

Monitoring biogas plants - An overview of methods and application to industry

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Overview



- The importance of monitoring in biogas plants
- Parameters used for process monitoring in biogas plants
- Challenges in establishing a process monitoring concept
- An approach on how to set stability limits



Possible reasons for process instabilities



- Feeding problems/changing feedstock
- Temperature changes
- Utilisation of high nitrogen feedstock
- Utilisation of high sulphur feedstock
- Trace element limitation
- Further inhibitory substances in feedstock
 - Heavy metal ions
 - Light metal ions
 - Antibiotics and disinfectants

Process monitoring can help to ...



- Identify instabilities during anaerobic digestion
- React on time before a severe crash happens
- Re-stabilise crashed plants
- Give an overall picture of the biogas process
- Accompany a successful start-up of a plant

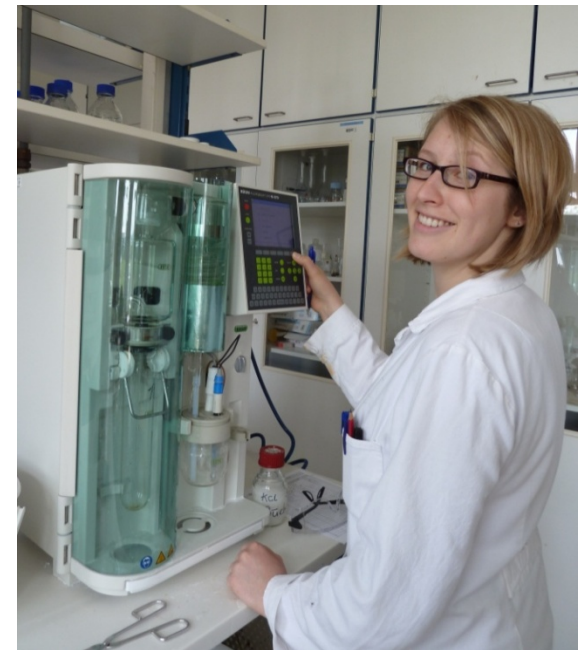


Monitoring parameters can be divided into



- Parameters characterising the process
- Early indicators of process imbalance
- Variable process parameters

Source: (Weiland, 2008)



Parameters characterising the process



- Quantity and composition of feedstock
- Biogas production and gas composition
- Fermentation temperature
- TS (total solids) / DM (dry matter)
- pH value
- Ammonium nitrogen ($\text{NH}_4\text{-N}$)

