JTI – Swedish Institute of Agricultural and Environmental Engineering

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with a focus on agriculture, energy and environment




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Co-digestion of sewage sludge and municipal biowaste with thermal hydrolysis pre-treatment

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This presentation will include:

- ***Short introduction to Växjö's thermal hydrolysis at WWTP Sundet co-digesting sewage sludge and food waste.***
- ***Preliminary results from still ongoing laboratory CSTRs tests, using Växjö's feedstock with and without thermal hydrolysis pre-treatment.***
- ***Process heat calculations.***

Evaluation project is a joint activity between SLU (Anna Schnürer, project leader) and JTI (Maria del Pilar Castillo, Johnny Ascue, Gustav Rogstrand & Mats Edström). The project is co-financed by The Swedish Energy Agency, The Swedish Water & Wastewater Association, Växjö, Cambi AS, SLU and JTI.

Background:

- ***Växjö's WWTP Sundet, co-digest sewage sludge and food waste. Some periods 2013 food waste contributing with ~ 50% of the biogas production.***
- ***Increasing substrate volumes, the digesting capacity not big enough. The strategy was then to plan for improvement of digestion capacity to meet predictions for year 2030.***
- ***Hygiensation capacity was desired.***

Predictions, substrates for digestion at Sundet

	Substrate Ton/year	DM[x] %	CH_4 prod. Nm^3/d	Vol. CH_4 [q] $Nm^3/m^3\&d$	HRT days	Org. load kg $VS/m^3\&d$
Substrates, year 2016	74 000	6.8	3900	1.24	17	3.3
Substrates year 2030	119 000	7.1	6900	2.17	11	5.6

x) DM: Dry Matter Content in substrate mixture
q) Volumetric methane production

Cambi offered an alternative

Substrate containing ~14 ton DM/d year 2016 and ~23 ton DM/d year 2030:

	Substrate Ton/d	DM %	CH_4 prod. Nm^3/d	Vol. CH_4 q) $Nm^3/m^3\&d$	HRT days	Org. load kg $VS/m^3\&d$
B.A.U.z) 2016	203	6.8	3900	1.24	17	3.3
B.A.U. z) 2030	328	7.1	6900	2.17	11	5.6
Cambi 2016	139 w)	10	5050x)	1.48x)	26	3.3
Cambi 2030	234 w)	10	8870x)	2.61x)	16	5.6

x) JTI's interpreting of contract data

z) B.A. U. = Business As Usual, no change in digestion capacity at Sundet

w) Including H_2O dilution after thermal hydrolyses to DM 10% for substrate mixture pumped into the digester. The addition of diluting water after thermal hydrolysis pretreatment year 2016: ~50 ton/d and year 2030: ~80 ton/d

q) Volumetric methane production. Active digestion volume is 3400 m^3

The Cambi installation at Sundet has been in operation since late 2014.

Short description of Cambis Thermal Hydrolysis

A. *Centrifuge dewatering of sewage sludge at Sundet from approx. 6% DM to approx. 16% DM reducing sludge quantity from approx. 150 ton/day to less than 60 ton/day.*

B. *Co-treatment of dewatered sludge and food waste in Thermal Hydrolysis Process **(THP)** including following step*
   1. *Heating the slurry in a first tank using recovered steam to 97 ^{o}C (Pulper tank)*
   2. *Increasing slurry temperature in a 2:nd tank (reactor tank) to 165 ^{o}C (at 6 bar pressure to avoid boiling) with steam injection from boiler (using pellets as fuel), treating time 20-30 minutes.*
   3. *Rapid pressure drop in a 3:rd tank (flash tank) resulting in cell destruction by steam explosion. The pressure drop reduces the temperature in the slurry to 102 ^{o}C, generating a lot of stem that is used to heat new slurry in 1st tank.*
   4. *Heat recovery from slurry and water dilution down to approx. 10% DM*
   5. *Slurry is pumped into the digesters*

Source: www.Cambi.com

Digestion tests

The purpose of the digestion test was to investigate:

1. how THP treatment on substrates digested at the WWTP plant Sundet effected biogas production in laboratory CSTR processes.
2. how difference in hydraulic retention time (HRT) effected the biogas production for a digestion process without pre-pasteurisation.
3. the process stability and microbiology

Method: Substrate

Parameter	A (reference)	B	C (THP)	D	Unit
Sludge	67%	67%	67%	67%	DM contri. x)
Food watse	33%	33%	33%	33%	DM contri. x)
Sludge sampl. point	Bellmer z)	Bellmer z)	Centrifuge q)	Centrifuge q)	
Thermal hydrolysis	No	No	Yes	No	

x) DM contribution to digested substrate mixture

z) Sludge thickening by a belt filter press manufactured by Bellmer

q) Decanter centrifuge manufactured by Noxon

Method: Substrate

Digestion process C:

