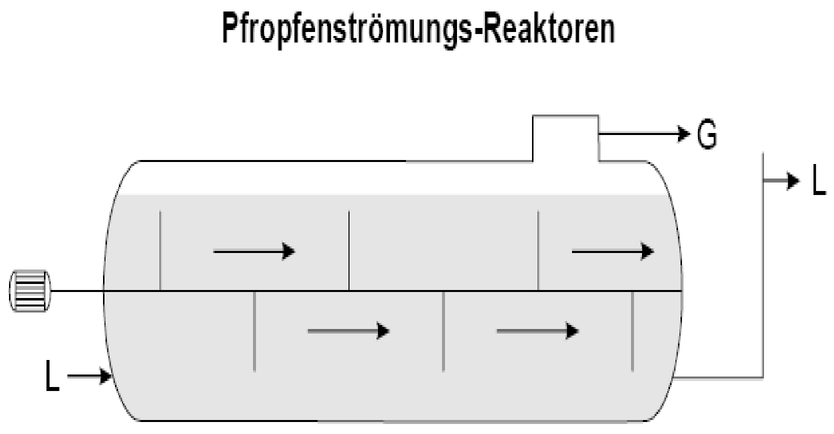
Technology choice

- Types of wet fermentation:

Standing Digesters:
thin and high or large and flat



Laying digester:
Streaming approach for wet substrates



Sibiu 1

Technology choice

- dry and wet fermentation: process conditions

	Wet fermentation	Dry fermentation
Organic partition	3 - 15%	> 30%
Process temperature	37°C (mesophil) oder 55°C (thermophil)	37°C (mesophil) oder 55°C (thermophil)
Room load	Between 0,8 kg/(m³*d) and 5,5 kg/(m³*d) (high digesters)	> 5,5 kg/(m³*d)
Staying time	from 15 to 45 days	from 15 to 45 days
Reduction of organic input	Depending on input material and process control	

Technology choice

- dry and wet fermentation: **investment**

	Wet fermentation	Dry fermentation
Delivery systems for input materials	Nearly equal	
Preparation of the input materials	Higher investment for storage and mix systems as well as separation of stones etc. in the entrance hall	More expensive transportation systems
Digestion		Higher costs through more expensive control components
Fertiliser usage	higher storage demand (95% water)	High costs to separate stones etc. from fertilizer; own costs for perculation production

Dry fermentation plants are often more expensive under equal pre-conditions.

Technology choice

- dry and wet fermentation: operation costs

	Wet fermentation	Dry fermentation
Delivery systems for input materials	Nearly equal	
Preparation of the input materials	Higher energy costs for mixing	Higher maintenance costs
Digestion	Higher energy costs for mixing	
Fertiliser usage	higher transport costs because of high useless water amounts	

Operation costs speak in favour of dry fermentation!

Technology choice

- Decision criteria between dry and wet digestion process

  Advantageous wet fermentation

  - Sites with nearby farms with cattle feedstock
  - Sites with a high portion of liquid input substances
  - Arbatory, grease, nutrition industry
  - Low investment for equal quality and power

  Advantageous dry fermentation

  - Sites with connection to farmers harvesting plants
  - Sites with guaranteed high bio waste input contracts
  - Sites with obligatory need to low constructions
  - Biomass substrates with high amounts of stones, etc.

Technology choice

- Process parameters

  All following parameters are influencing the efficiency of the digestion process and should therefore regularly be checked:

  - Input materials
  - Staying time
  - pH-value / buffer capacity
  - Carbon acids
  - Sulphur hydrogen
  - NH3
  - Hindering substances
  - Composition of bacteries

Technology choice

- Biogas use in cogeneration units: container solutions often cheaper as individual installations in own construction halls

Biogas technology choice

- Separation of fertiliser into liquid (=fugat, recyclat, perculat) and nearly compost equal solid fractions
  - Physical constitution of the fertiliser determine technology to use: separator with screws, centrifuges and presses
  - Separation shall optimise the whole process dient der Optimierung der Prozessführung

- ➢ Fugat use is substituting additional water supply to stipulate the biogas process
- ➢ Through special types of fermentation bacteries within the fugat, the input materials can easier and earlier be cracked; hydrolysis takes already place in the mixture components