→ These parameters are necessary for finding reasons of a process imbalance



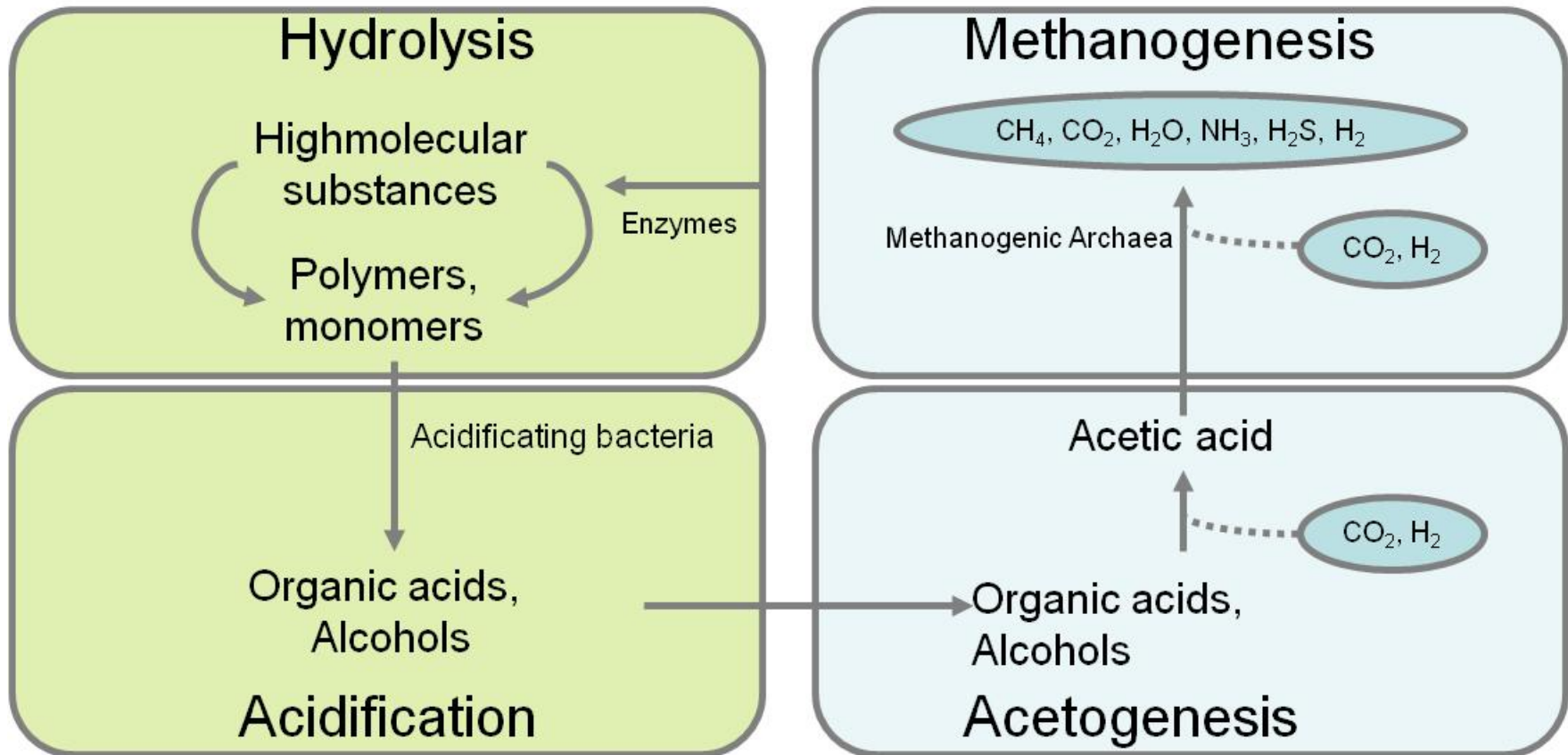
Early indicators of process imbalance



- Volatile fatty acids (VFA)
 - Alkalinity ratio (German: FOS / TAC) - titration
 - Gas measurement (CH_4 , CO_2 , H_2)
 - Redox potential
 - Complex monitoring of mixed parameters (online!)
 - NIRS (Near infra-red spectrometry)
 - Electronic nose
 - ...
- These parameters give information on current process stability, but often not the reason why!



4 steps of anaerobic digestion



Variable process parameters



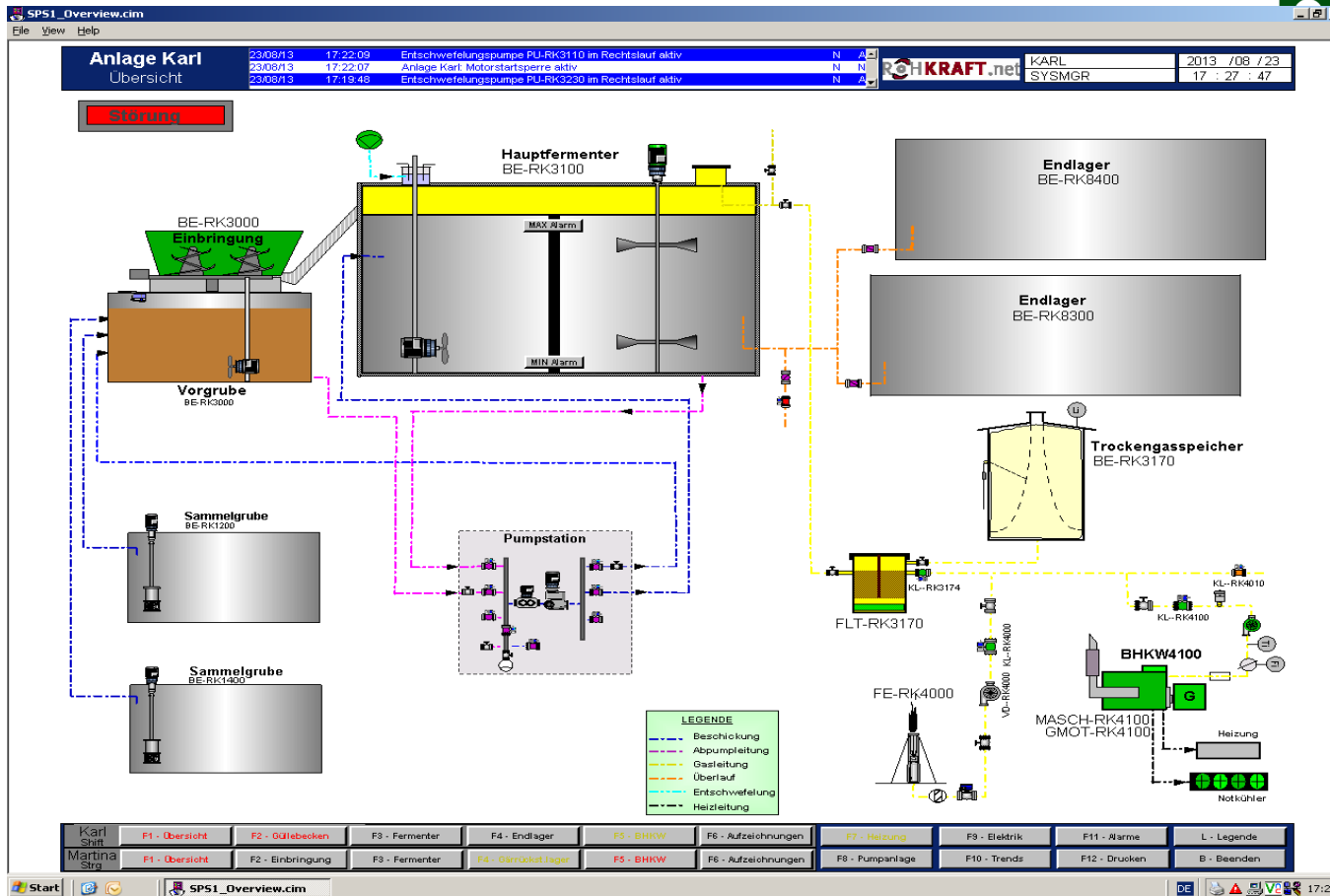
- Organic loading rate (OLR)
 - If too high, acidification can occur
 - Retention time (RT)
 - If too low, washing out of microorganisms can occur
- These parameters may be varied by the operator (to some extent)**



