Two phase anaerobic digestion

Bernd Linke
Leibniz-Institute for Agricultural Engineering
www.atb-potsdam.de

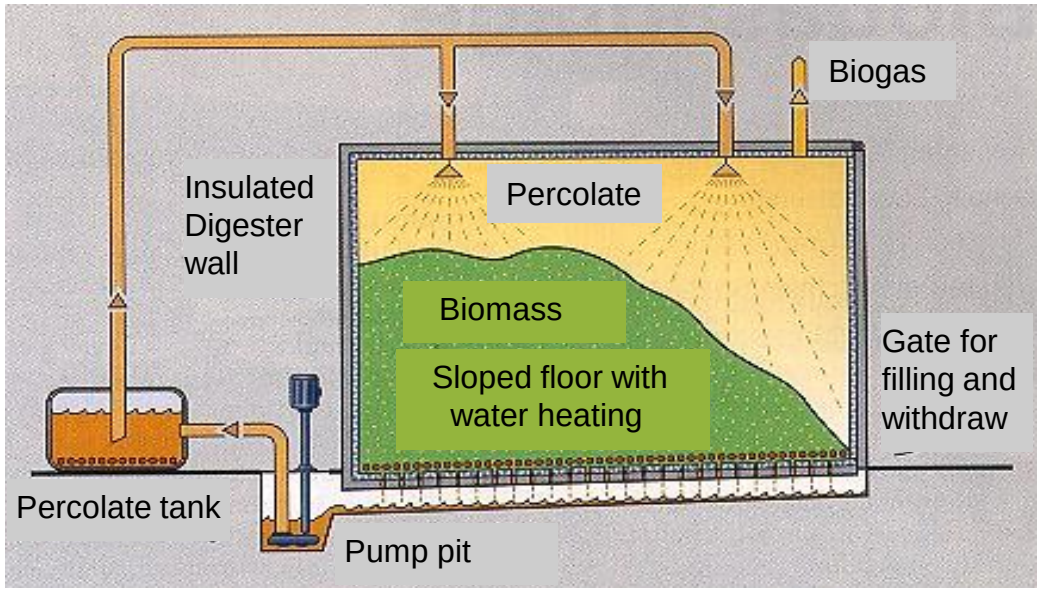
- Brief description of two-phase systems
- Case study BioFerm/ Vissmann Group
- Batch operation experiments
- Continuously operation experiments
- Advantages of Two-phase systems

Brief description of two phase systems

Anaerobic Digestion (AD) for structural biomass, Percolation of biomass (solid phase) by means of a liquid phase with low parasitic energy consumption due to the lack of moving parts

- **Process A (batch)**: Mixing of digested material (inoculum) with feed, percolation for 20 – 40 days,
- **Process B (batch)**: Percolation of feed without inoculum for 20 – 40 days, degradation of VFA in a methane reactor
- **Process C (continuously)**: Percolation in a floating bed digester, (Biomass lift up), degradation of VFA in a methane reactor at high OLR

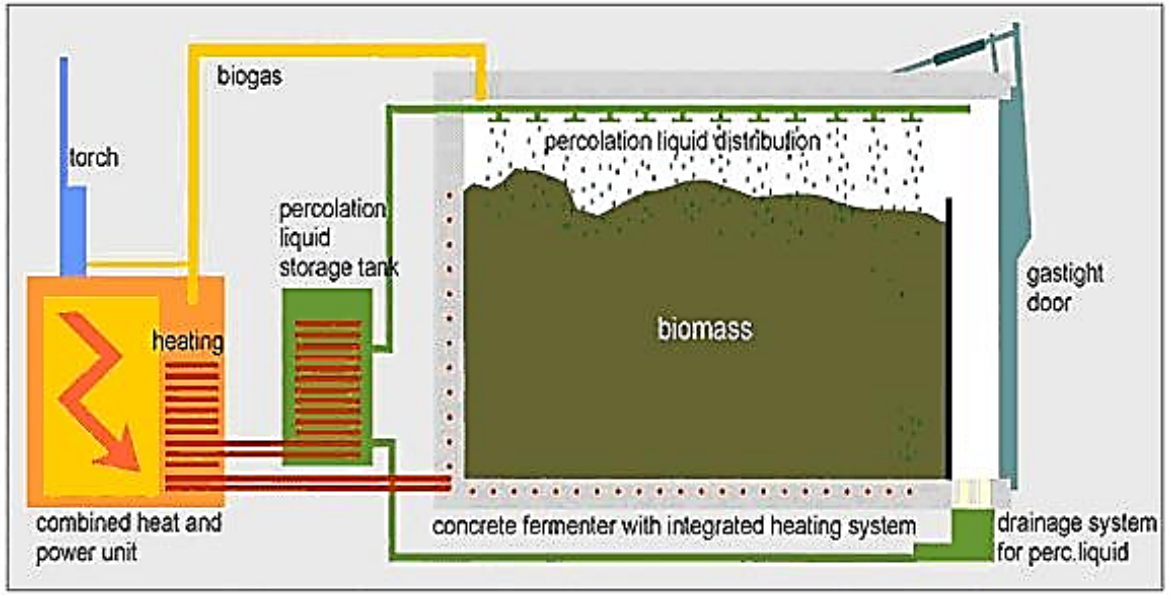
Two phase, one step, Bioferm/Vissmann Group
Biomass with inoculum (Process A)



