BIOENERGY FOR SUSTAINABLE RURAL DEVELOPMENT

LAMNET PROJECT WORKSHOP
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Overview of Biogas Technology and Legislative Framework for Biogas Utilization in Europe

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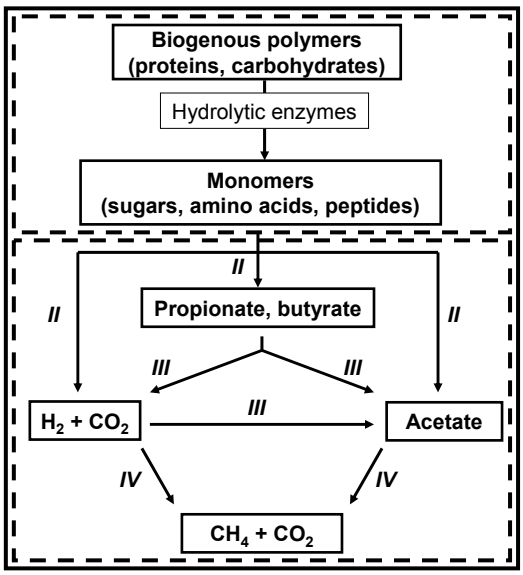
Structure

- Biochemical Process of Biogas Production
- Technical Systems
- Peculiarities of Framework
- Biogas Utilization in Germany
- Environmental Effects
- Conclusions

Biochemical Process of Biogas Production



I Hydrolysis

II Fermentative bacteria

III Acetogenic bacteria

IV Methanogens

One-stage process

Two-stage process:

Separation of hydrolytic and methanogenic stage

(modified after http://www.uasb.org)

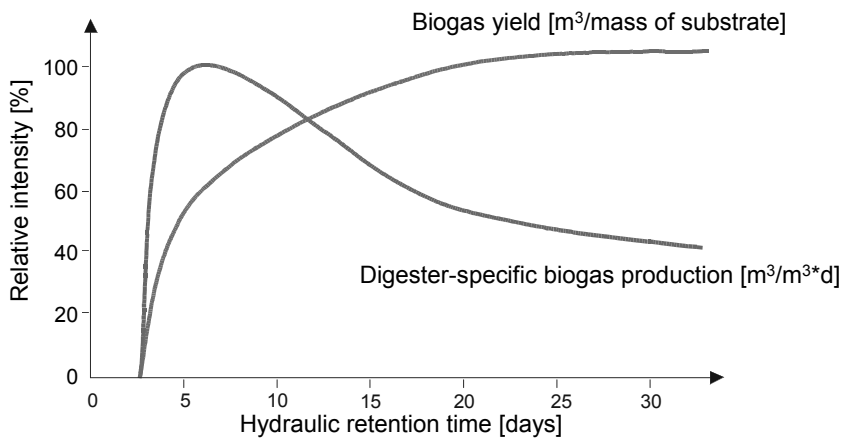
Biochemical Process of Biogas Production

Steps	Temperature	pH	Air environment	Redox-potential
Hydrolysis	Higher the T° the faster up to 55°C	~ 6	Microaerophil	-
Acidogenic Phase		4 – 6	Strict anaerobic	-
Acetogenic Phase	Mesophil ~35°C	Tolerance range 6,8 – 7,5	Strict anaerobic	Minimal –330mV
Methanogenesis	Thermophil ~55°C			

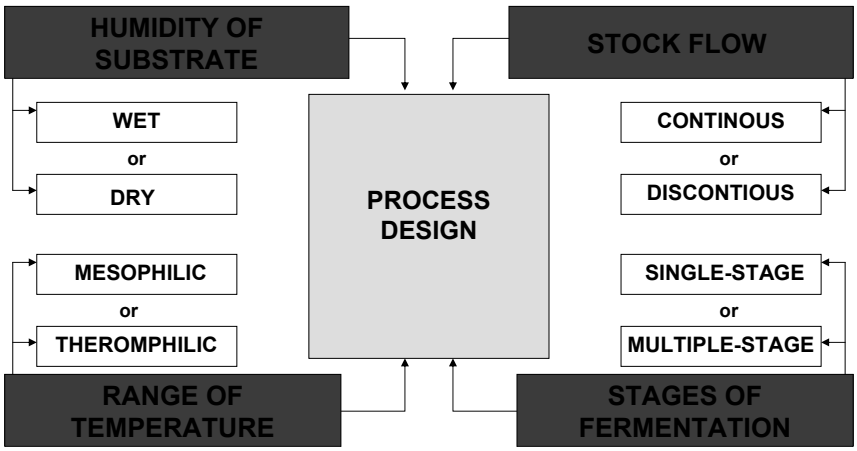
Biochemical Process of Biogas Production

Substrate	Reaction
Carbohydrate f.e.: Glucose	$C_6H_{12}O_6 \rightarrow 3\ CO_2 + 3\ CH_4$ 50 % : 50 %
Fat f.e.:Palmitic acid	$2\ C_6H_{32}O_2 + 14\ H_2O \rightarrow 9\ CO_2 + 23\ CH_4$ 28 % : 72 %
Protein (average)	$2\ C_{13}H_{25}O_7N_3S + 12\ H_2O \rightarrow 13\ CO_2 + 13\ CH_4 + 6\ NH_3 + 2\ H_2S$ 38 % : 38 % : 18 % : 6 %