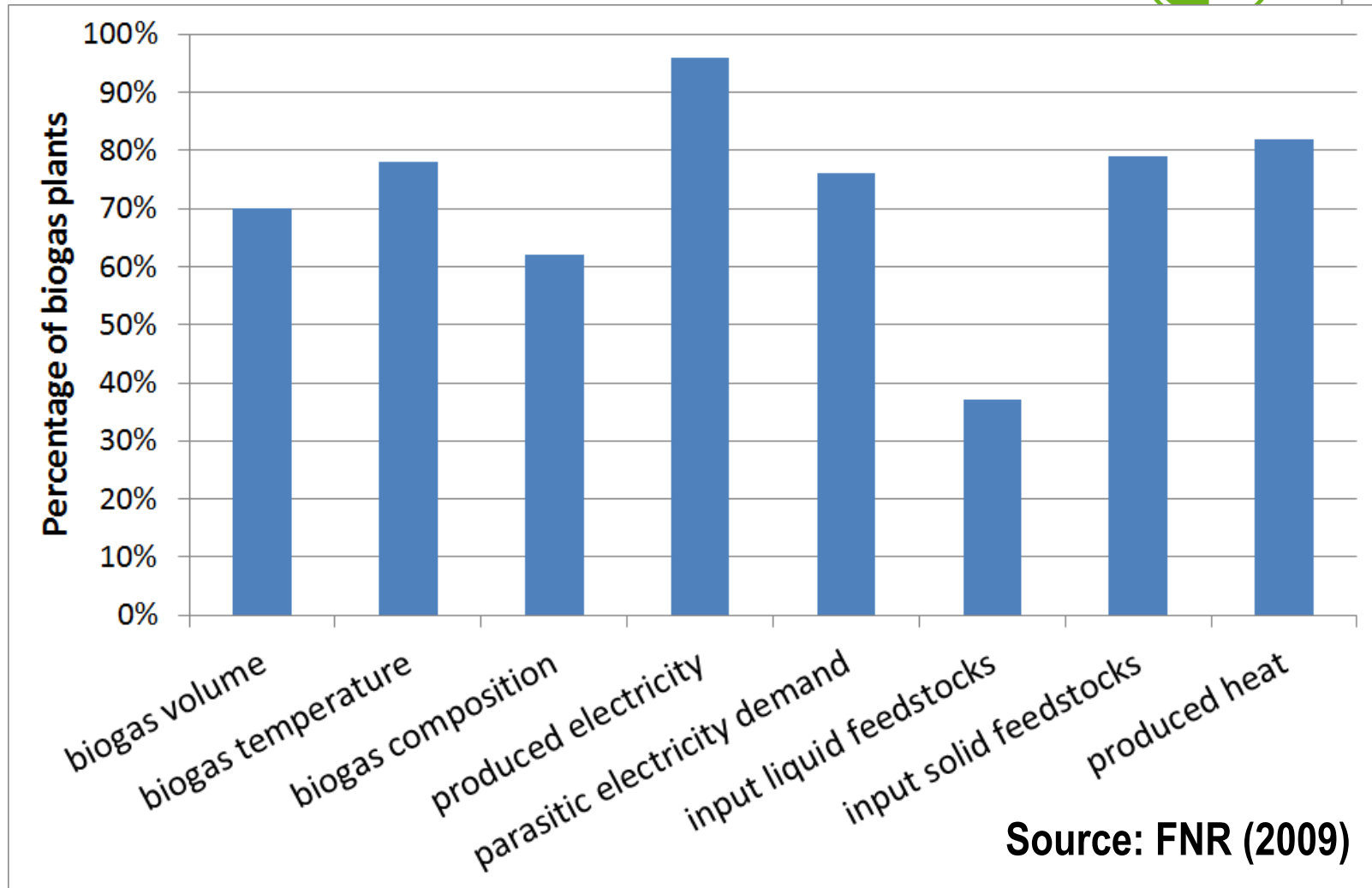
Challenges in establishing a process monitoring concept



