Learn form mistakes of experienced ones: project development and engineering

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AKADEMIE FÜR ERNEUERBARE ENERGIEN

Milestones

2008 – date Associate Professor, Akademie für Erneuerbare Energien, Luechow,
www.akademie-ee.de
Seminars: Biomass for Energy, Facility Design, Construction, Bio-Fuels

2006 – date Senior Consultant, Krieg & Fischer Ingenieure, Goettingen
www.kriegfischer.de
Education of engineers, waste technology

Krieg & Fischer Ingenieure GmbH

1999 – 2006 Foundation of Krieg & Fischer Ingenieure, Goettingen
HRM, Head of Construction Division, Financial Accounting

1990 – 1998 Employed at several companies, farm-scale biogas plants in Germany, collaboration with German Biogas Dissamination Projects, concept studies, evaluation of biogas projects in Africa and South-East-Asia,

1990 Co-founder of German Biogas Association, Freising,
www.biogas.org

Fachverband Biogas e.V.

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General Outline

Key aspects of

- Project Developement
- Substrates
- Dimensioning
- Operation of Biogas Plants

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Project development

Key Aspects:

- Intention of AD
- Benefit of AD
- Substrate
- Dimensioning
- Operation

Project development – Key aspects I

Intention of AD

- Health Care
- Wastewaster Utilization
- Replacement of Firewood, LG
- Saving of Energy
- Increasing Ratio of Biomass Renewables

Benefit of AD

- Health Care Costs of Public Budget
- Improvements in Living Standard
- Environmental Precautions
- Food processing at a lower price
- Achieve Business Approval
- Renewable Energy Business

Project development – Key aspects II

Substrate

- Kind and Composition
- Daily Mass or Volume
- Gas Production Rate
- Fate of Digestate

Dimensioning

- Flow rate, Throughput
- Flowability, Handling
- Loading Rate (COD, VS)
- Hydraulic Retention Time, Biomass Recovery
- Substance Concentration
- Balance of AD
- Unchecked Production (Digestate, Energy)
- Reserve Capacity

Project development – Key aspects III

Operation

- Acceptance of Job, Sozial Standing
- AD Awareness Level
- Understanding (Intention, AD)
- Personal skills
- Level of Technology (regional, sectoral)
- Reasonable Availability (Maintenance, Spare Parts)
- Share in Outcome
- Profit

Intermediate Result I

Considering Key aspects lead to appropriate plant design and successful continuing operation.

Intention of AD

\+ Benefit of AD

\+ Substrate

\+ Dimensioning

\+ Operation

Appropriate AD

Key aspect – Substrate – Characteristics I

Effluents from Animal Housekeeping

What need to be known:

- Animal species, feed base
- If bedding material, what kind
- Age of Effluents (Maturity)
- TS, VS, TKN, Alkalinity, Particle size
- Kind and amount of Impurities (chains, ropes, fork-tines, stones)
- Load curve (differences in time and quantity)

Key aspect – Substrate – Characteristics II

Municipal organic solid waste

What need to be known:

- Pretreatment at source (Separation)
- Kind of Package
- Particle size
- Quantity of trash (metals, glas,chinaware, wires, ropes, stones)
- Load curve (differences in time and quantity)

Key aspect – Substrate – Characteristics III

Liquid food waste

What need to be known:

- History of origin

- Chemical composition:
  - TN, TKN, Ammonia-N
  - Phosporus (Total)
  - Sulfate, Sulfide (Total)
  - TOC
  - Alcalinity (as CaCO3), pH-value

- Concentrations:
  - Total Solids, TDS, Volatile Solids, Ash Content
  - COD (soluble), (total), BOD (soluble)

- Quality:
  - Protein, Fat, Carbohydrates, Calories

- Load curve (differences in time and quantity)

Key aspect – Substrate – Characteristics IV

Energy crops

What need to be known:

- Chemical composition:
  - Nitrogen (Total)
- Concentrations:
  - Total Solids, (TSS), Volatile Solids, Ash Content
- Quality:
  - Protein
  - Fat
  - Carbohydrates
  - Crude Fibre,
  - Lignin, mineral fraction (e.g. sand)
  - Calories
- Particle size
- Load curve (differences in time and quantity)

Intermediate Result II

Beware of trash !

If you follow this, AD will produce biogas (energy) ongoing, as precalculated.

Key aspect – Dimensioning – Energy Calculation

Input (Substrate) [Mg/a], [Mg/d]

Total Solids [% fresh matter] → Daily mass of TS [Mg/d]

Volatile Solids [% TS] → Daily mass of VS [Mg/d]

Specific Gas Production [l/kg VS] → D. (raw) Gas production [m³/d]

Specific Methane Concentration [%] → D. Methane production [m³/d]

Cal. Value Methane (H_i) [kWh/m³) → D. Gross energy prod. [kWh/d]

Remark:

Solely soluble organic compounds in biomass can be biologically converted into Biogas.