Kinetics of Biogas Production



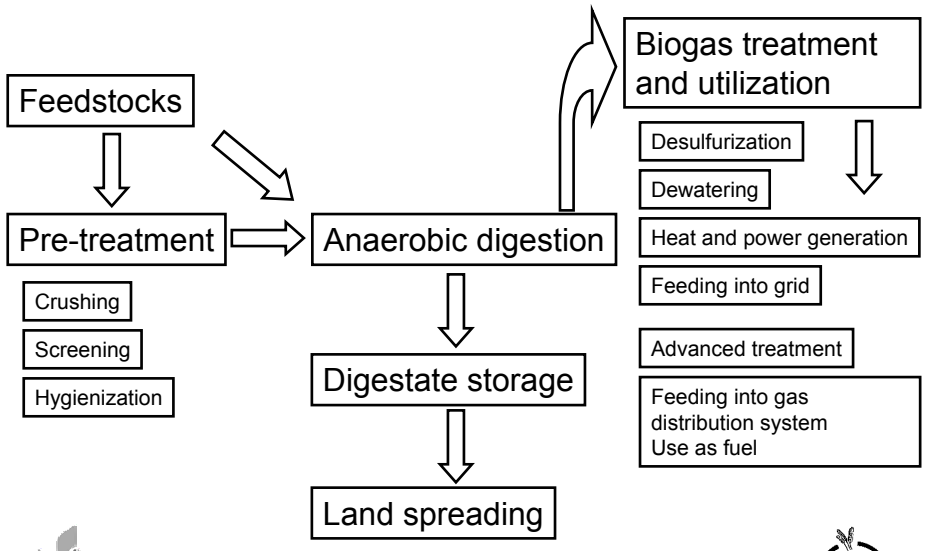
Process Design Characterisation



Technical Systems: General Objectives

- Maintain a stable digestion process
- Maintain continuous methane production
- Accomplish high methane yields by means of:
  - Optimized feedstock mixture
  - Appropriate pre-treatment
  - Optimized digester operation
- Keep building costs reasonably low

Technical Systems: Process Overview



German Biogas Association

Feedstocks: Origins and Potential Risks

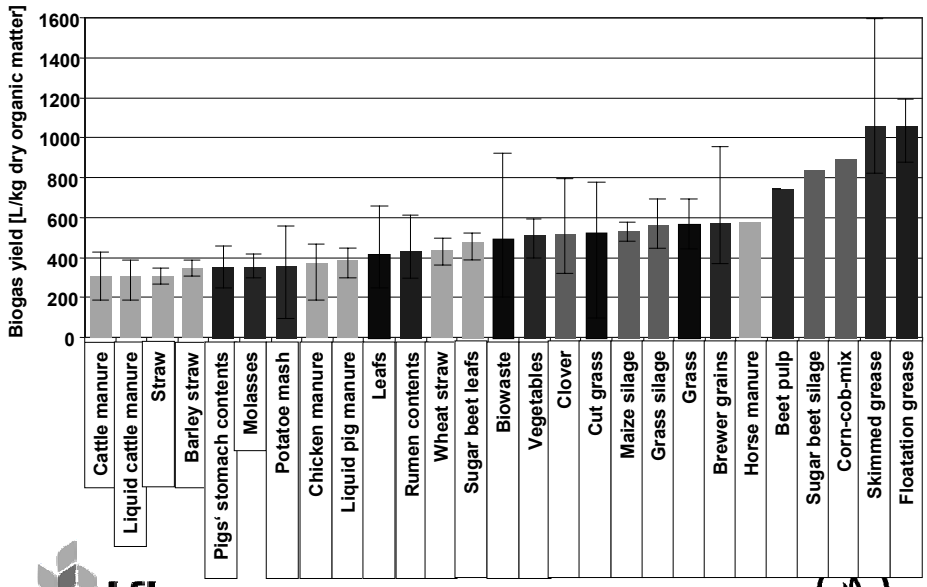
Harmless	Pathogens	Contraries	Pollutants
Maize, grain, grass, beets, etc.	Biowaste	Biowaste	Sewage sludge Biowaste Roadside grass
Manures Sugar beet leafs Straw	Spoiled foodstuffs	Spoiled foodstuffs	Wastes from vegetable oil production
Cut grass Greens	Rumen contents Contents of grease-skimming tanks Stomach/gut contents Blood meal	Canteen kitchen wastes	(Skimmed grease)
Vegetables Brewer grains Beet cuttings Starch	Canteen kitchen wastes Household wastes		

Renewable primary products | Agricultural wastes | Municipal wastes

Industrial wastes | Slaughterhouse wastes | Others

German Biogas Association

Feedstocks: Biogas Yields



Feedstocks: General Requirements

- Have to be biologically degradable under anaerobic conditions (e.g., no woody material)
- Suspension should have a dry matter content between approximately 2 and 15 % to be pumped
- Feedstocks with more than 15 % dry matter content need special input systems
- Should have a balanced nutrient content, at least in mixture
- Must have no bactericidal properties
- Should contain no persistant pollutants (organic compounds, heavy metals, antibiotics) or pathogens in view of agricultural use of digestate

Technical Systems: Process Overview

Feedstocks

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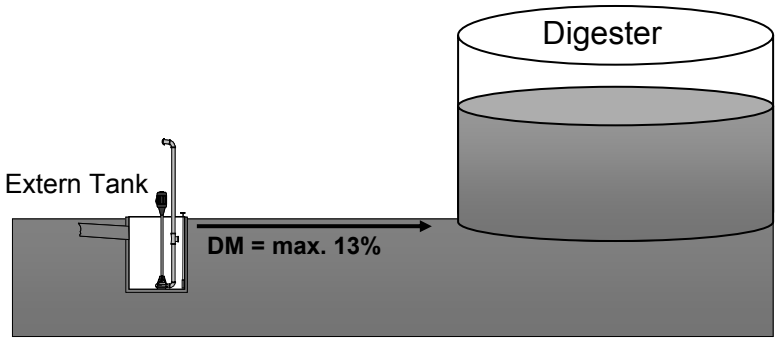
Pre-treatment