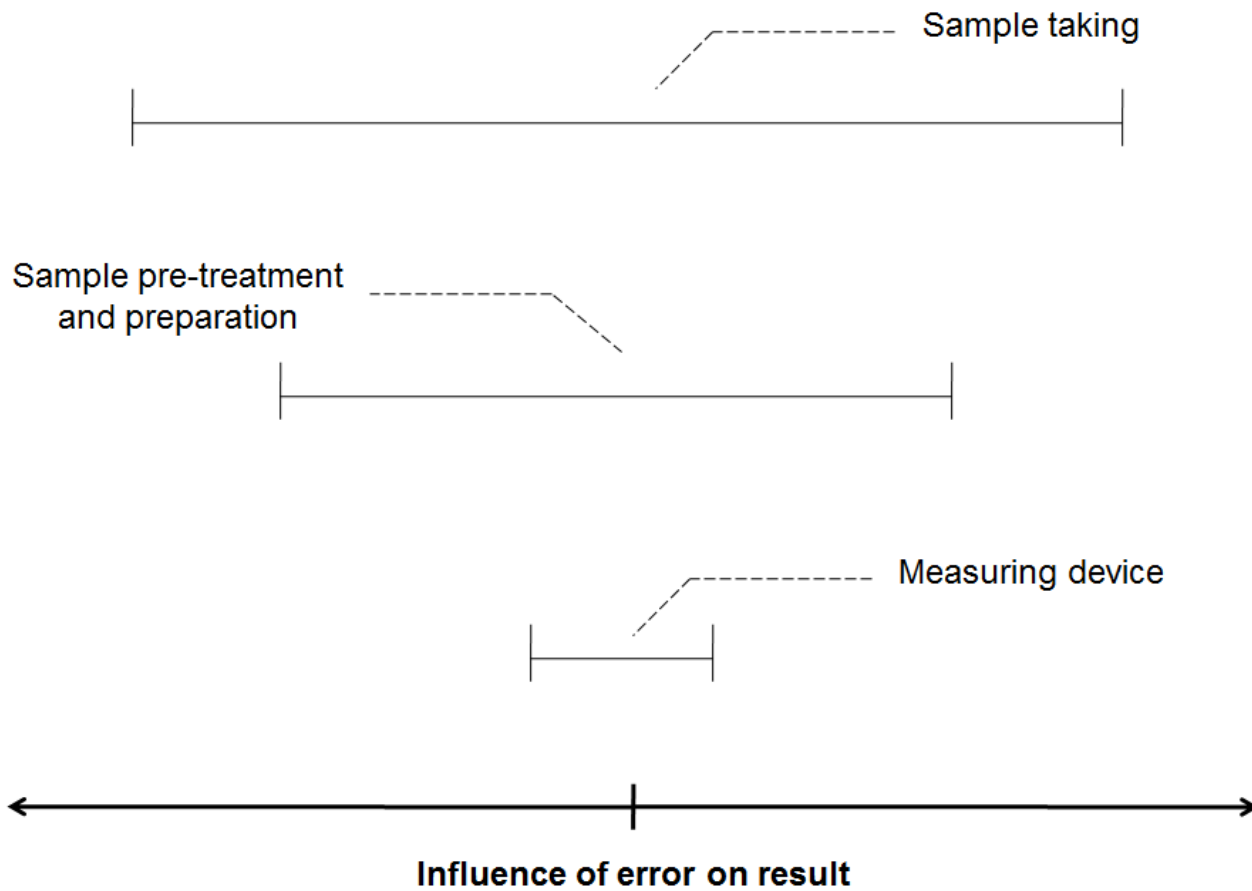
Offline vs. online data



Available infrastructure at the biogas plant



Influence of sampling





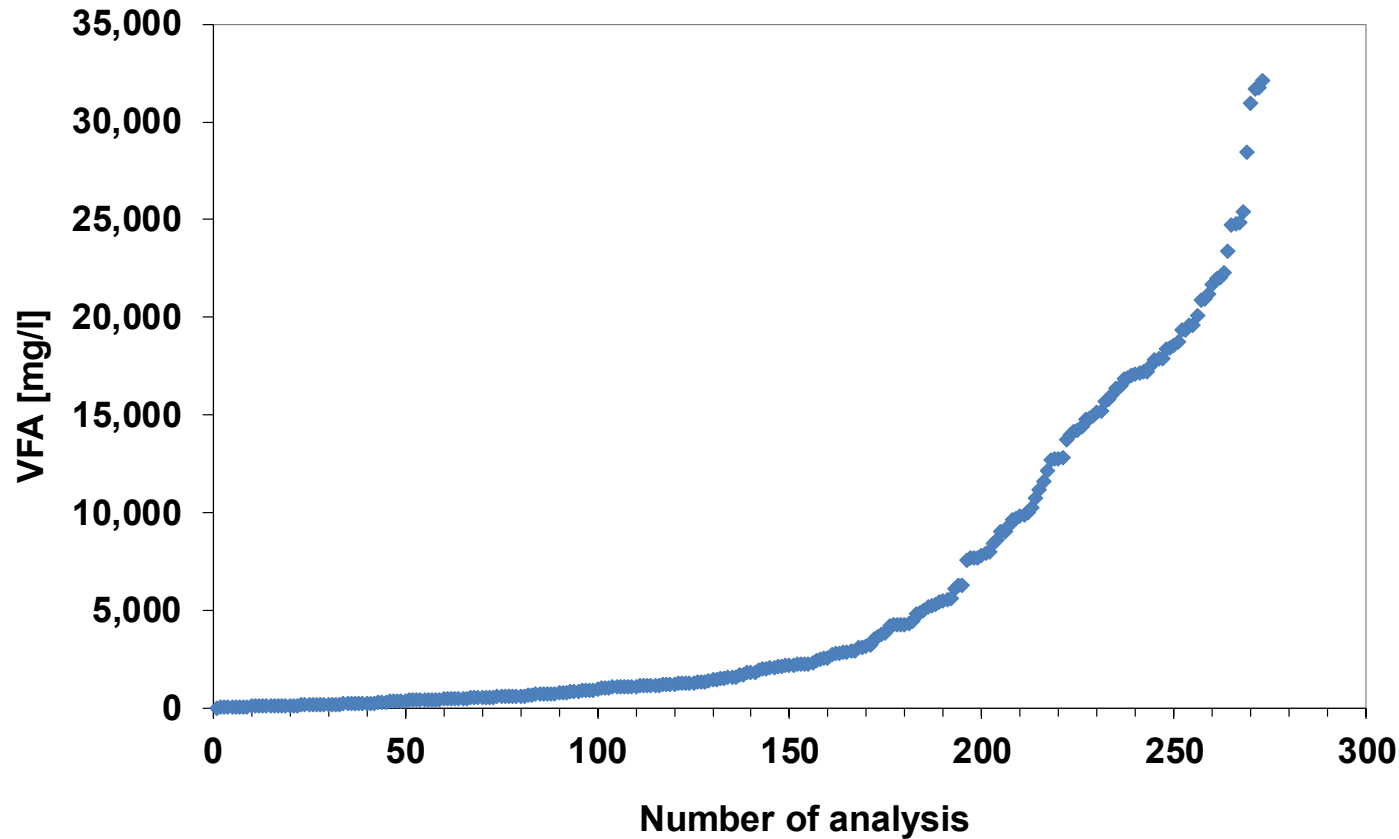
An approach on how to set stability limits