Key aspect – Dimensioning – Mass Balance I

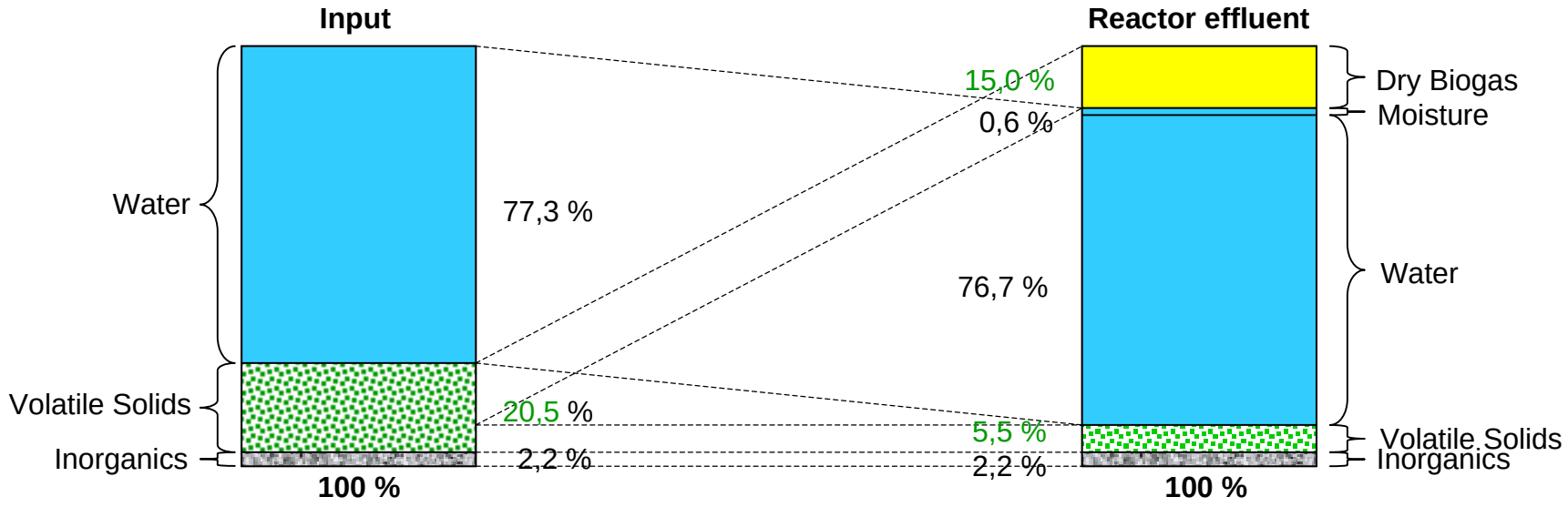
Example

Input		Starch	Oil	Raw Potato	Sludge	Total
Input (t/a)		4.495	636	97.610	6.583	**109.324**
Input (t/d)		12,32	1,74	267,42	18,04	299,52
Total solids (%)		60,0%	100,0%	20,0%	30,0%	**22,7%**
Total solids (t/a)		2697,0	636,0	19522,0	1974,9	24829,9
Total solids (t/d)		7,4	1,7	53,5	5,4	68,0
Volatile solids (% TS)		90,0%	95,0%	90,0%	90,0%	**90,1%**
Volatile solids (t/a)		2.427	604	17.570	1.777	22.379
Volatile solids (t/d)		6,7	1,7	48,1	4,9	61
Water (t/a)		1.798	0	78.088	4.608	84.494
Water (t/d)		5	0	214	13	231
spec. Gas Production rate (m³/t VS)		600	1.000	600	700	
(dry gas, Normal conditions	1,18 kg/m³					
Biogas						
Gas production (m³/a)		1.456.380	604.200	10.541.880	1.244.187	13.846.647
Gas production (m³/d)		3.990	1.655	28.882	3.409	37.936
Gas production (t/a)		1.719	713	12.439	1.468	16.339
Gas production (t/d)		4,71	1,95	34,08	4,02	44,76
Water content:	4%	69	29	498	59	654
Wet Gas 37°C (t/a)		1.787	741	12.937	1.527	16.993
Wet Gas 37°C (t/d)		4,90	2,03	35,44	4,18	46,56

Key aspect – Dimensioning – Mass Balance II

Example

Reactor effluent						
Total solids (t/a)						8.491
Total solids (t/d)						23
Volatile solids (t/a)						6.040
Volatile solids (t/d)						17
Water (t/a)						83.841
Water (t/d)						230
Output (t/a)				6 Monate:	46.166	92.331
Total solids (%)						9,2%