- Crushing
- Screening
- Hygienization

Pre-treatment: Input Systems

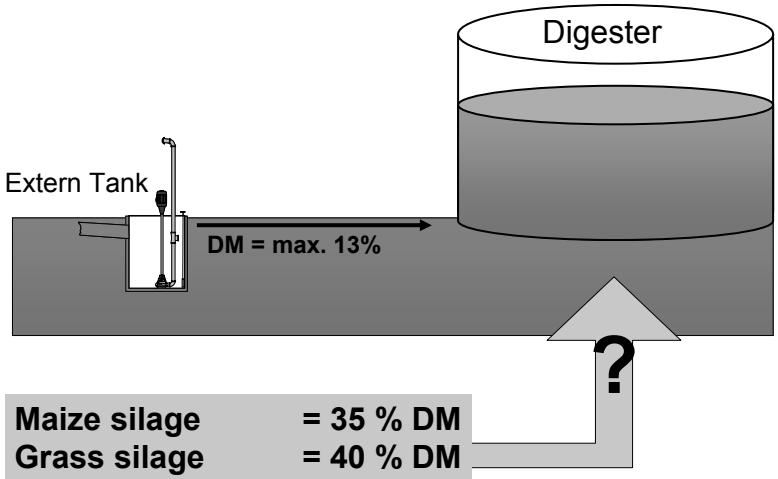


Pre-treatment: Input Systems

Extern Tank

System:
The Feedstock is mixed with manure and pumped to the digester.

Pre-treatment: Input Systems

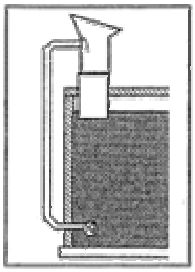


Maize silage	**= 35 % DM**
Grass silage	**= 40 % DM**
Manure	**= 35 % DM**
Straw	**= 90 % DM**

Pre-treatment: Input Systems

Re-injection System

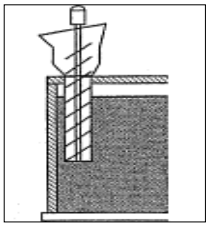
System:
The Feedstock is washed with digested material and pumped to the digester.



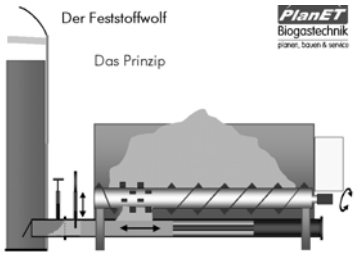
Pre-treatment: Input Systems

Mix Tank

System:
The Feedstock is mechanically mixed, cut and pressured into the digester.



Pre-treatment: Input Systems



Mix Tank

System:

The Feedstock is mechanically mixed and pushed into the digester.

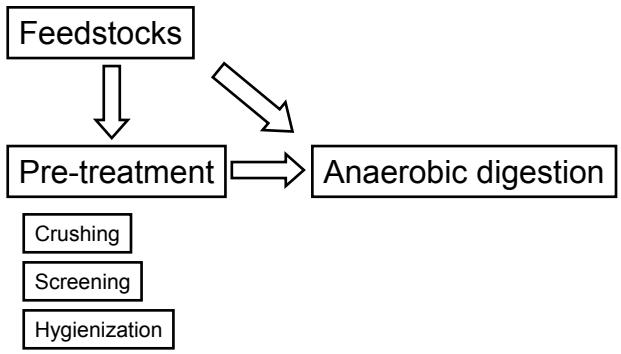
Pre-treatment: Input Systems

Mix Tank

System:

The Feedstock is mechanically mixed and pushed into the digester.

Technical Systems: Process Overview



Technical Systems: Digester Designs

Cylindrical stirred tanks
Material: Concrete (or steel).

Heat insulation:
Typically foamed plastic.

Covering:
Sheet metal or wood.

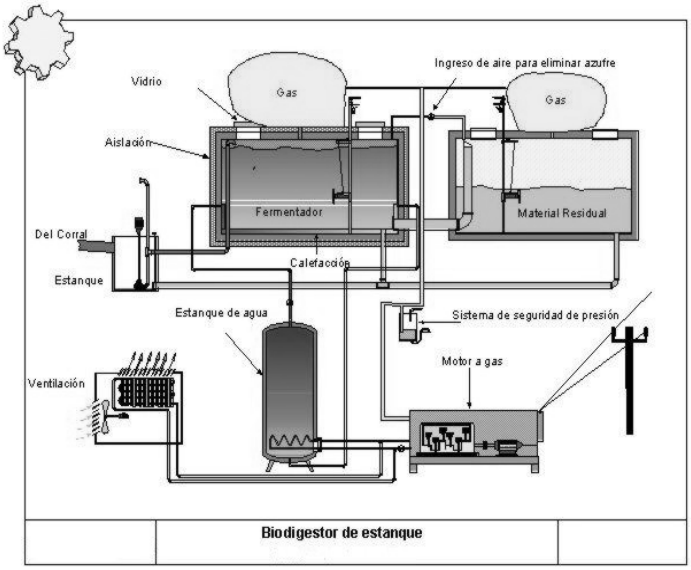
Technical Systems: Digester Designs

Biogas storage in the digester under a stretch hood.