BIOFERM™ ENERGY SYSTEMS
VIESSMANN Group

ATB

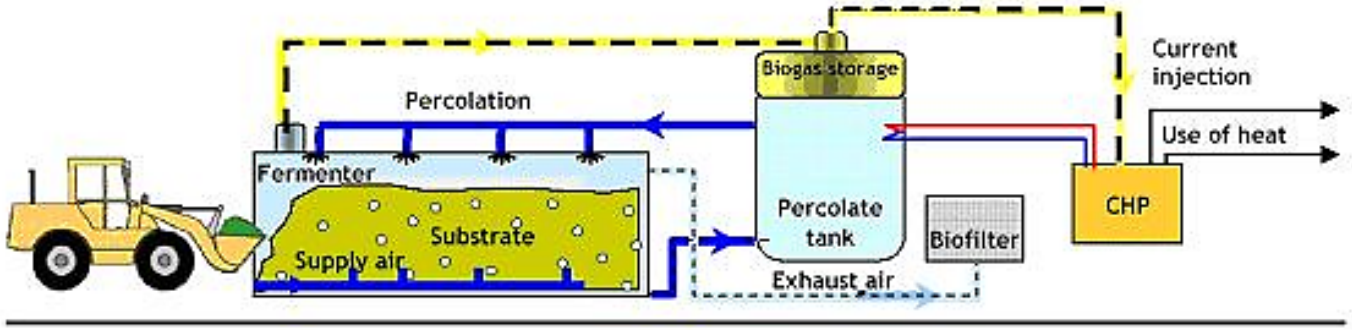
Two phase, one step, Bekon Technology
Biomass with inoculum (Process A)



BEKON
Energy Technologies GmbH & Co. KG

ATB

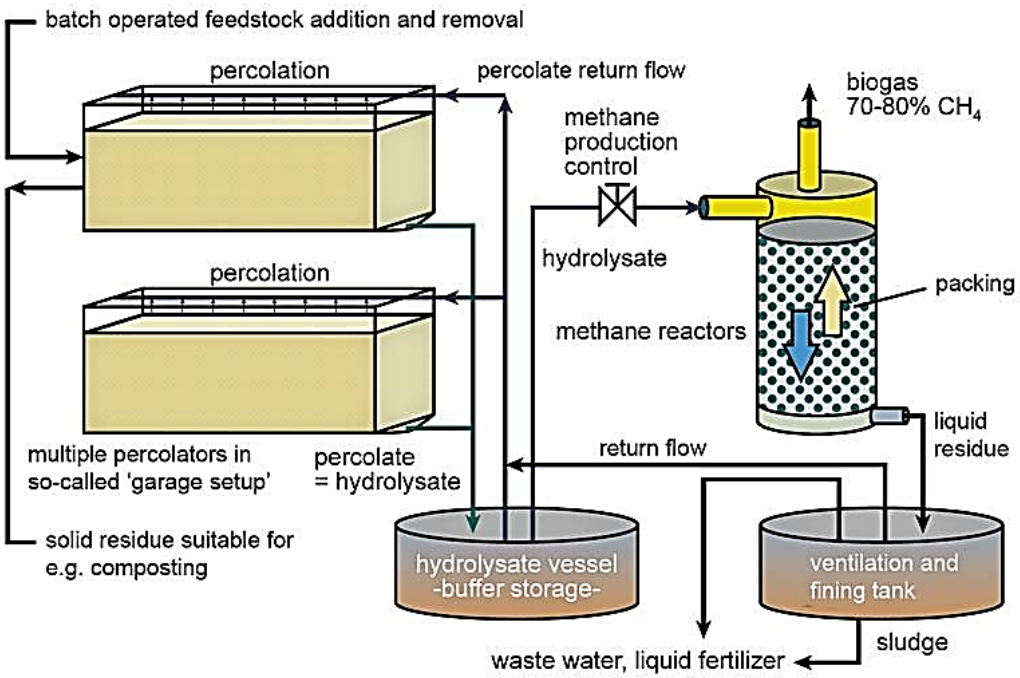
Two phase, one step, Loock Biogas systems
Biomass with inoculum (Process A)



LOOCK BIOGASSYSTEME

ATB

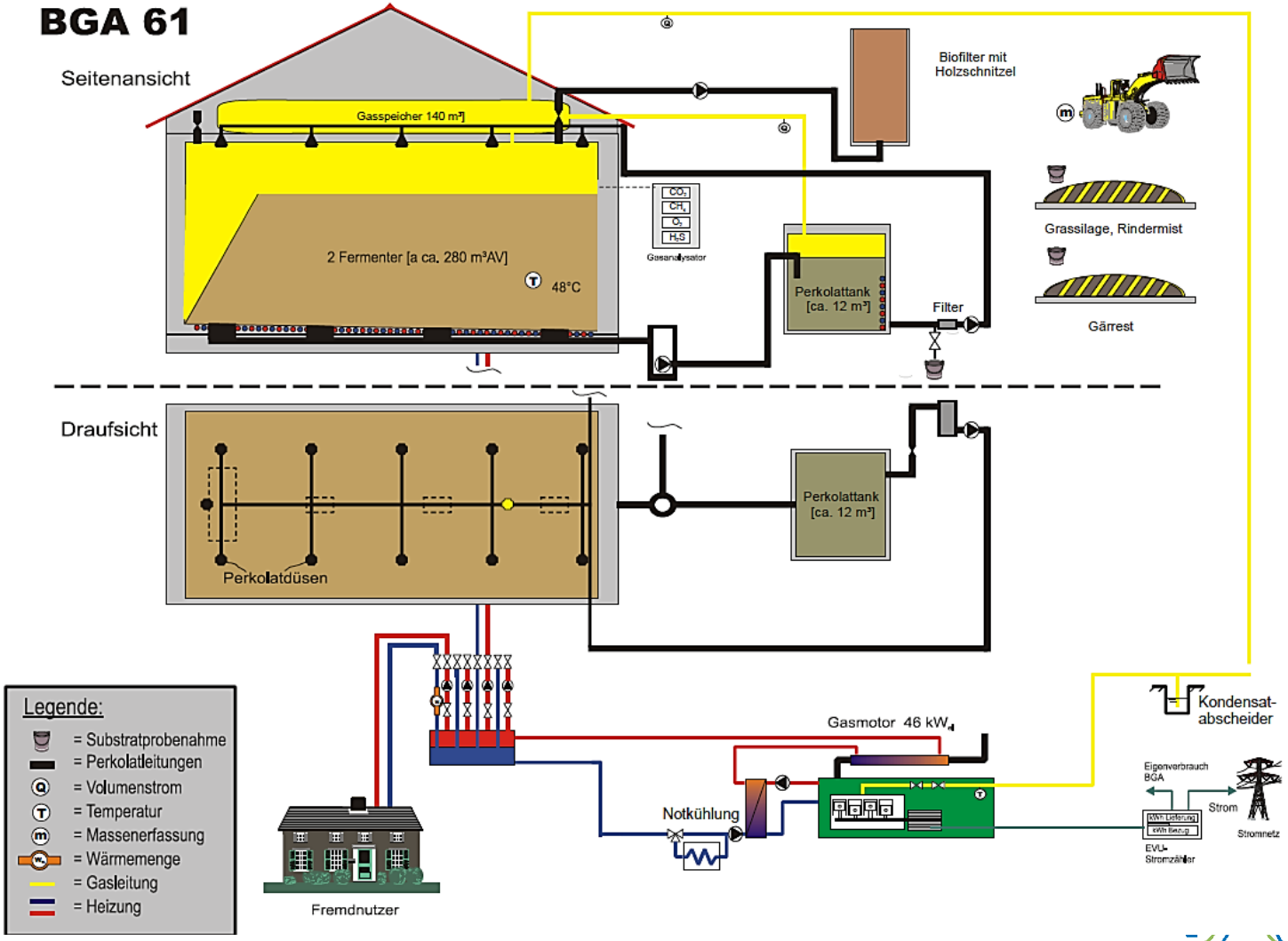
Two phase, two steps, Gicon Technology
Biomass without inoculum (Process B)



