IWAMA
Interactive Water Management

Interreg
Baltic Sea Region

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Energy Production in WWT

Thermal disintegration of surplus sludge – results of pilot and full scale investigations at WWTP Grevesmühlen with the Haarslev HCHS system

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Fakultät für Ingenieurwissenschaften
FB Maschinenbau / Verfahrens- und Umwelttechnik

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HOCHSCHULE WISMAR
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DBU research project (AZ 31037-23)

WWTP Grevesmühlen

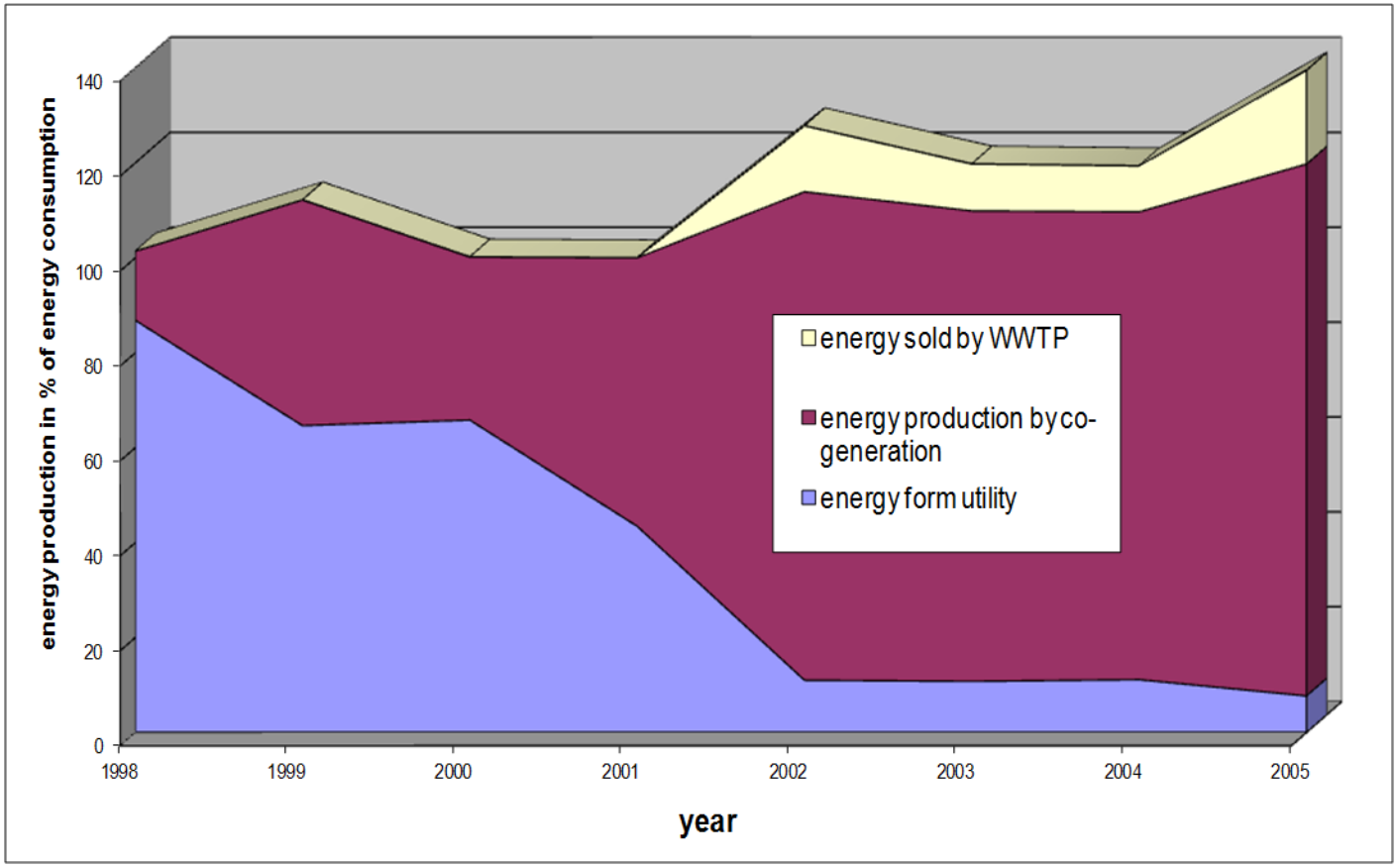
- Capacity 45.000 PE (current extencion to 65.000 PE)
- central sludge treatment plant for 100.000 PE (also for external WWTPs Dassow, Lüdersdorf, Boltenhagen, …)
- Co-fermentation of sludges from grid traps (hotels, restaurants) and industrial pre-treatment plants (mainly food industry – i.e. dairy and bread)

→ Production of 200% of electricity of WWTP consumption

- Coverage of the power consumption of pumping stations and water work Wotenitz of Grevesmühlen
- Savings of some 100.000 €/a electricity costs

Quelle: ZVG; Ausbauzustand des Klärwerks 2002

Energy balance – WWTP Grevesmühlen



Quelle: Zweckverband Grevesmühlen

Basics of sewage sludge disposal

- **A WWTP, that can not dispose its sewage sludge environmentally sound, does not make sense (Karl Imhoff, 1925)**
- Dried digested sludge is the ideal initial situation for an environmentally sound and cost optimal solution for sewage sludge disposal as dried digested sludge is:
  - almost indefinitely storable
  - most reduced in quantity –weight and volume
  - high in calorific value

but:

→ Drying of digested sludge is energy intensive

Basics of sewage sludge treatment

Tasks of the optimization of the sewage sludge treatment are:

Increase of the degree of degradation in anaerobic digestion

- **Less dry matter, more biogas**

Improval of the dewatering characteristics

- **Less sludge mass, less water to evaporate**

An approach to optimize sewage sludge treatment is:

Thermal sewage sludge disintegration

Basics of sewage sludge disintegration

Tasks of the thermal sewage sludge disintegration are:

- **Destruction of (intact) cells**
  - making available the cell juice for anaerobic degradation,
  - improving the dewatering characteristics of the sludge
- **Decomposition of sewage sludge components**
  - making sewage sludge components available for anaerobic degradation,
  - improving the dewaterability due to a reduction of the water binding capacity of the sludge components

Pinnekamp observed already in the 1980 an improval of the biogas production due to thermal disintegration and demonstrated the potential of thermal sewage sludge disintegration.