Biogas technology choice

- Separation
  - Reducing chemical fertiliser necessities

Technology choice

- Site necessities

  - Area demand of a biogas plant is depending on the necessary components
  - Utilising industrial, commercial and community bio waste, the big vehicles demand for a greater entrance area to handle transport
  - Input materials are prodused only one a year und have to be stored for a complete winter

  - Storage for silage is highly land consuming
  - It should be ensured, that all components can be reached through mobile shifting

Pictures from biogas plants

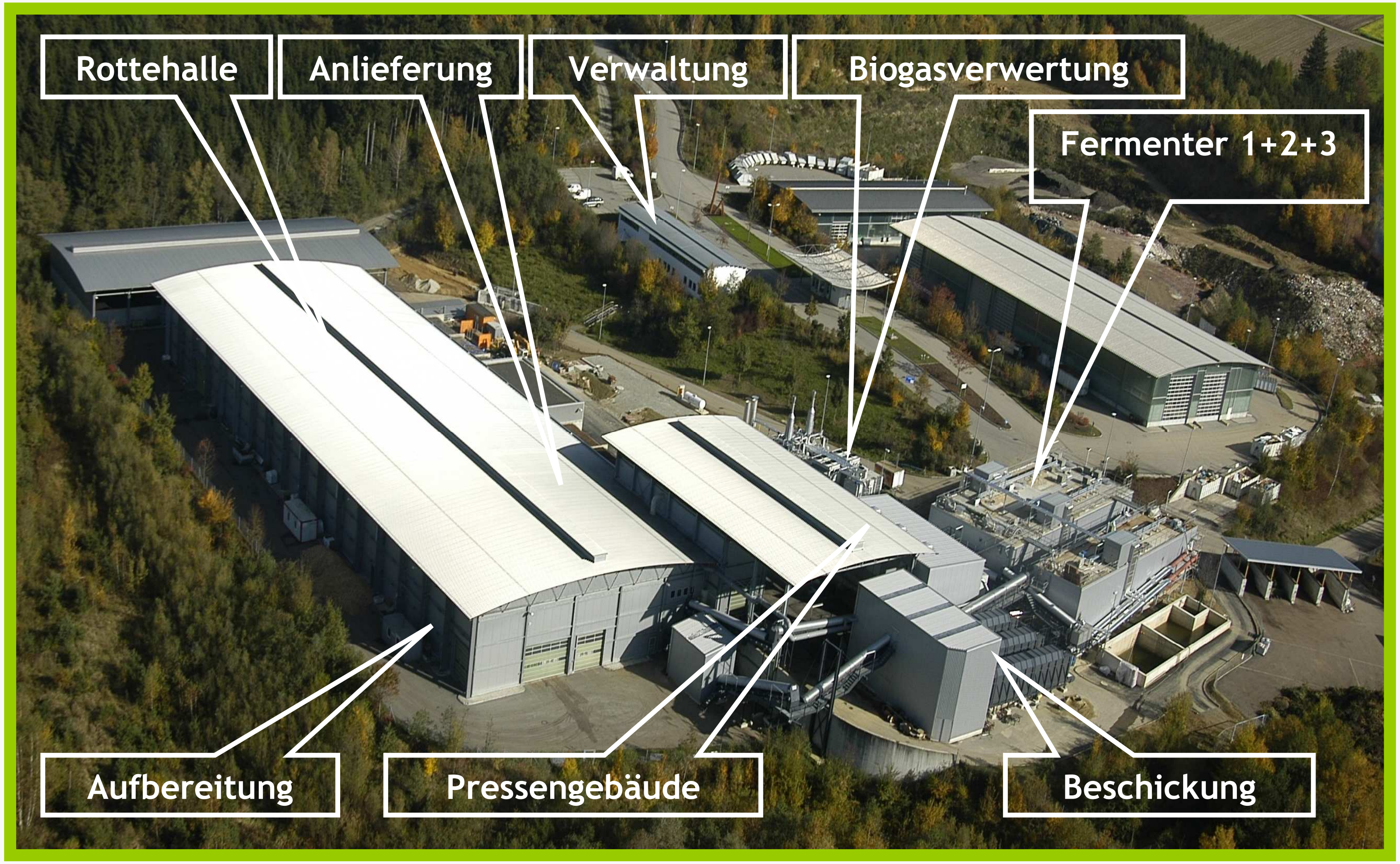
- Wet fermentation for agricultural input materials

Pictures from biogas plants

- Wet fermentation for all types of input materials

Pictures from biogas plants

- Dry fermentation plant




Thanks for your attention