GICON
Großmann Ingenieur Consult GmbH

ATB

Case study BioFerm/ Vissmann Group (A)



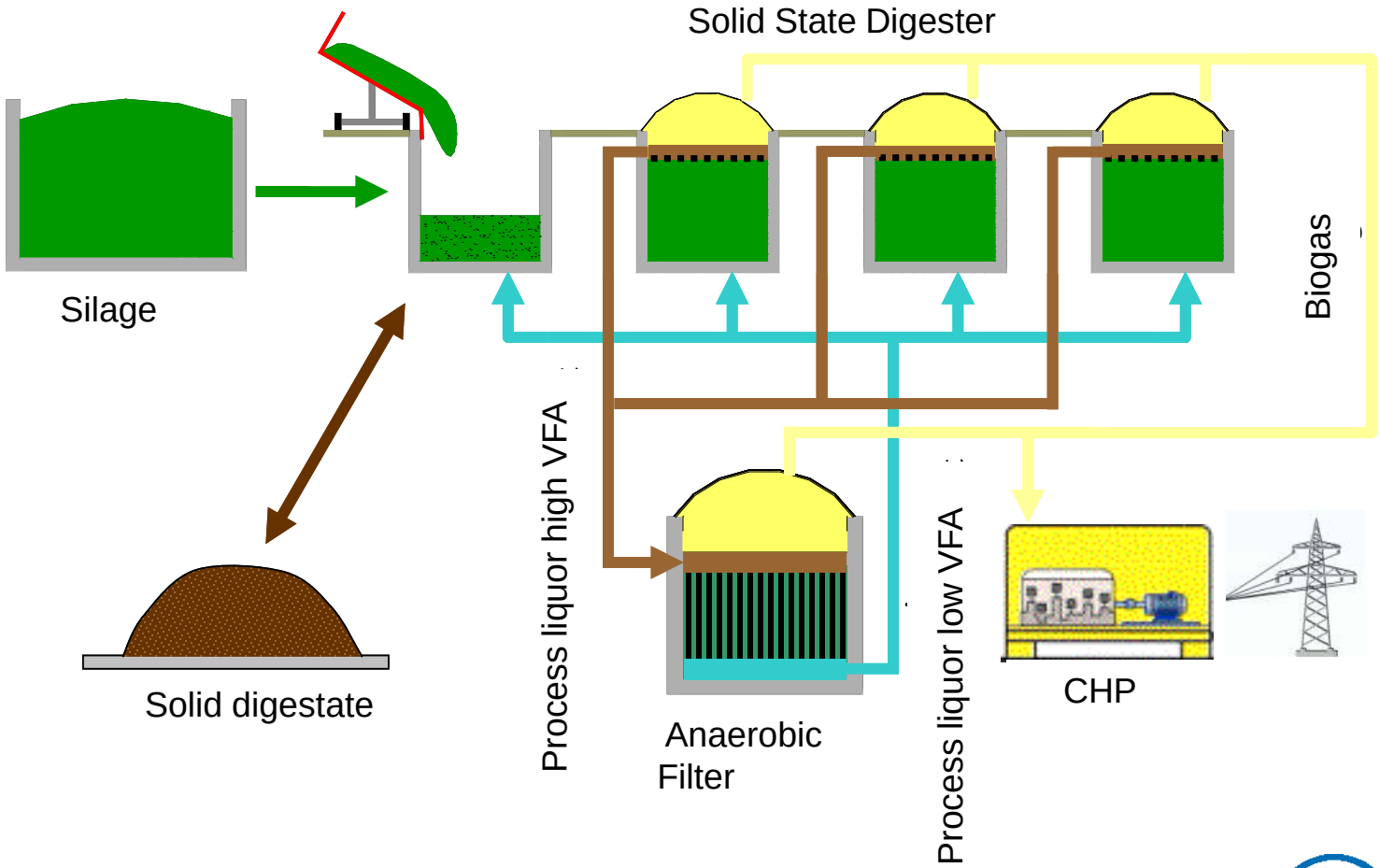
Case study BioFerm/ Vissmann Group (A)