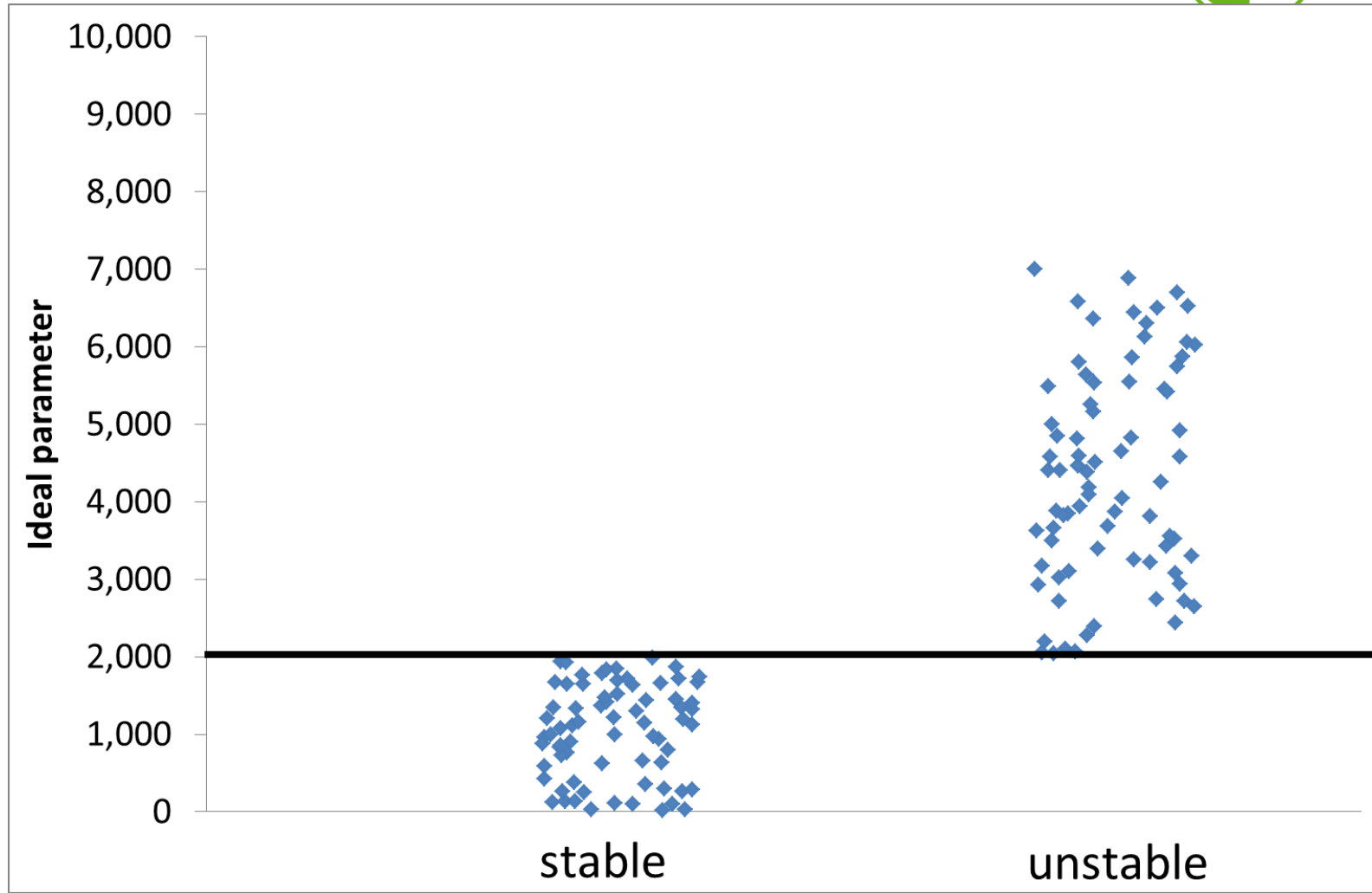
How to interpret monitoring data?