Single-layer

With additional soft cover

Technical Systems: Digester Designs



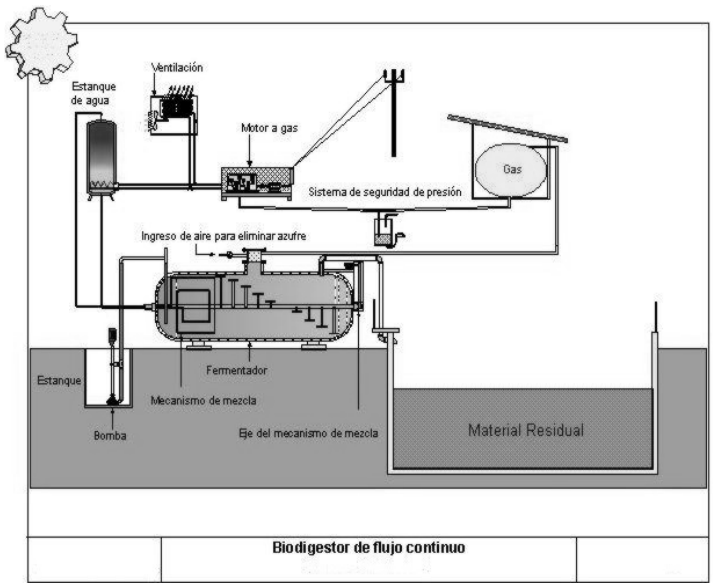
Biodigestor de estanque

Technical Systems: Digester Designs

Horizontal tubular digesters.
Material: steel (or concrete).

Multi-beam paddle mixers with longitudinal axle that can be heated.

Technical Systems: Digester Designs



Technical Systems: Isolations

- Minimization of process energy need
- Avoid temperature losses
- Avoid temperature differences

Materials:

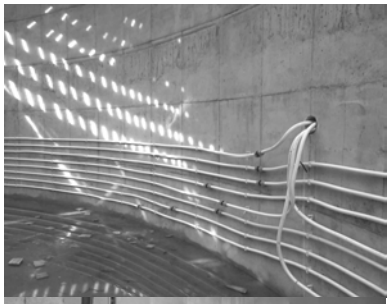
Floor and roof
(concrete roof): Styropor

Wall and roof (plastic cover):
Polystyrol

Technical Systems: Heating

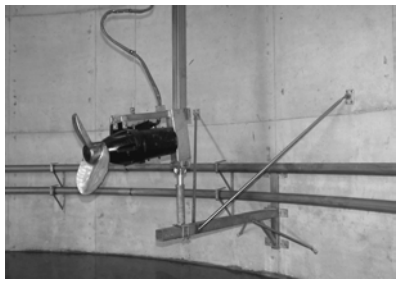
Warming the digesting substrate at optimal temperature.

Compensation of the lost temperature.

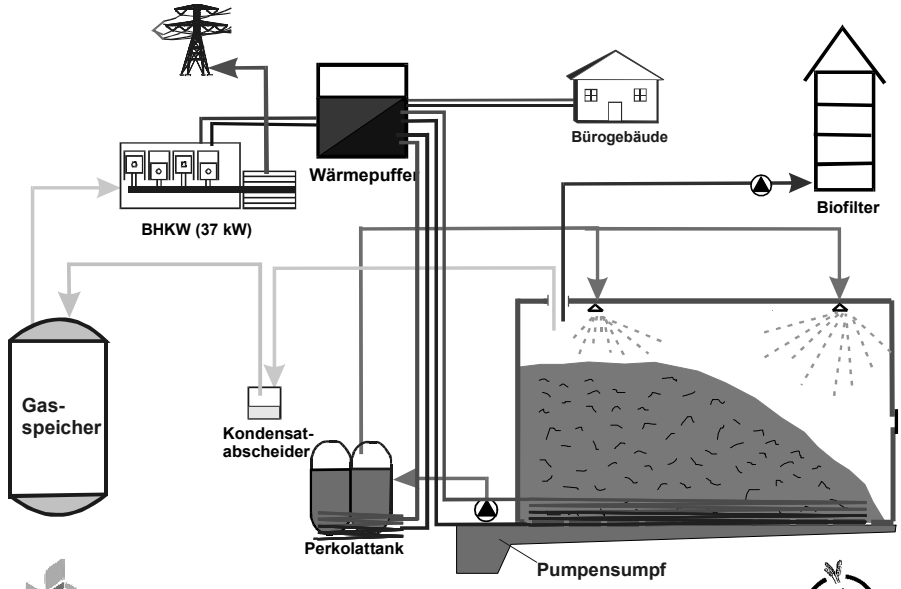


Technical Systems: Mixing

- Homogenization
- Estimulate gas exit
- Avoid sink material
- Avoid floating material, crushing of crust