Parameter	Data
Farm data	5 ha cropland, 125 ha grassland, 70 sheep, 12 cows
Substrate feed	1034 t/a, 52% grass silage, 31% fresh grass, 14% cattle manure, 3% hay, % fresh mass (FM)
	TS = 37% FM, VS = 33% FM, NH_4-N = 1kgt^{-1}, N_{tot} = 9.9 kgt^{-1}
Digester	2 digester each 408 m^3, 1 percolation tank 12 m^3
Digester operation	Residence time 18 days, proportion of digestate in the mixture 39% FM, T = 48°C, pH = 7.6, OLR = 1.9 kgVSm^{-3}d^{-1}. Ac = 1.7 kgt^{-1}

Case study BioFerm/ Vissmann Group (A)

Parameter	Data
Digester performance	VS-biogas/methane yield y = 309/155 m^3t^{-1} (54.3% CH_4) biogas/methane productivity R = 0.57/0.29 $m^3m^{-3}d^{-1}$
Digestate quality	TS = 23.6% FM, VS =1 5.7% FM, NH_4-N = 1.2 kgt^{-1}, N_{tot} = 7.2 kgt^{-1} Residual methane yield (20°C, 60 days) 5.4 m^3t^{-1} FM
Biogas utilisation	CHP (46 kW_{el}.); 364 KWh_{el}/day, current sale in power grid, 1368 KWh_{th}/week heat utilisation, replacement of fossil fuels

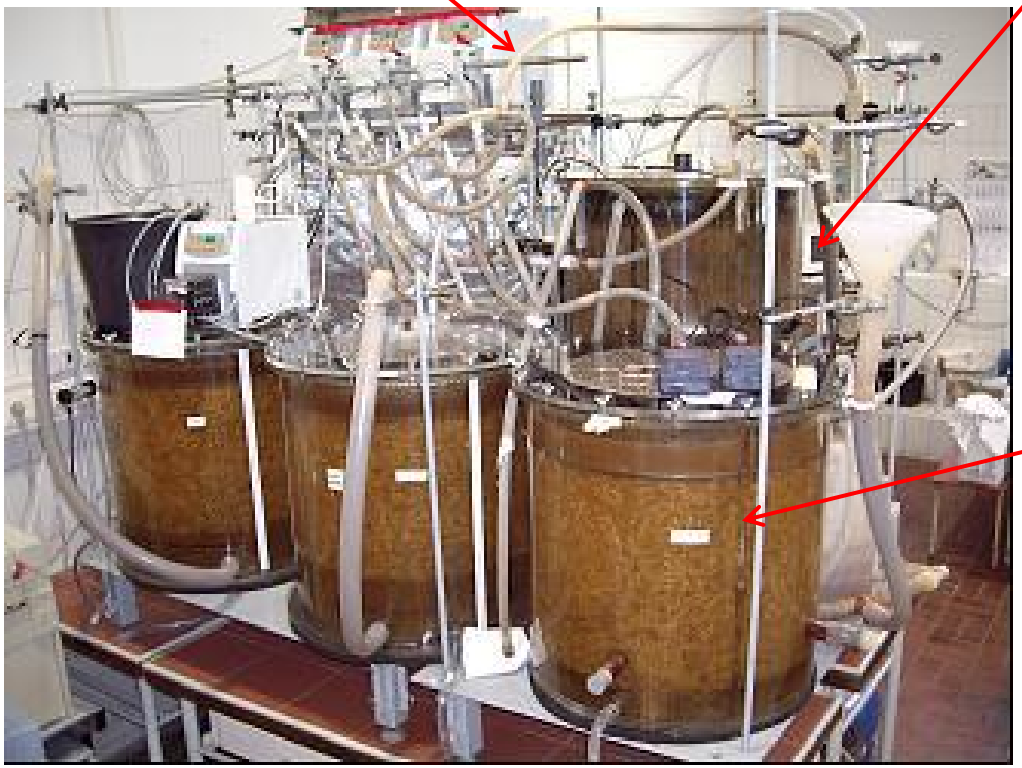
Two phase, two steps, Experimental plant