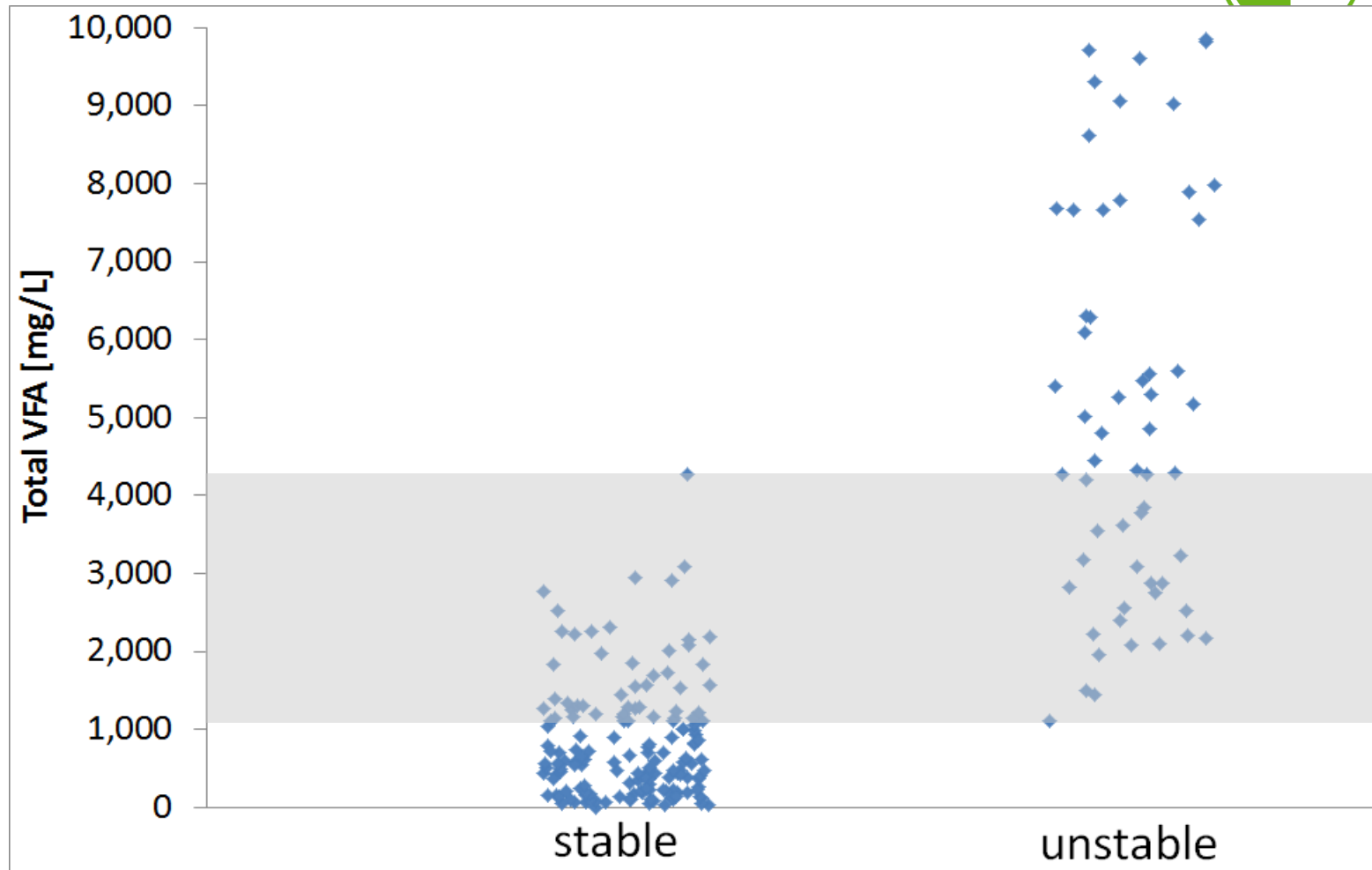
Total VFA concentrations of samples that reached an Austrian laboratory for biogas plants (Laaber, 2011)



Stability limits - What we wish to have ...