(Treatment at 120 – 170 °C for 0,5 h → +40% biogas from SS)

Bench scale experiments

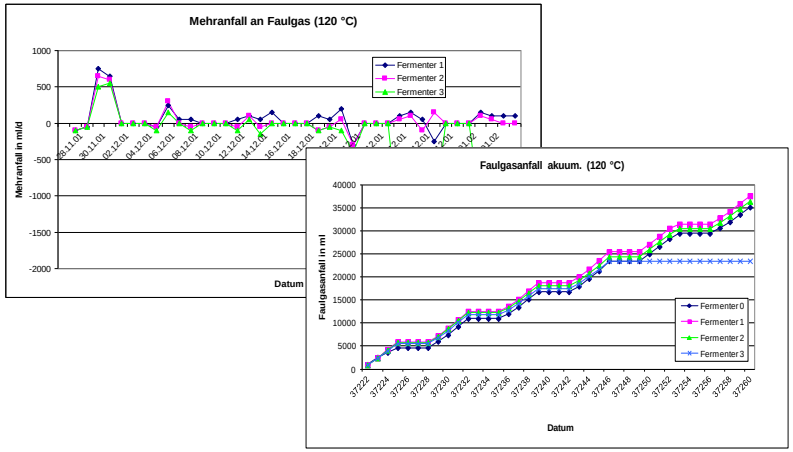
2006

- First experiments in the wastewater lab of Hochschule Wismar
- Investigation of the influence of a thermal pre-treatment of SS (surplus sludge) on anaerobic digestion

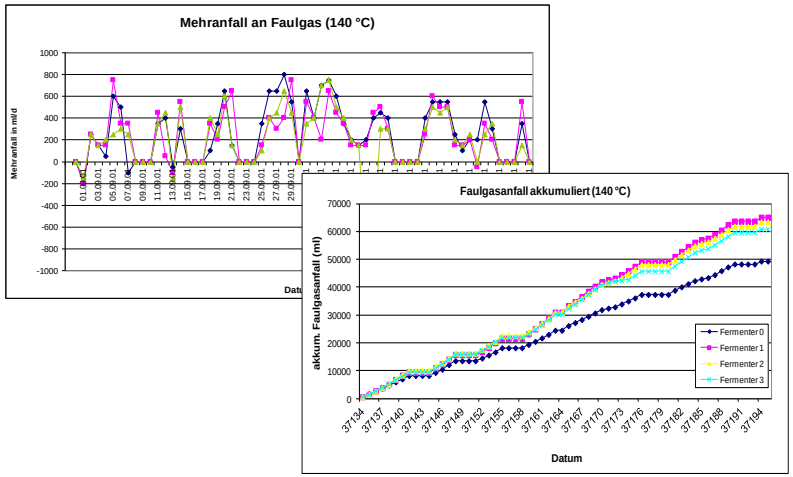
2014

- Discontinuos and continuos experiments for several month investigating the effects of thermal disintegration of SS on anaerobic digestion

Bench scale experiments 2006



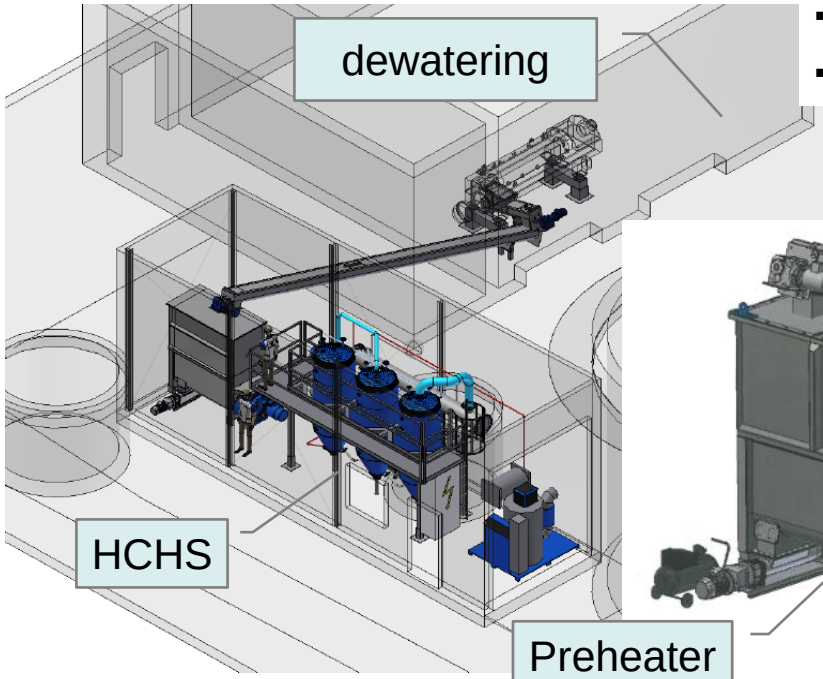
- **Disintegration at 120 °C**
  - No significant effects on biogas production in anaerobic sewage sludge digestion