Two phase, two steps, Lab-scale

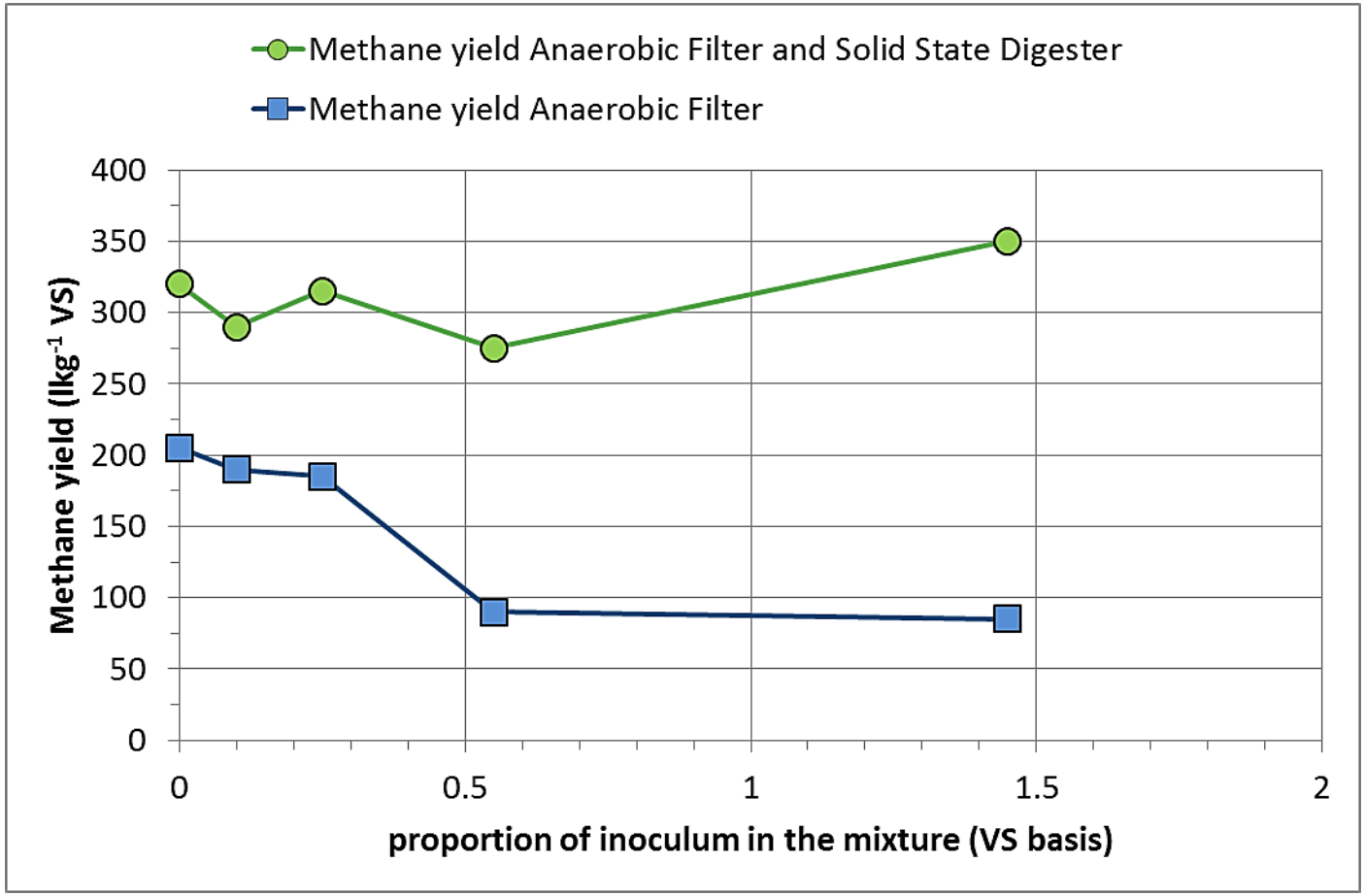
peristaltic pumps

Fixed film digester (FFD 50L)

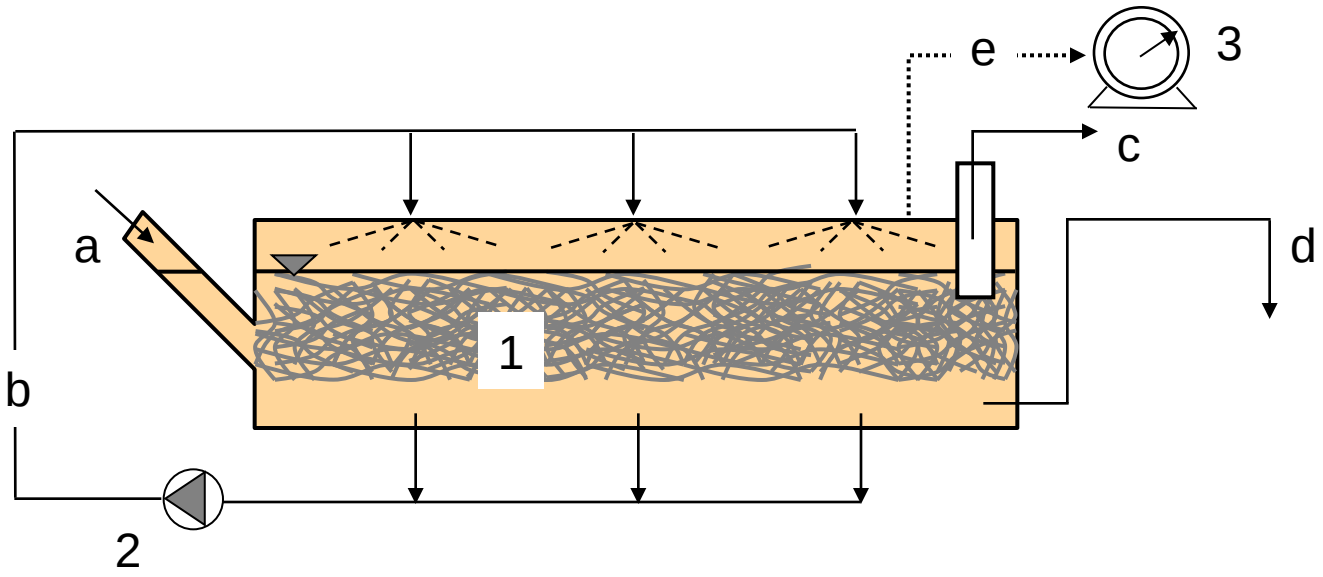


Solid state digester (SSD 50L)

Methane yield as function of inoculum proportion (whole crop silage)