The reality - Total VFA concentrations



Data from 51 Austrian biogas plants - based on Laaber (2011)

Limits - early indicators of process imbalance



	Range of the parameter
Total VFA [mg L ⁻¹]	< 1,000 mg L ⁻¹
	1,000 – 4,000 mg L ⁻¹
	> 4,000 mg L ⁻¹
Alkalinity ratio (FOS/TAC)	< 0.3
	0.3 – 0.8
	> 0.8
H ₂	< 100 ppm
	100 - 500 ppm
	> 500 ppm

Source: Drogg (2013)
for mesophilic CSTR

Training of biogas plant operators



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General recommendations for avoiding process imbalances



- Continuous feeding
- Continuous feedstock mix (e.g. manure and biowaste)
- Careful change of feedstock mixes
- Avoid temperature changes
- Constant intervals and intensity of agitating
- Continuous process control

Source: (Clemens, 2012)

Conclusions



- The anaerobic process is a complex chain of subsequent and interacting degradation steps
 - biological monitoring of a biogas plant is highly important
- Some monitoring parameters are essential for indicating an upcoming process imbalance, whereas others help to find the reason for it
- Various challenges exist: available infrastructure, influence of sampling, online vs. offline data, skills of the operators
- No clear stability limits can be defined, rather recommended ranges

IEA Bioenergy Task 37 – Technical brochure on process monitoring of biogas plants



Available at: <http://www.iea-biogas.net/technical-brochures.html>

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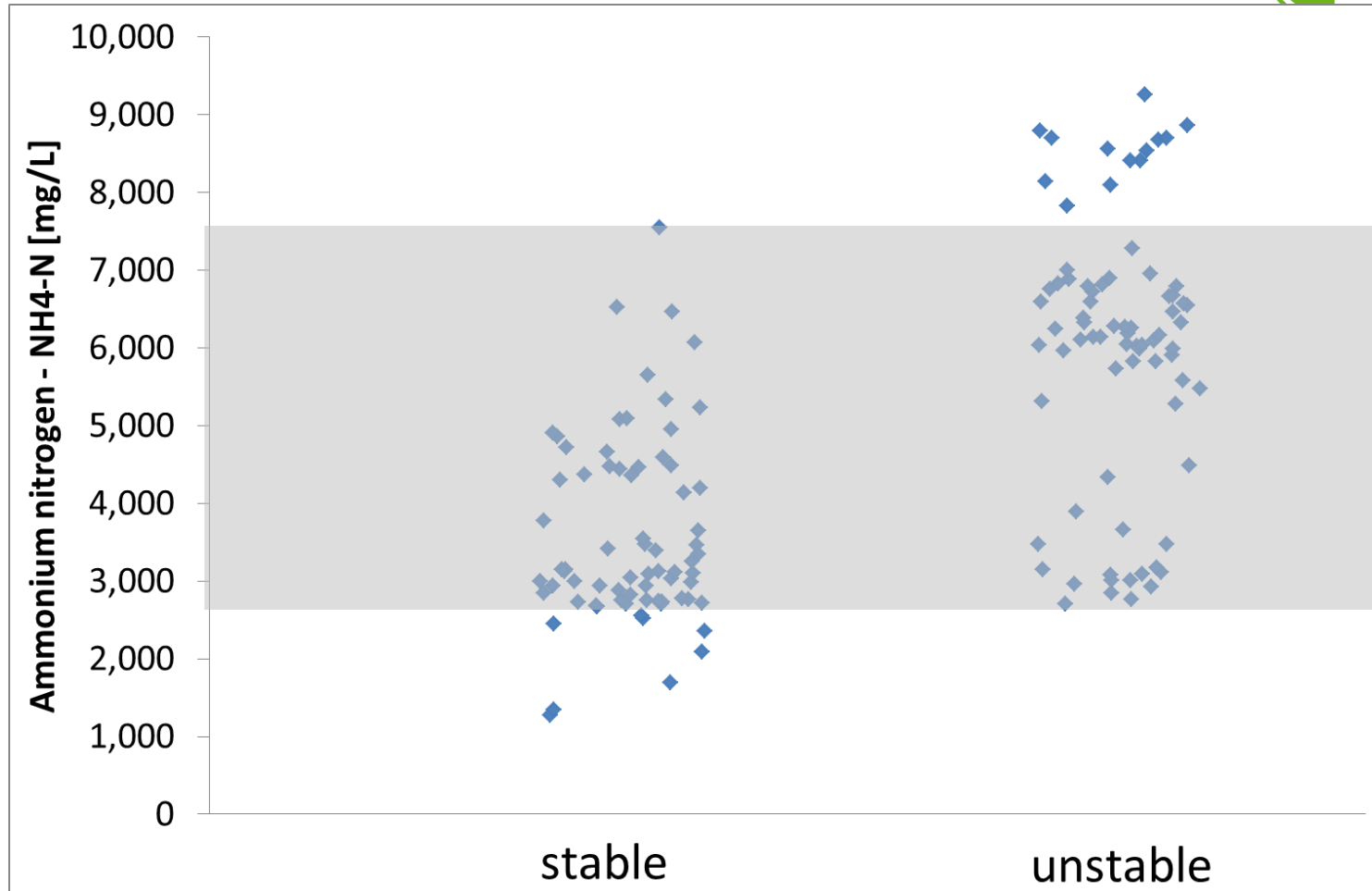
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References