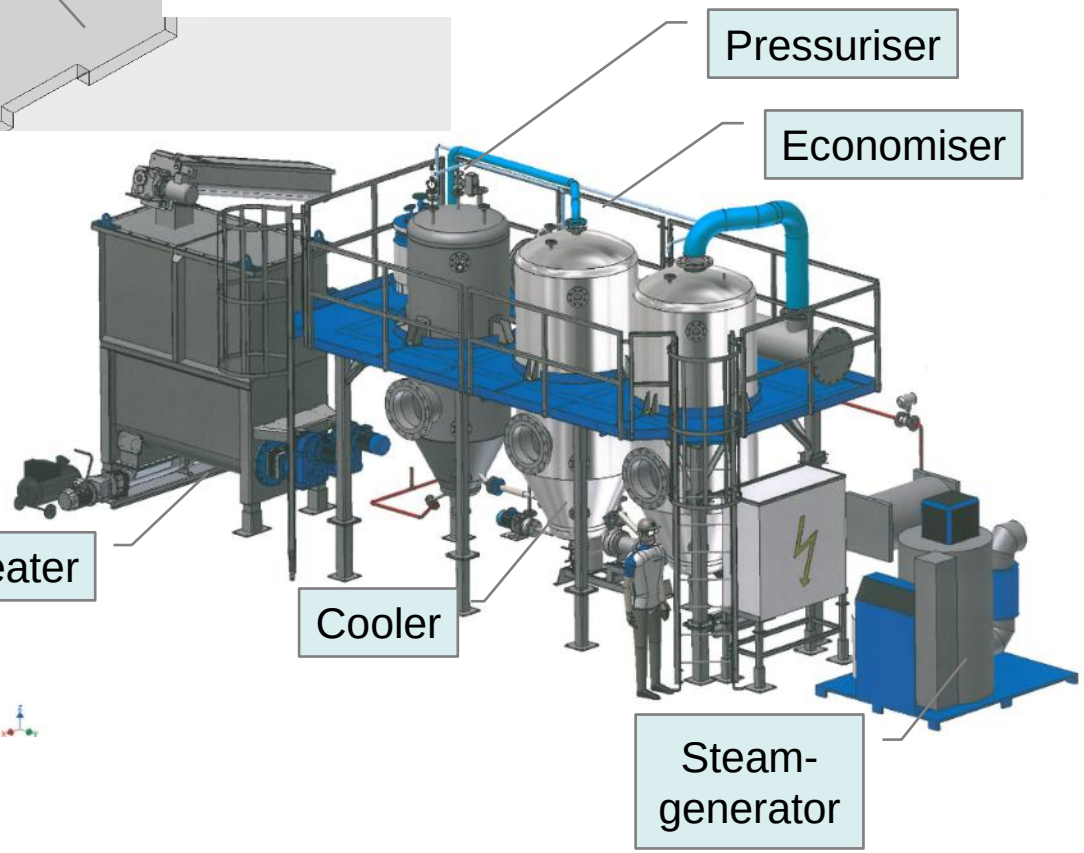


- **Disintegration at 140 °C**
  - Significant effects on the anaerobic digestion
  - 20 % increase in biogas production

Full scale HCHS at WWTP Grevesmühlen

- Throughput 1 - 2 t/h dewatered SS
- 15 – 20% DM





HAARSLEV INDUSTRIES

HCHS-plant at WWTP Grevesmühlen

1

2

3

4

Fig. 1-3: WWTP Grevesmühlen

Fig. 4: WWTP Wola Dalza, Łancut, Polen

Results – bench scale - discontinuous

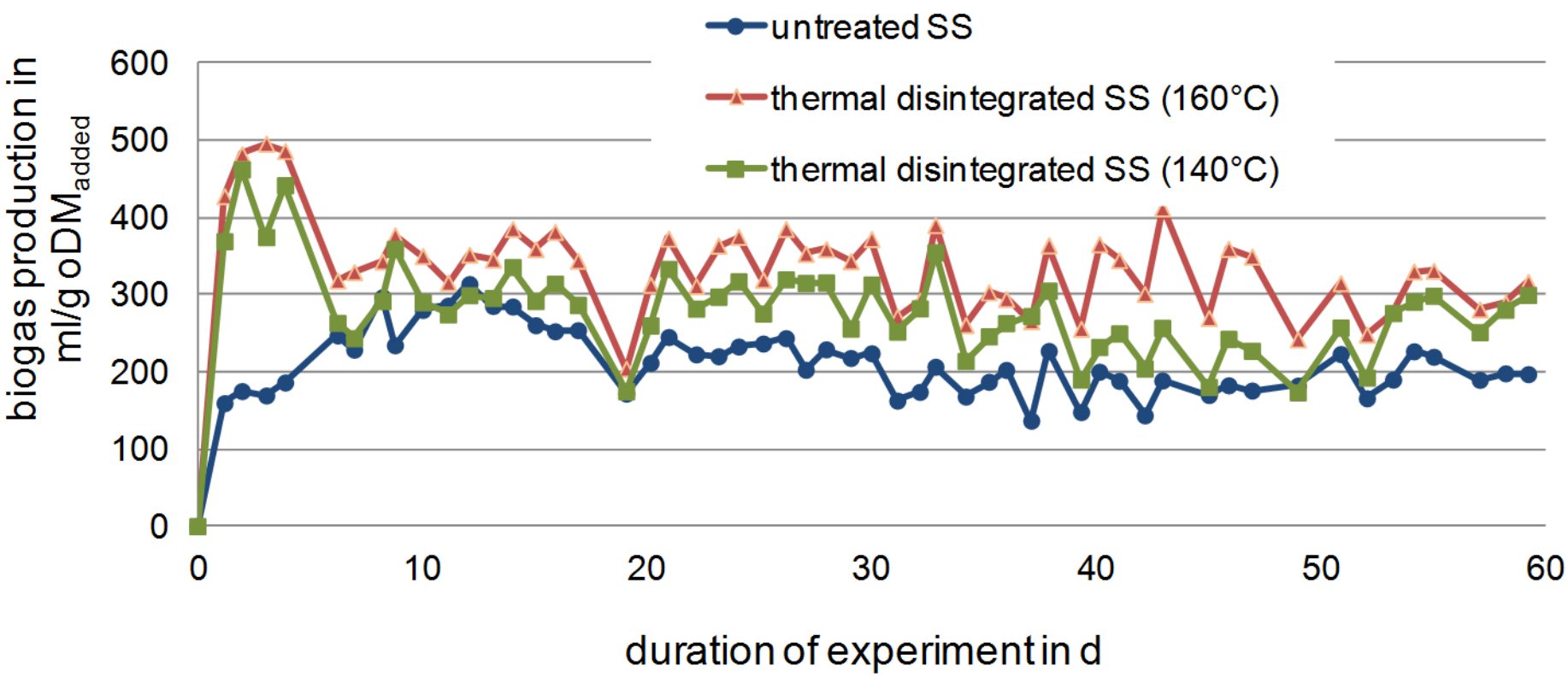
- Discontinuous experiments with dewatered SS
- Biogas production is +30% as a result of disintegration with 160 °C