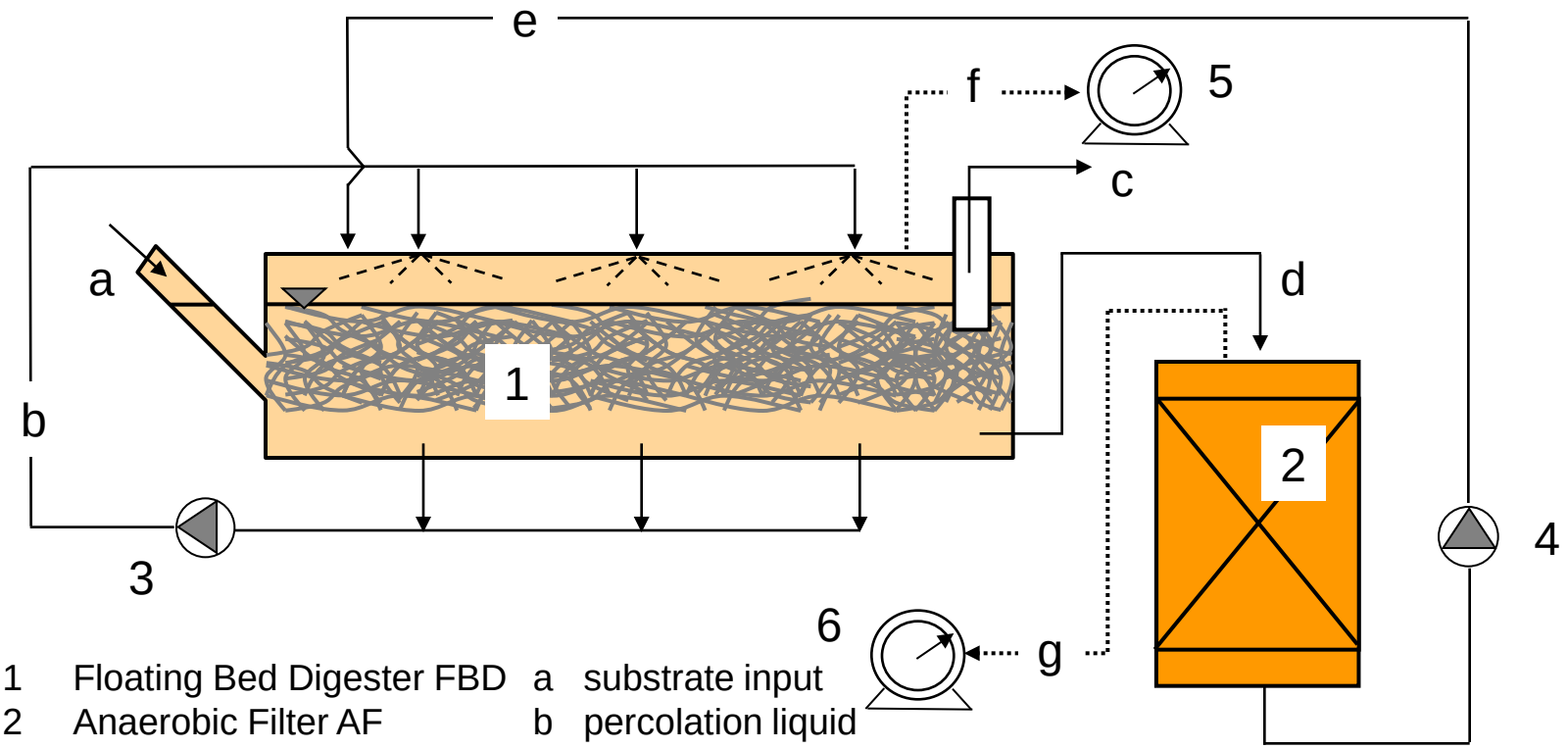
Continuously fed 540 L Floating Bed Digester (FBD)



1 Floating Bed Digester FBD
2 peristaltic pump
3 wet gas meter

a substrate input
b percolation liquid
c solid digestate
d liquid digestate
e biogas

Continuously fed Floating Bed Digester (FBD, 55L) coupled with 40 L Anaerobic Filter (AF 40L)



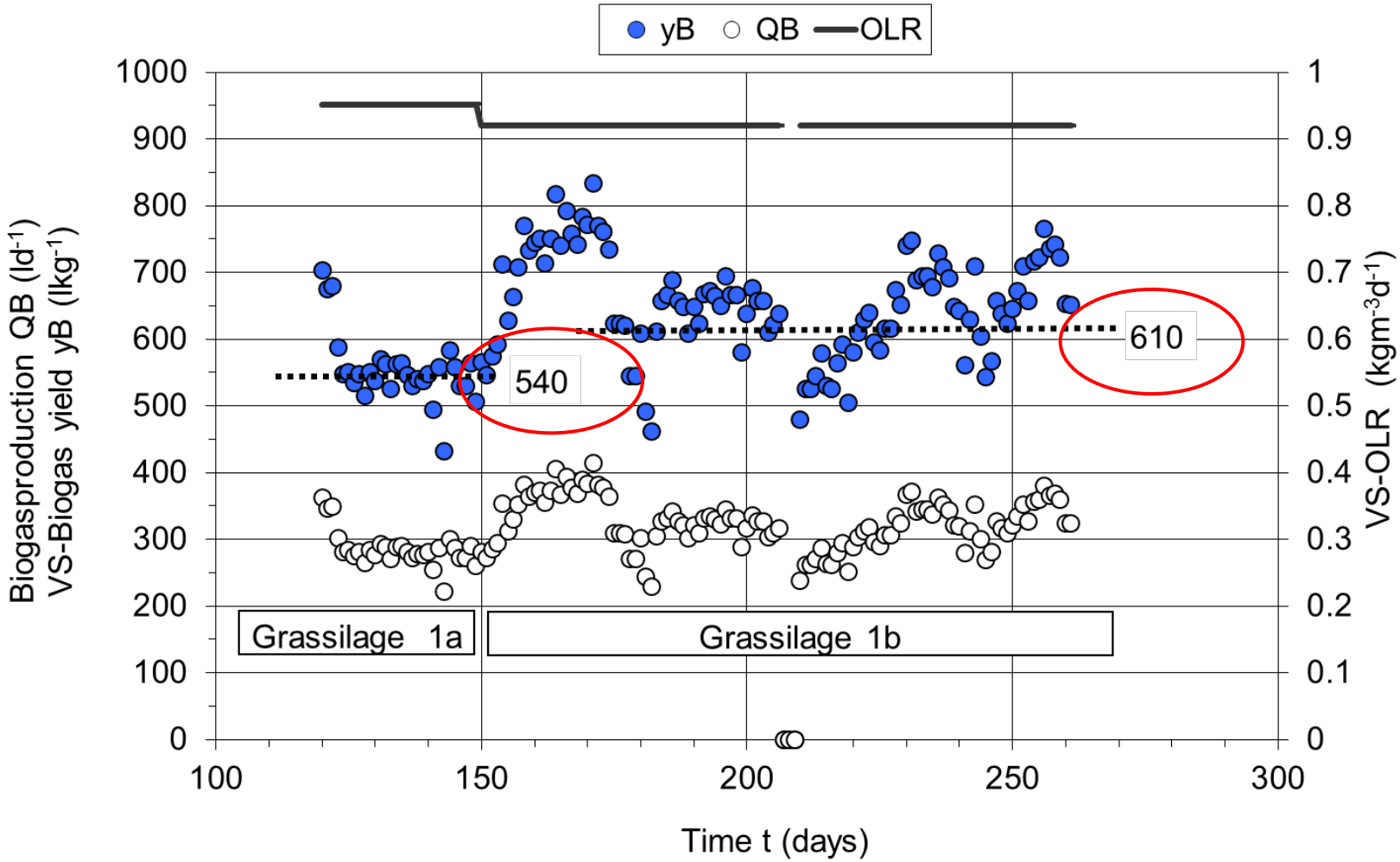
1	Floating Bed Digester FBD	a	substrate input
2	Anaerobic Filter AF	b	percolation liquid
3	peristaltic pump FBD	c	digested material
4	peristaltic pump AF	d	influent AF
5	wet gas meter FBD	e	effluent AF
6	wet gas meter AF	f	biogas from FBD
		g	biogas from AF