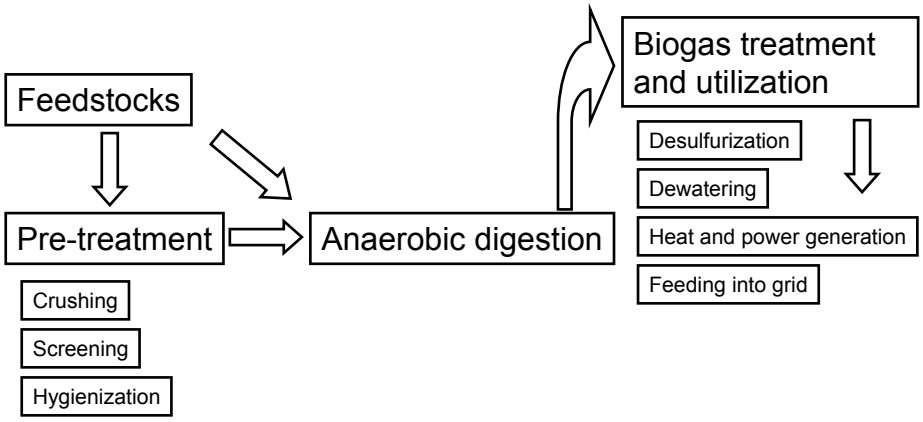


Technical Systems: Dry Fermentation



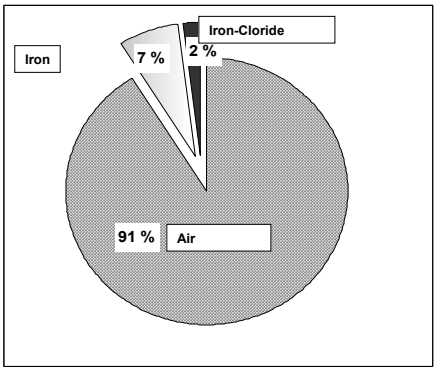
Technical Systems: Dry Fermentation

Technical Systems: Process Overview

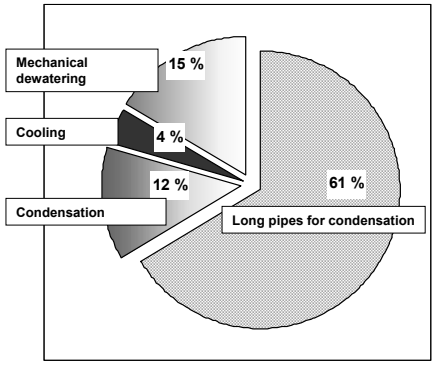


Technical Systems: Biogas Treatment and Utilization

- Desulfurisation



- Dewatering

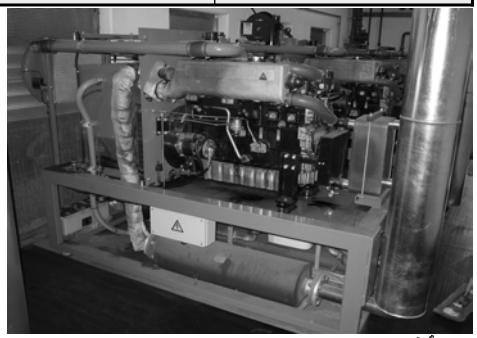


Technical Systems: Biogas Treatment and Utilization

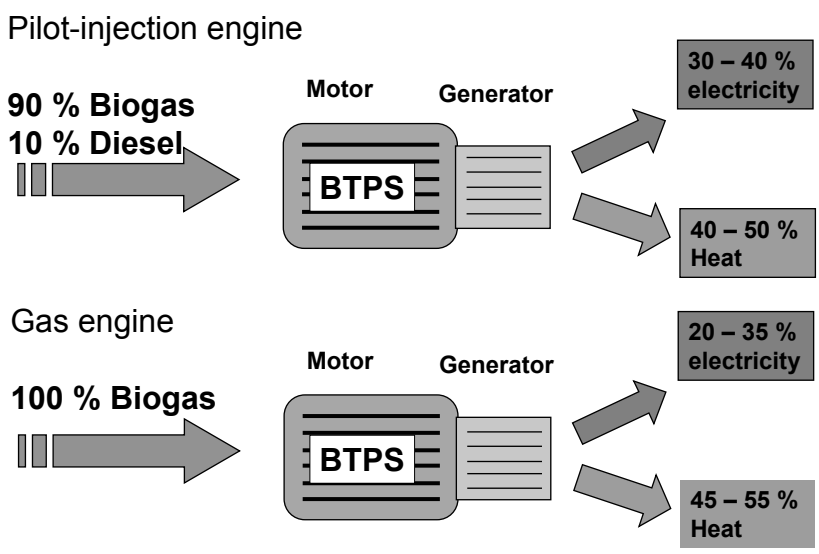
	Raw gas	Treated gas
Methane (CH_4)	55 - 70 Vol.-%	55 - 75 Vol.-%
Carbon dioxide (CO_2)	25 - 40 Vol.-%	25 - 45 Vol.-%
Oxygen (O_2)	0 Vol.-%	0 - 1 Vol.-%
Water (H_2O)	~ 40 g/m³ (saturated)	10 – 12 g/m³
Hydrogen sulfide (H_2S)	20 – 20.000 ppm	0 – 200 ppm

Combined heat and power generation:

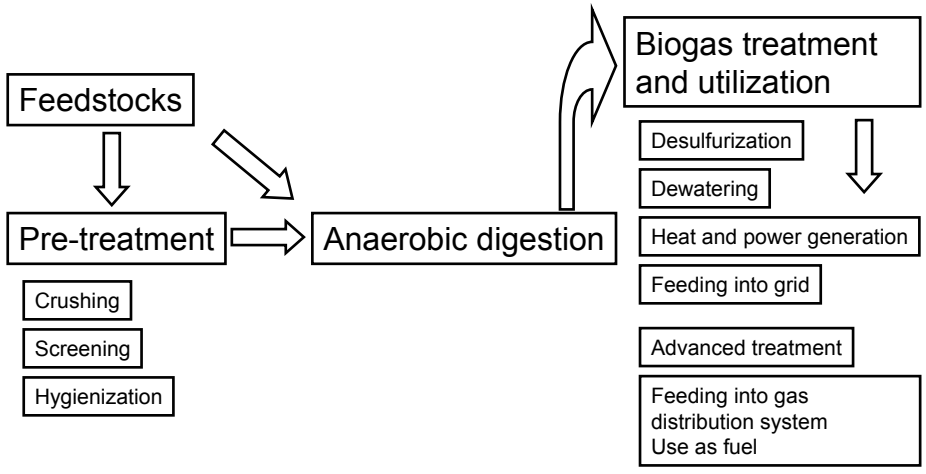
- Pilot-injection engine
- Gas engine



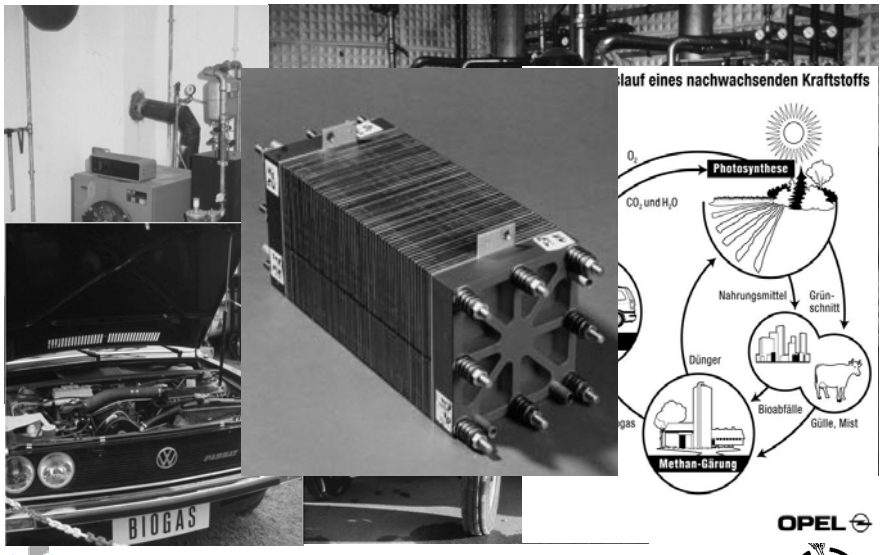
Technical Systems: Biogas Treatment and Utilization



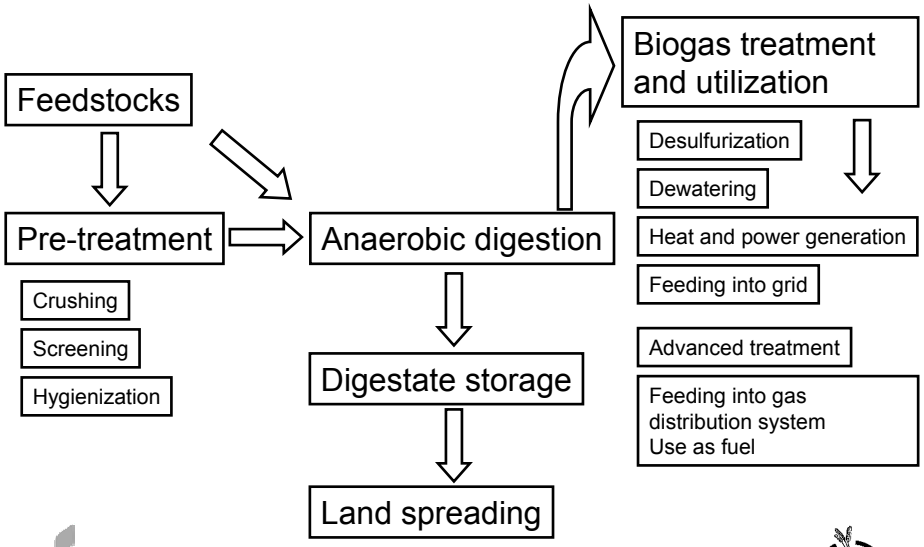
Technical Systems: Process Overview



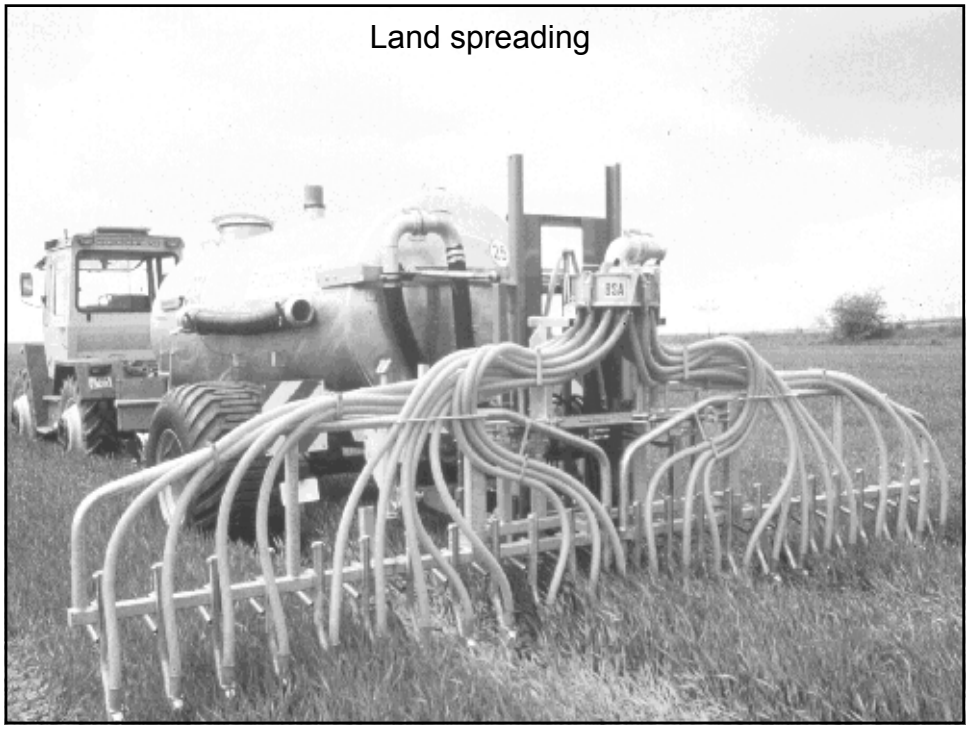
Technical Systems: Biogas Treatment and Utilization