2014

sludge sample	t	biogasproduction						
		Ref/70°C	140°C		150°C		160°C	
	d	ml/g VSS	ml/g VSS	%	ml/g VSS	%	ml/g VSS	%
1	14	215			338	157		
2	9	360	412	114			432	120
4	13	315	358	114			447	142
5	14	330	440	133			436	132
6	16	378					500	132

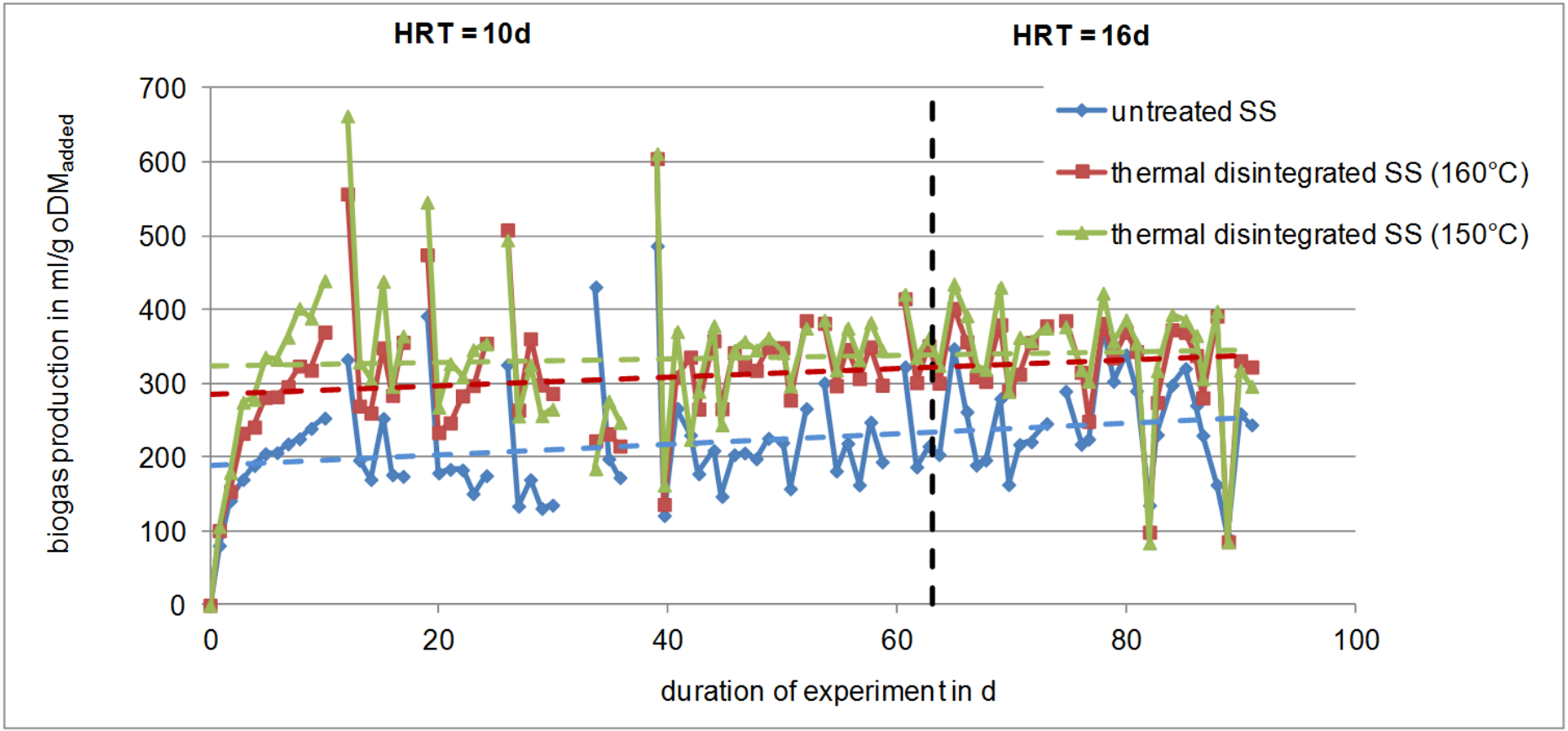
Bench scale continuous experiments – series I

- continuous bench scale experiments with app. 10% DM for 60 days
- Increase in biogas production is +40 % with 160 °C disintegration



Continuous bench scale experiments - series II + III

- Continuous bench scale experiments with app. 5% DM
- Increase in biogas production is +28% with 160 °C disintegration and HRT = 16 d