- Substrate from Sundet
- Pilot THP from Cambi for heat pretreatment/steam explosion x)
- Temperature/preassure:165^{o}C/6 bar
- Time: 30 minutes

Digestion process A, B &D:

- Substrate from Sundet
- None heat pretreatment (neither THP nor hygiensation at 70^{o}C)

x) There are difficulties connected to substrate sampling treating substrate in a thermal hydrolyses plant. The pilot THP was difficult to empty after treatment. There are also losses of volatile organic acids connected to the thermal hydrolyses, not possible to collect

Method: Digestion

4 CSTR digesters with 5 L active volume operated at 37 °C

Process	A (reference)	B	C	D	Unit
THP	No	No	Yes	No	
HRT	18	11	16	17	Days
DM z)	6.5	6.5	9.4	10.0	%
Organic load	3	5	5	5	g VS/l&d
Time x)	5 HRT	3.8 HRT	3.5 HRT	3.3 HRT	Days

x) Time in operation at stated organic load, shown as number of HRT for respective digetsion process

z) Samples dried at 105 °C without compensation of VFA content in substrate mixture

Method: Heat demand calculation

All the heat demand calculations in this presentation connected to Cambi's thermal hydrolyses is simplified! The accuracy in used methodology is limited. The methodology calculating process heat demand is prepared by JTI based on the general thermo-dynamic equation:

$$E = m * c_p * \Delta t.$$

- ***Cp-water: 4.2 kJ/kg^{o}C***
- ***Cp-dry matter: 1.6 kJ/kg^{o}C***

The THP reactor tank is pressurized to 6 bar. The assumption is that the equation still is valid for both added substrate and water that the boiler converting to steam that is condensed to water at 165 ^{o}C in the THP reactor.

Result: Digestion test

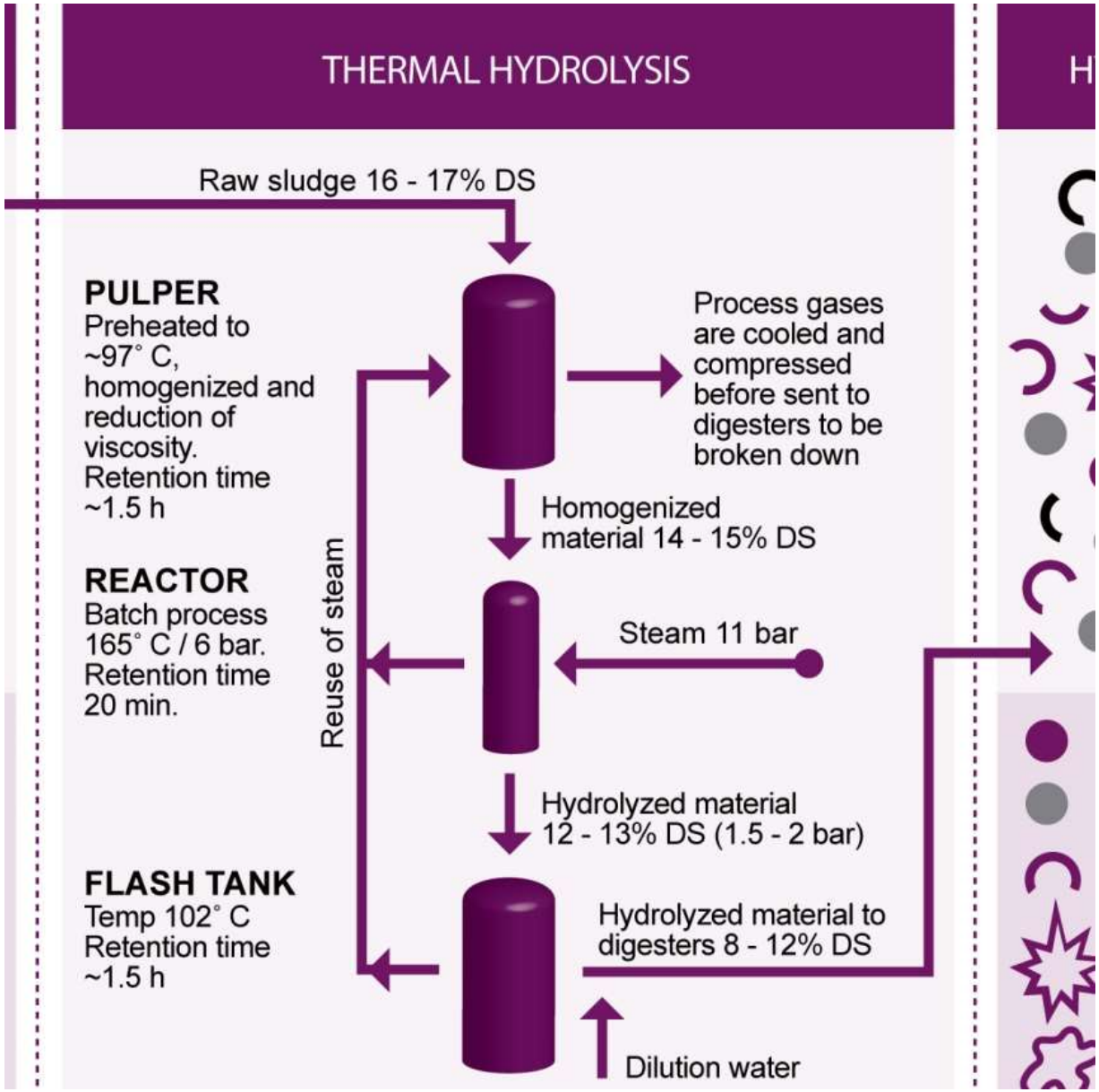
4 CSTR digesters with 5 L active volume operated at 37 °C