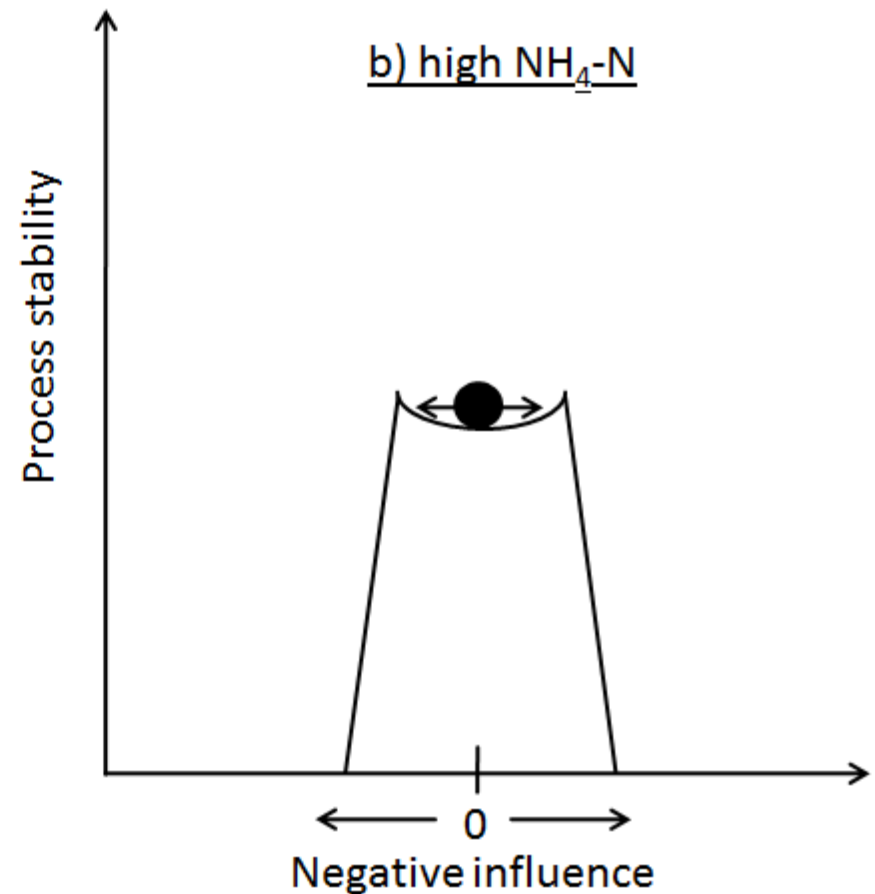
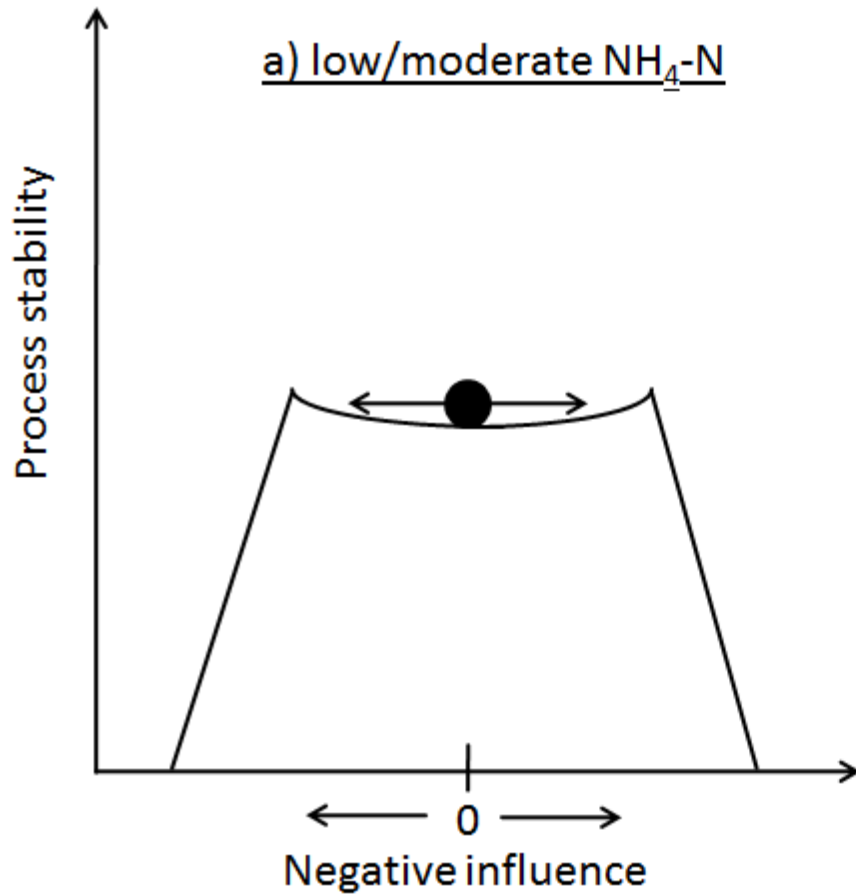
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The reality - NH₄-N concentrations



Data from 51 Austrian biogas plants - based on Laaber (2011)

Adaptation to high NH_4 -Nitrogen is possible



Limits - parameters characterising the process



	Range of parameter
NH₄-N	< 5,000 mg L ⁻¹
	> 5,000 mg L ⁻¹
pH	7 - 8
	< 7
	> 8
TS	< 10
	> 10

Source: Drosig (2013)
for mesophilic CSTR