Pilot scale investigations

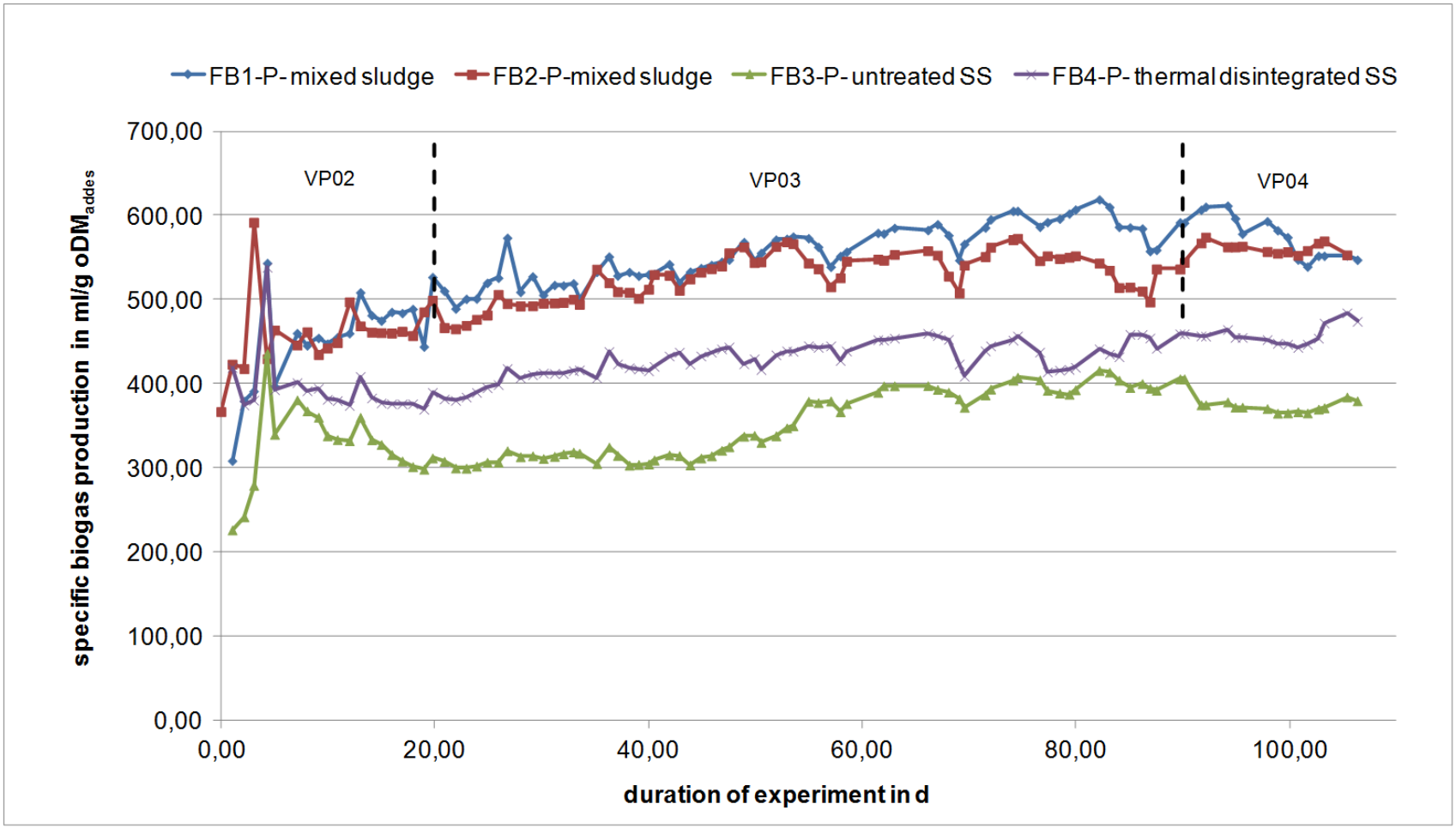
- Operation of 4 pilot scale digesters with V_{eff} = 500 l
- Investigation of the influence of thermal disintegration on specific biogas production [l/kg DM_{added}]
- **ht-FB1** – mixed sludge*
- **ht-FB2** – mixed sludge*
- **ht-FB3** – un-pre-treated surplus sludge
- **ht-FB4** – thermal disintegrated SS

* Mixture of primary sludge, Co-substrates, thermal disintegrated and un-pre-treated surplus sludge

→ Increase of the portion of the thermal disintegrated surplus sludge in 3 phases of 33% each

Pilot scale experiments - results

- Continuous operation over 100 days with app. 5% DM
- Increase in biogas production is +28% with 150 – 160 °C and HRT = 18 d