Analysis of Feed-Gras Silage

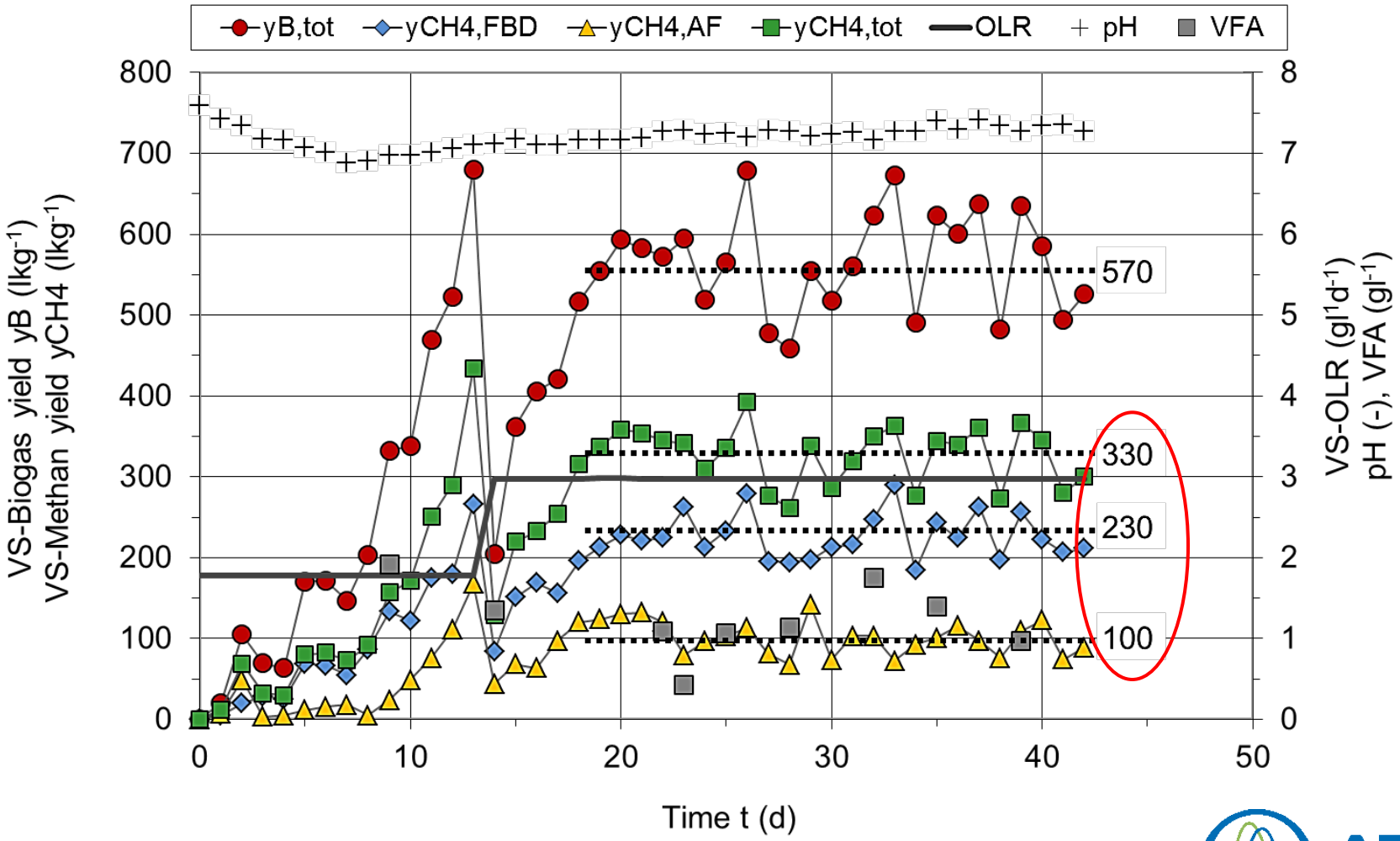
Feed	pH	TS	VS	Raw Fibre	Sugar	N_{tot}
	-	% FM	% TS	% TS	% TS	% FM
Grassilage 1a*	5.1	55.6	92.4	35.2	2.0	1.25
Grassilage 1b*	5.2	53.0	93.7	32.2	9.8	1.12
Gassilage 2**	4.2	36.0	90.9	30.0	3.1	1.08

* Feed used for FBD (540 L) trials
* Feed used for FBD (55L) with AF (40L) trials

Results from 540 L Floating Bed Digester (FBD)