Key aspect – Dimensioning – Composition

Maintain constant composition of the feed

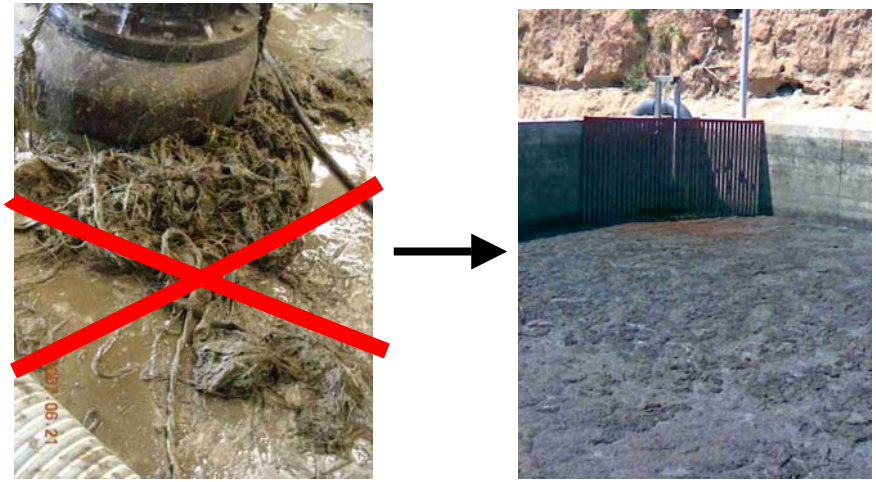
Guide Values

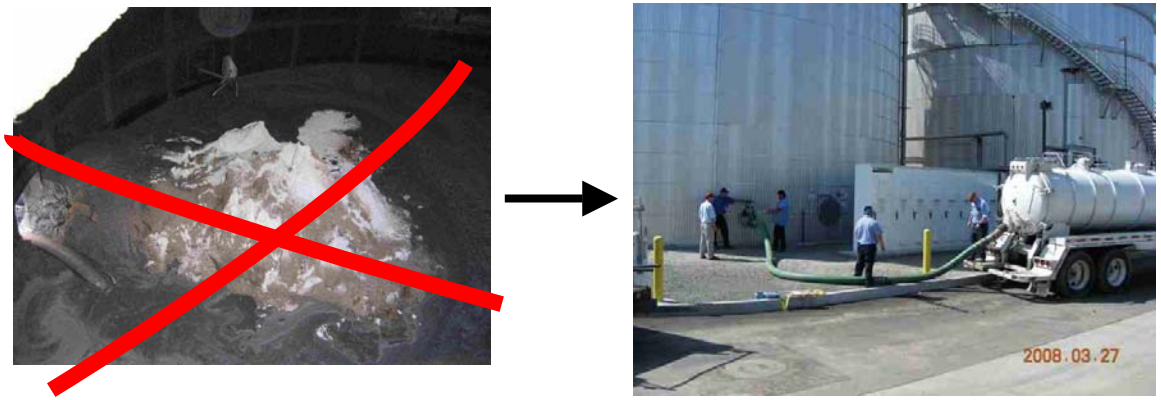
- C/N/P-ratio: 125 / 5 / 1 (by mass)
- Total Nitrogen: < 5 g/l (fresh matter)
  (CSTR, single stage fermentation)
- same / similar ratio of fast – medium – slowly degradable compounds (e.g.: sugar – cellulose – fat)
- As larger acidity of feed compared to alcalinity of digestate as more subsets in daily feed

Key aspect – Dimensioning – Technical Questions I

Hydraulic Aspects

- Clogging
- Stratification
- Viscosity (changes during digestion)