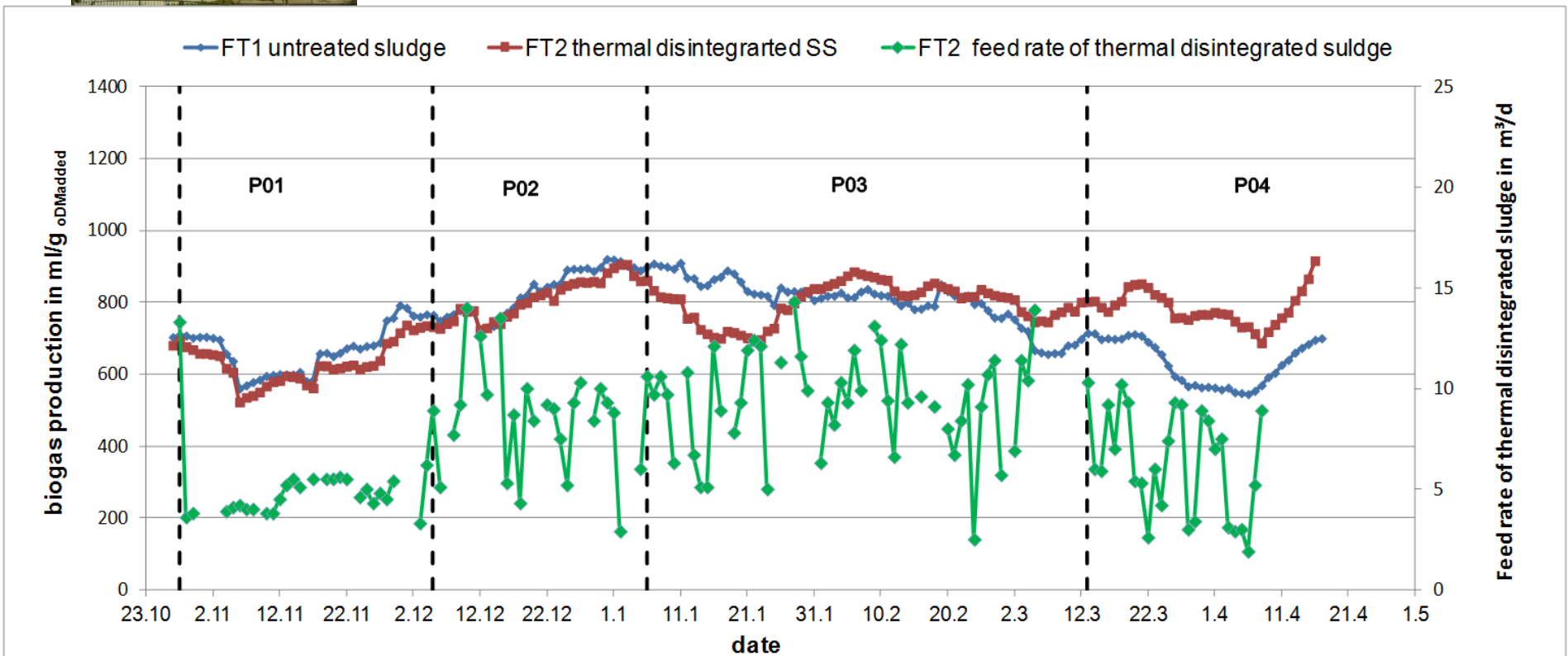
Pilot scale experiments - results

- Increase in biogas production +28 %
- Increase in oDM degradation +11 %-points (40,3 % → 51,4 %)

type of sludge	untreated surplus sludge (reference)	treated surplus sludge at 150-160°C	mixed sludge (co-substrate, PS, SS, hydrolysed SS/PS)
spec. biogas production in ml/g VSS_{added}	325	415	530
increase in comparison to reference in %		27,7	
degradation of VSS added in %	40,3	51,5	51,4
increase in comparison to reference in %		11,2	

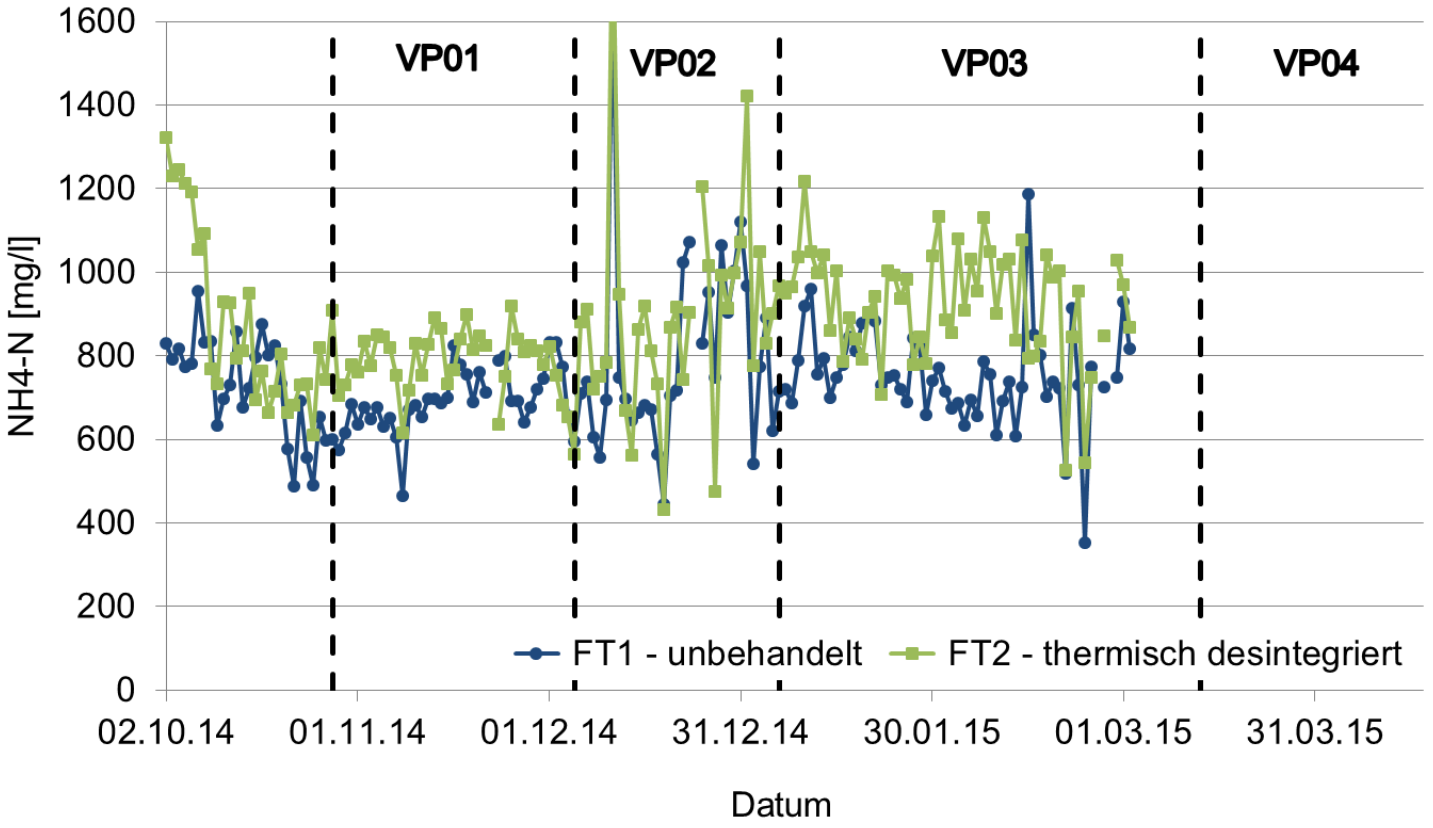
Full scale operation – results – biogas production