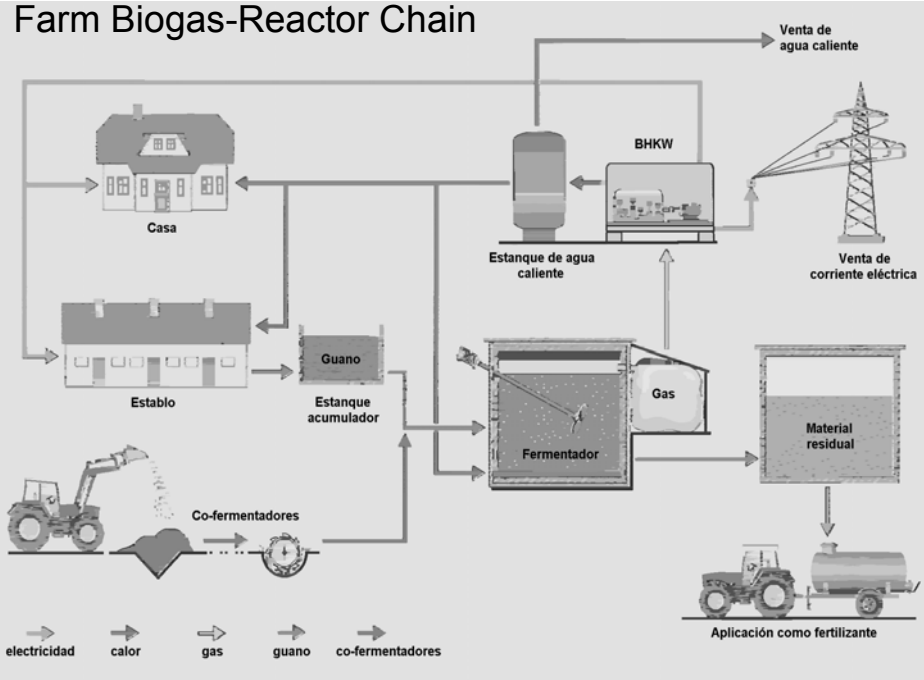
Technical Systems: Process Overview



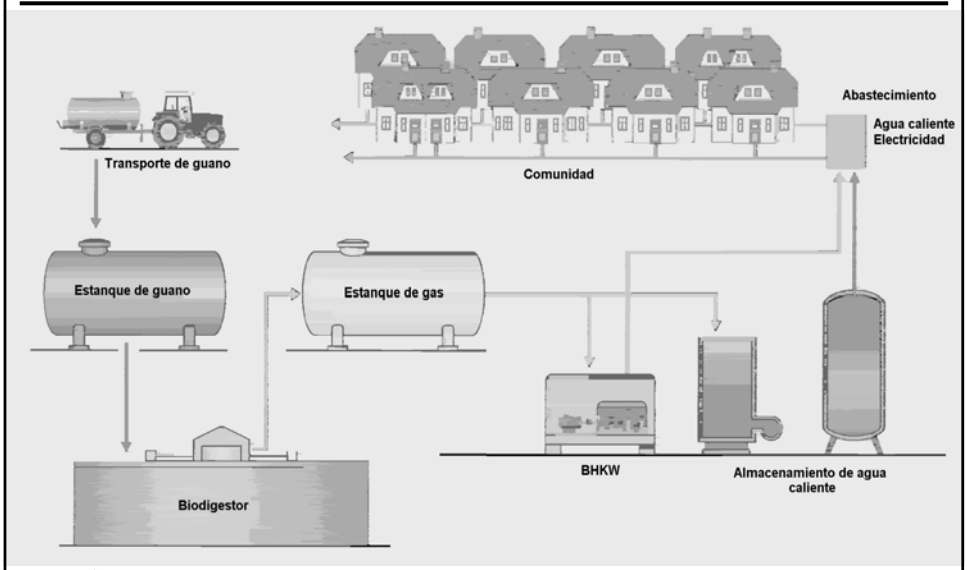
Land spreading



Farm Biogas-Reactor Chain



Comunal Biogas-Reactor Chain



Peculiarities of Framework

- Economic Feasibility
- Legal Feasibility

Framework: Economic Feasibility

ANALYSIS OF COSTS:

- PROJECT DEVELOPMENT
- TECHNICAL EQUIPMENT
- RUNNING COSTS

ANALYSIS OF INCOME:

- SALES OF ENERGY

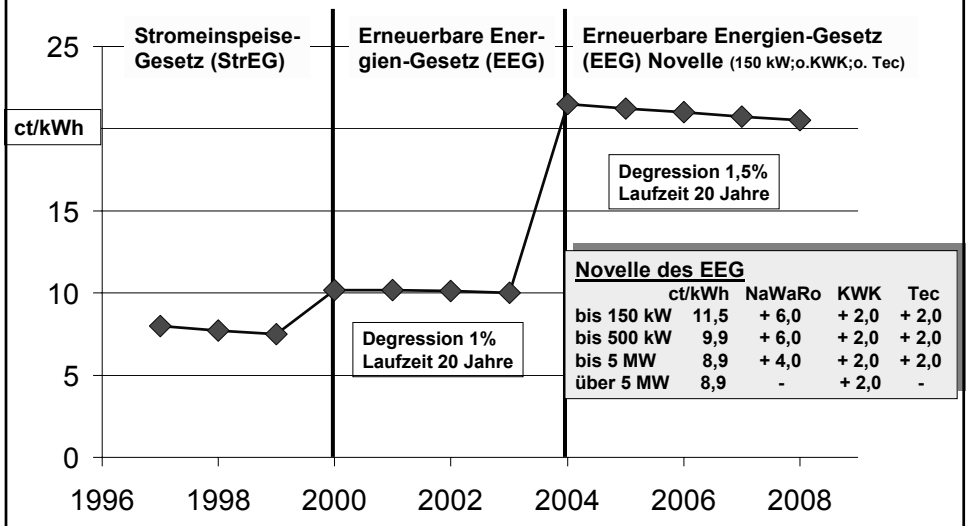
  $\Rightarrow$ FIXED COMPENSATION

- DISPLACEMENT OF FERTILIZER COSTS
- SALES OF CO_2 EQUIVALENTS

Framework: Legal Feasibility

- **WASTE AND DIGESTED MANAGEMENT**
- **ELECTRICITY INJECTION**
- **PREVENTION OF EMISSION**
- **RULES OF PLANNING AND CONSTRUCTION SAFETY**

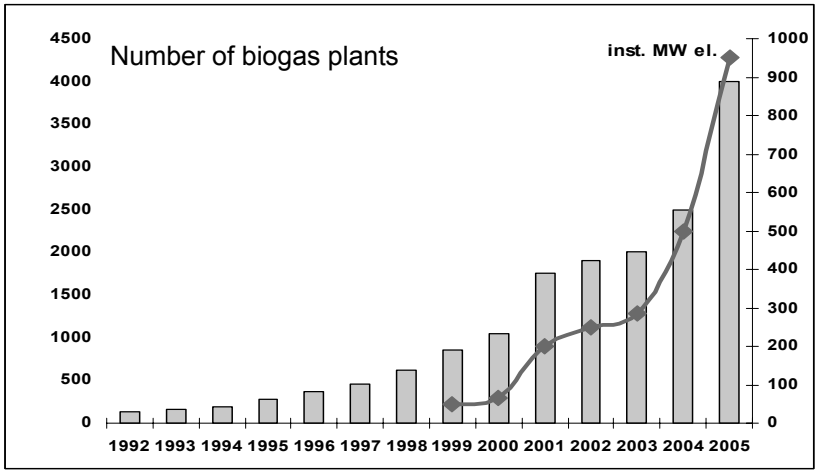
Development of Biogas Utilisation in Germany



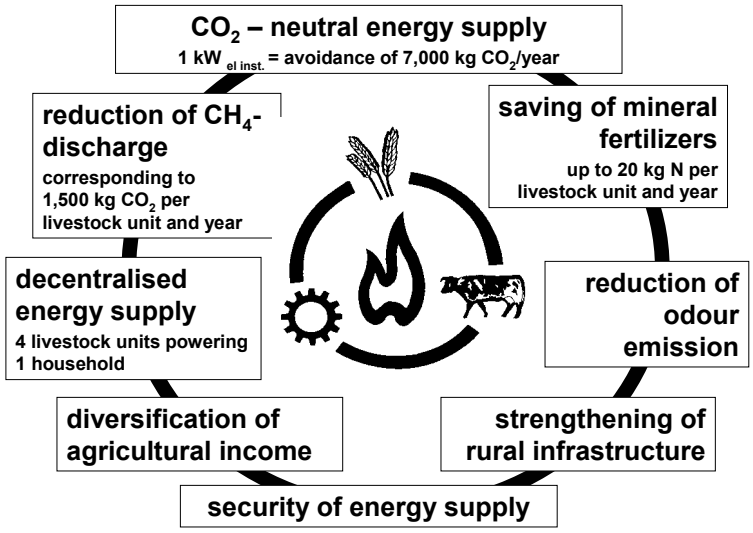
Novelle des EEG

	ct/kWh	NaWaRo	KWK	Tec
bis 150 kW	11,5	+ 6,0	+ 2,0	+ 2,0
bis 500 kW	9,9	+ 6,0	+ 2,0	+ 2,0
bis 5 MW	8,9	+ 4,0	+ 2,0	+ 2,0
über 5 MW	8,9	-	+ 2,0	-

Development of Biogas Utilisation in Germany



Environmental Effects of Utilizing Biogas Technology in Agriculture



Summary and Conclusions

- Technology of agricultural biogas plants significantly improved last two decades.
- Nevertheless, still considerable potential for optimization and development in the fields of:
  - Agitation
  - Biogas treatment
  - Biogas utilization
  - Plant dimensioning
- Profitability of biogas production and utilization strongly depends on legal framework and business environment.
- Keeping investment costs low and improving the efficiency of energy recovery are important factors to improve profitability of biogas plants.

Thank you for your attention!

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