Parameter	A (reference)	B	C	D	Unit
THP	No	No	Yes	No	
(HRT)/(OLR)	(18)/(3)	(11)/(5)	(16)/(5)	(17)/(5)	(Days)/ (gVS/L&d)
Specific CH4 prod x)	366	360	417	365	L/g VS
Volumetric CH4-prod x)	1.14	1.80	2.08	1.83	L/L&d

x) Measured methane production at 22 °C and at 1 atm. VS in substrate is given without compensation of VFA content in substrate mixture, analysing VS.

Basis for heat calculation for Cambi THP

Thermal Hydrolysis with Cambi THP (source: www.Cambi.com)



Heat demand and methane production, a comparison

*The energy evaluation have not stared yet at Sundet. Calculated figures are **JTI:s** interpreting of Cambi process at Sundet and a more "traditional" hygienisation. Both systems digest 13.9 ton DM/d.*

Cambi digestion (yr 2016). Thermal hydrolysis at 165°C of substrate to pulper 15.8% DM.

	Temperature °C	DM	Flow Ton/d	Heating MJ/d	Heating MWh/d
Slurry to pulper tank		15.8	87.7		
Recovered steam in flashtank			8.1		
Slurry from pulper tank	97-165	14.5	95.8	24 900	6.92
Heating by boiler, steam	10-165		15.3	9 980	2.77
Total outflow from THP-reactor		12.5	111.1	34 880	9.69
Methane prod. (5050 m^3 CH_4/d) x)				*178 000*x)	*49.5*x)

x) Result from laboratory test indicate 10% lower methane production

Traditional digestion (yr 2016). Hygienisation of substrate with DM 6.8%

Temperature (°C)	Flow Ton/d	Heating MJ/d	Heating MWh/d
10->37	203	22 100	6.1
10->70	203	49 000 x)	13.6
Methane prod. (3900 m^3 CH_4/d)		*138 000*	*38.3*

x) Heat recovery is possible by heat exchanger. Is this included, the process heat will be reduced.

Conclusions & remarks

- The laboratory digestion tests resulted in 15% higher specific methane production with Cambi THP treated substrate mixture.
- Extended HRT for digestion process without thermal hydrolyses, by increased DM in substrate mixture, did not result in a higher specific methane production
- Process B without heat pretreated operated at 5 g VS/l&d OLR and 11 days HRT was remarkable robust!
- Thermal hydrolysis seems to be a rather energy competitiveness pre-treatment method, compared with traditional hygienisation at 70 ^{o}C. Key factor: a) the reduction of sludge amount to treat & b) the steam recovery from flash tank preheating the next batch in the pulper tank to approx. 97 ^{o}C.
- The digesting tests also includes 2 additional CSTR- processes and more than 20 BMP-tests.
- The project is still in still in progress both with laboratory digestion tests and at Sundet. The project will end at 31/12 2015. Measurements at Sundet will be accomplish during this fall. => All the results in this presentation is preliminary!
- Experiences from WWTP Sundet with Cambis THP will presented at Nordiwa (wastewater management and technology in the Nordic countries) 4-6 November in Bergen (Norway).

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