- Operation of digester FT2 with mixed sludge with increasing portions of thermal disintegrated surplus sludge in 3 phases



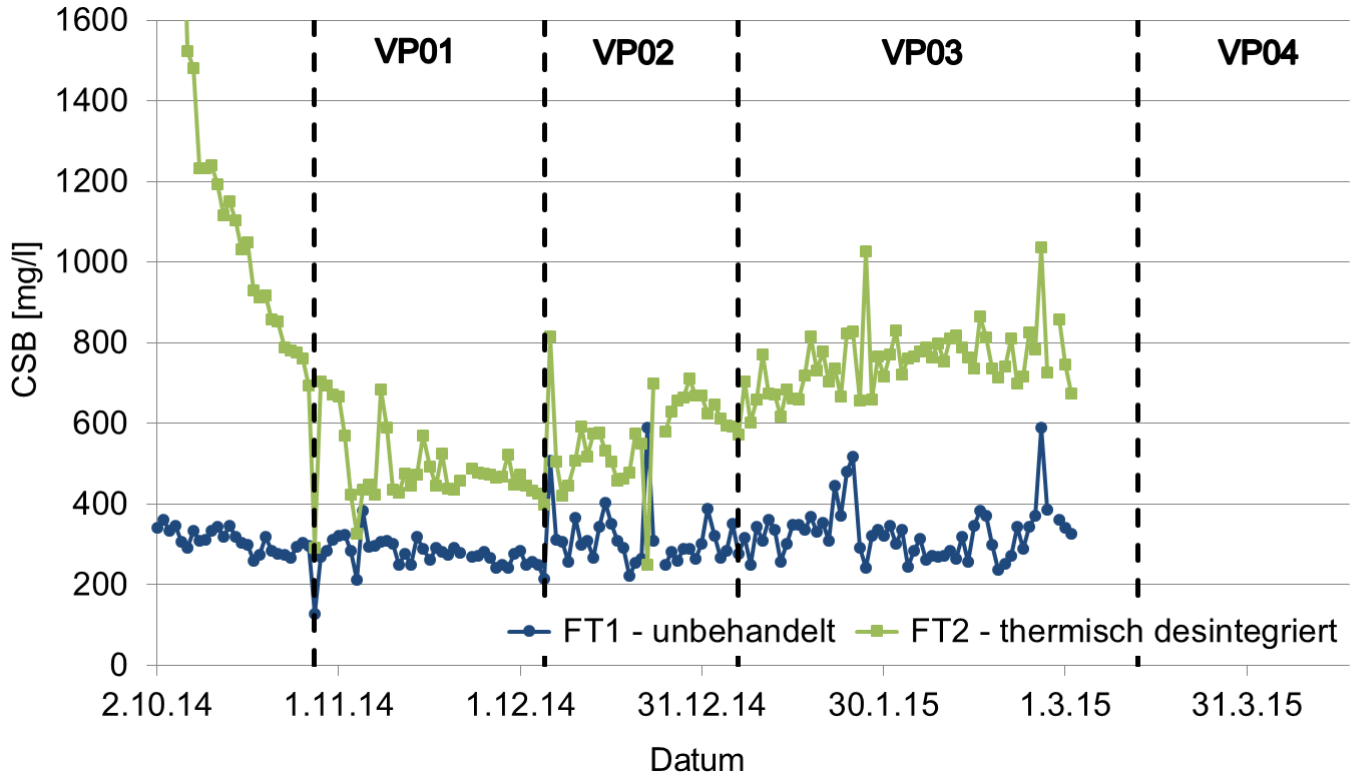
Full scale operation – results – ammonia conc.

- Modest increase in NH_4-N due to increased protein degradation



Full scale operation – results – COD in solution

- Increase in COD in solution is app. 500 mg/l in centrate of centrifuge
- Increase in COD in WWTP effluent is app. 5 mg/l



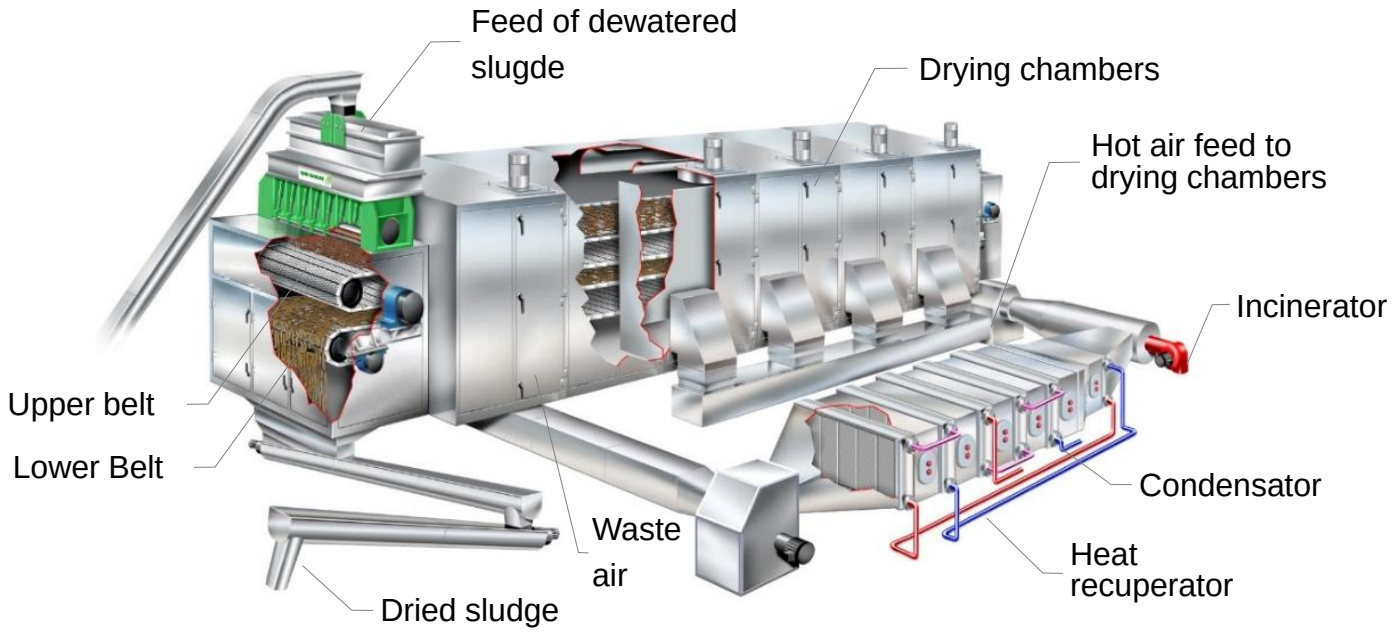
Full scale operation – results - dewatering