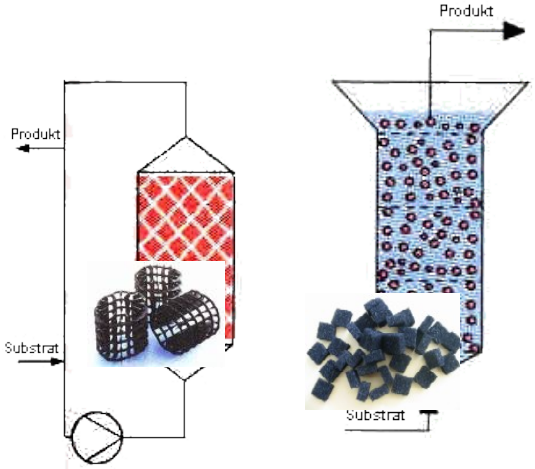


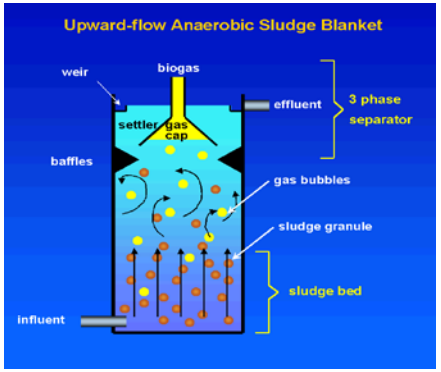
Results from Floating Bed Digester (FBD, 55L) coupled with 40 L Anaerobic Filter (AF 40L)

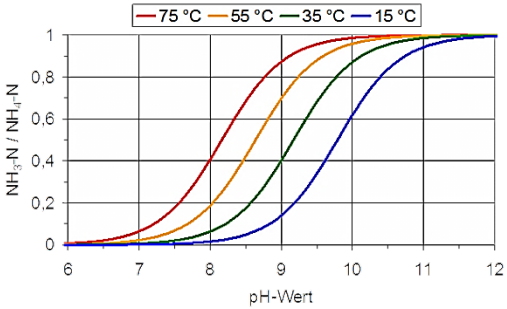


Treatment of process liquor for VFA degradation

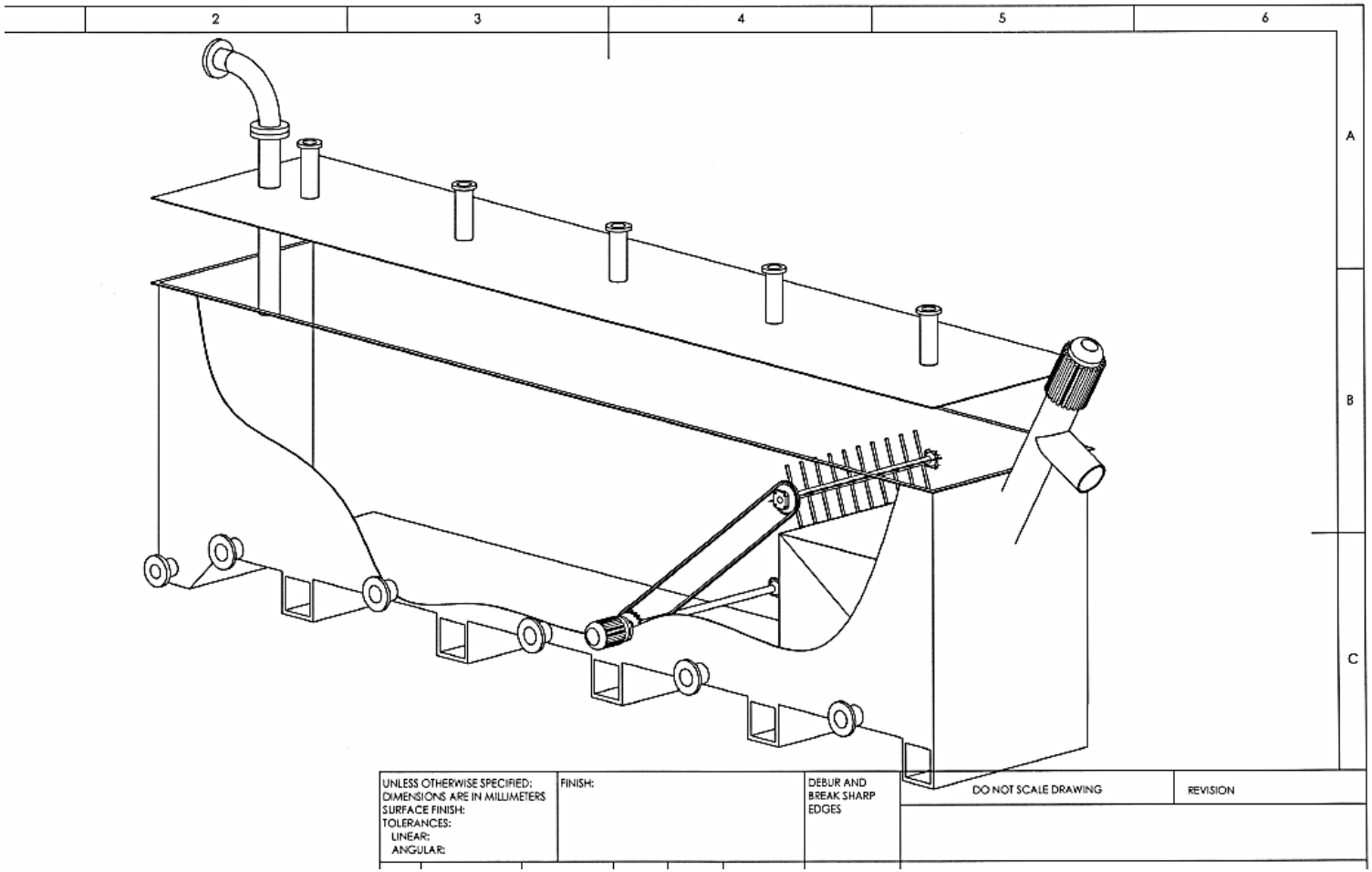
- High performance digesters with biomass retention for degradation of VFA and soluble organic compounds → inhibition at low pH-value
  - Anaerobic filter digester
  - Fluidized bed digester
  - UASB digester
- Removal of Ammonia → inhibition at high pH-value
  - Desorption (stripping) of NH3 by means of air, steam at low pressure
  - Precipitation of NH_4 by adding of $MgCl_2$ and H_3PO_4 → $MgNH_4PO_4$ (Struvit)







Draft of a FBD



Thank you
for your attention!