Maintain constant operation

Key aspect – Dimensioning – Technical Questions II

Reliable Installation

Approved Fitting and Piping

Grinder inline

MID

Level Limit Switch

Temperature Sensor

Pressure transmitter

Chopper Pump

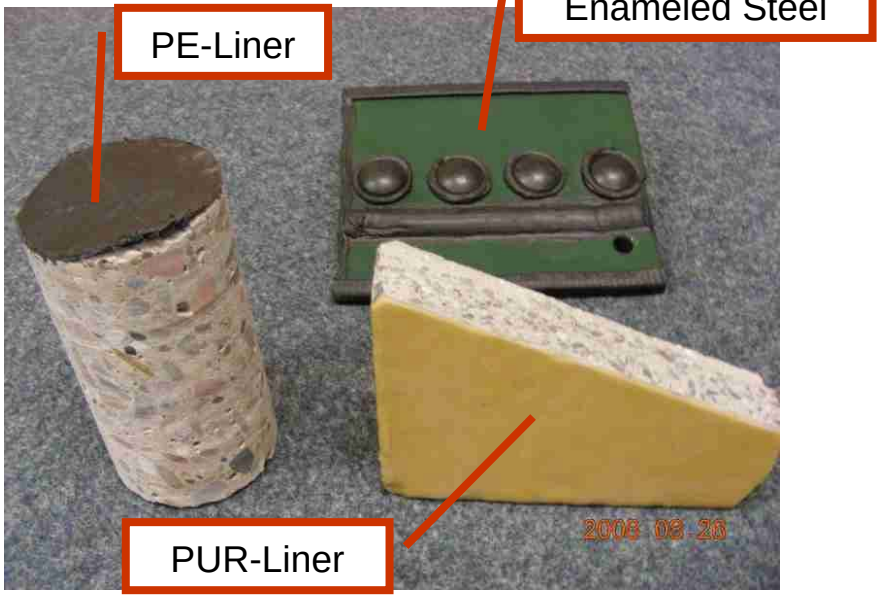
Rock-Box

Maintain constant operation

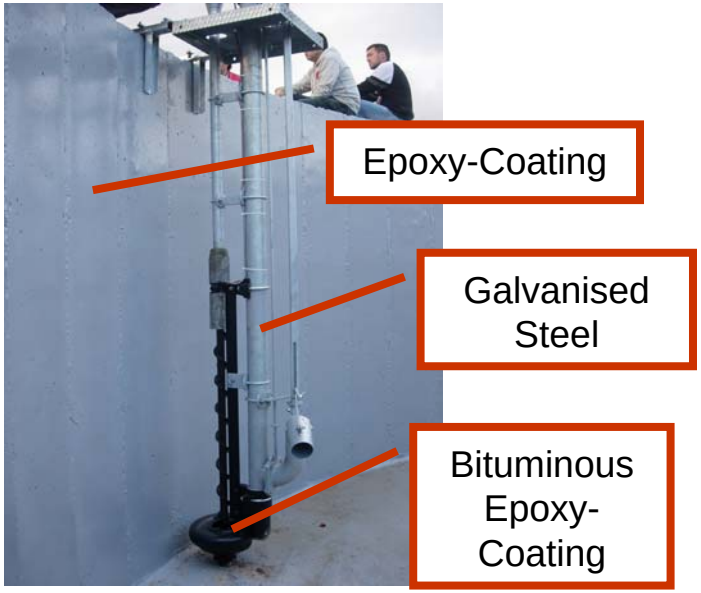
Key aspect – Dimensioning – Technical Questions III

Corrosion (chemical, statical)

Protection (gas phase)



Protection (submerged)



Key aspect – Dimensioning – Technical Questions IV

Abrasion

Major Problems of Positive-displacement Pumps
(If applicaton is inadequate)

e.g. stones

e.g. robes and wires

Key aspect – Dimensioning – Technical Questions V

Digester Design

- Waste water, 100 % SS, no solid matter
  - → Fixed bed reactor, fixed biomass
  - → Floating slugde, restrained biomass
  - → Completely mixed with biomass recovery
- Slurries, solid matter < 10 %
  - → Completely mixed tank
  - → Plug flow design
- Dung, Organic waste, Silage, solid matter > 20 %, fibrous matter
  - → Diluted matter (Dilution mostly via recirulation of digestate = Inoculation)
    - → completely mixed
    - → partly or intermittent mixed
    - → plug flow design
  - → Inoculated matter (normally blend of fresh and digested solids)
    - → solids stationary, circulated liquid
    - → plug flow design

Intermediate Result III

You must consider:

- Quality of the media (transported, mixed and stored)
  + structure, + viscosity, + abrasiveness,
  + temperature, + pressure, + pH-value, + stratification risk
- Changes in composition during AD of the media
- Quality of construction and technical equipment
  + acid protection, abrasion protection
- Dimension and Design of the equipment
  + reserve capacity, + sufficient internal cross section
  surface / volume, sedimentation zones
- Easy and safe maintenance and repair

Key aspect – Operation

Rules to run a digester

- Maintain constant feed rate and composition
- Avoid overfeeding and abrupt changes
- Avoid foaming

  Don´t: add substrate with a low pH value
  add substrate with a considerably high protein content
  overfeed the digester
  mix improper and/or inconsistent
- Choose an appropriate temperature and keep it constant
- Mix as much as necessary and as little as possible

  Keep in mind: all in - all out.
- Maintain continuity in mixing (continuous or intermittent)

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Thank you - Cok tesekkürler for listening and patience