- Dewatering was investigated with a full scale HILLER centrifuge

Results:

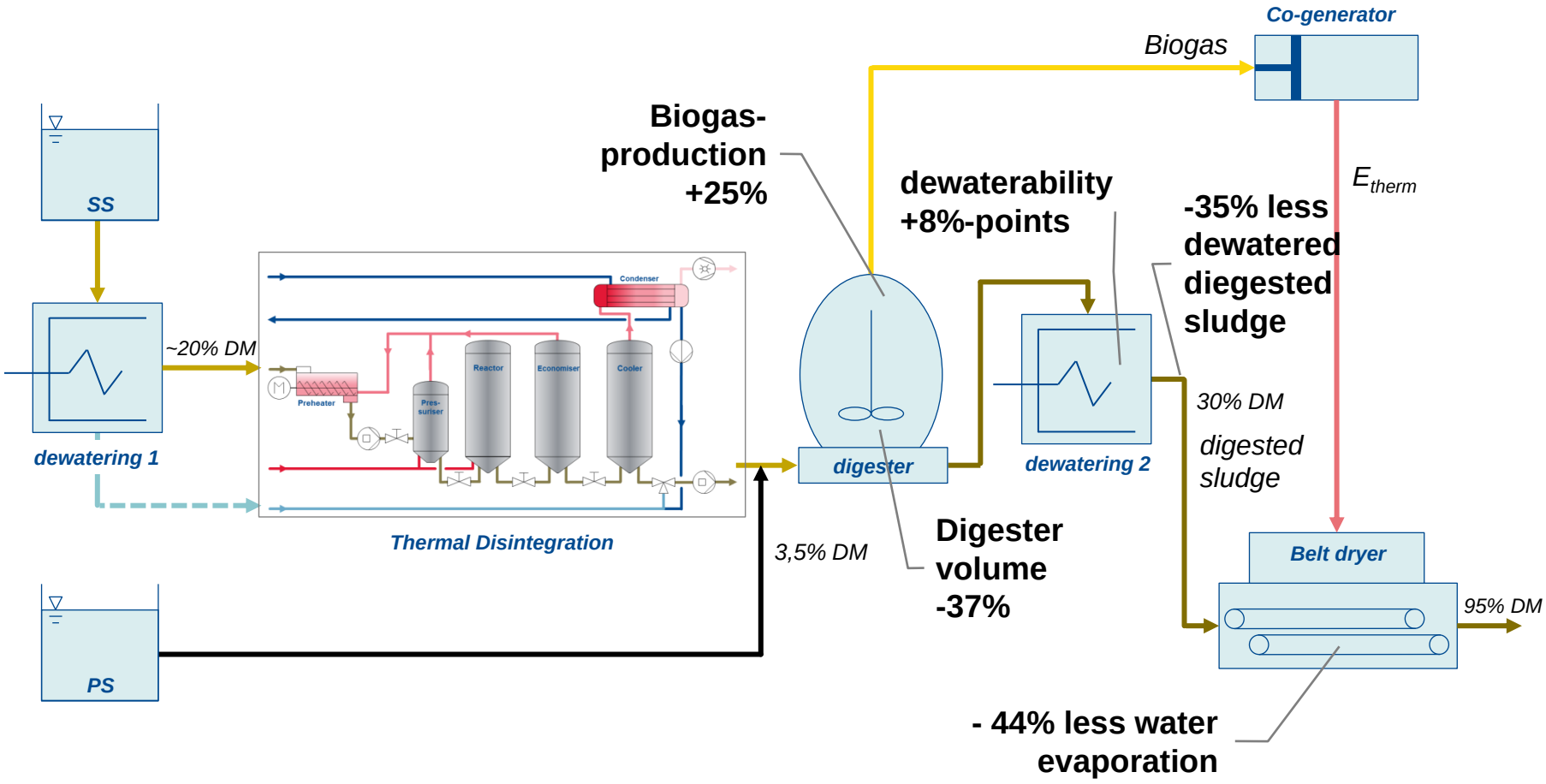
- Digested sludge with thermal disintegrated surplus sludge (FT2): 33% TR
- Digested sludge with un-pre-treated surplus sludge (FT1): 25 % TR
  - Increase in DM is 8 %-points
  - Slightly less flocculant consumption 14 kg/t_{DM} with 25 m^3/h throughput
  - Centrate with good quality

Belt dryer BD 3000/x



- Partial / full drying
- Granular product
- Direct heating
- Indirect heating
- Fexible heat resource
- Easy accessibility
- Heat recovery
- Modular units
- Small waste gas flow

Einsparpotenziale



Summary and conclusions

- The quantity of dewatered digested sludge for disposal is reduced by 35 %.
- In combination with a thermal surplus sludge disintegration a full drying of the sewage sludge becomes possible with the WWTP internally produced heat with moderate digestion of co-substrates.
- The required drying capacity and the required thermal energy for the drying can be reduced by thermal surplus sludge disintegration by almost 50 %.
- For disinfection thermopilic digestion instead of disintegration of all sludge might be considered
- The research was finanically supported by DBU (German national foundation for environmental protection) and Haarslev Industries

Thank you very much for your attention