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Regional Mobilizing of Sustainable Waste-to-Energy Production

biogas potential of organic wastes

Baltic Sea Region
Programme 2007-2013

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IBU – Institute for Biotechnology and Environmental Research

- Environmental monitoring
- Microbiology, sanitation, soil and water conservation
- Water and wastewater engineering
- Biotechnology

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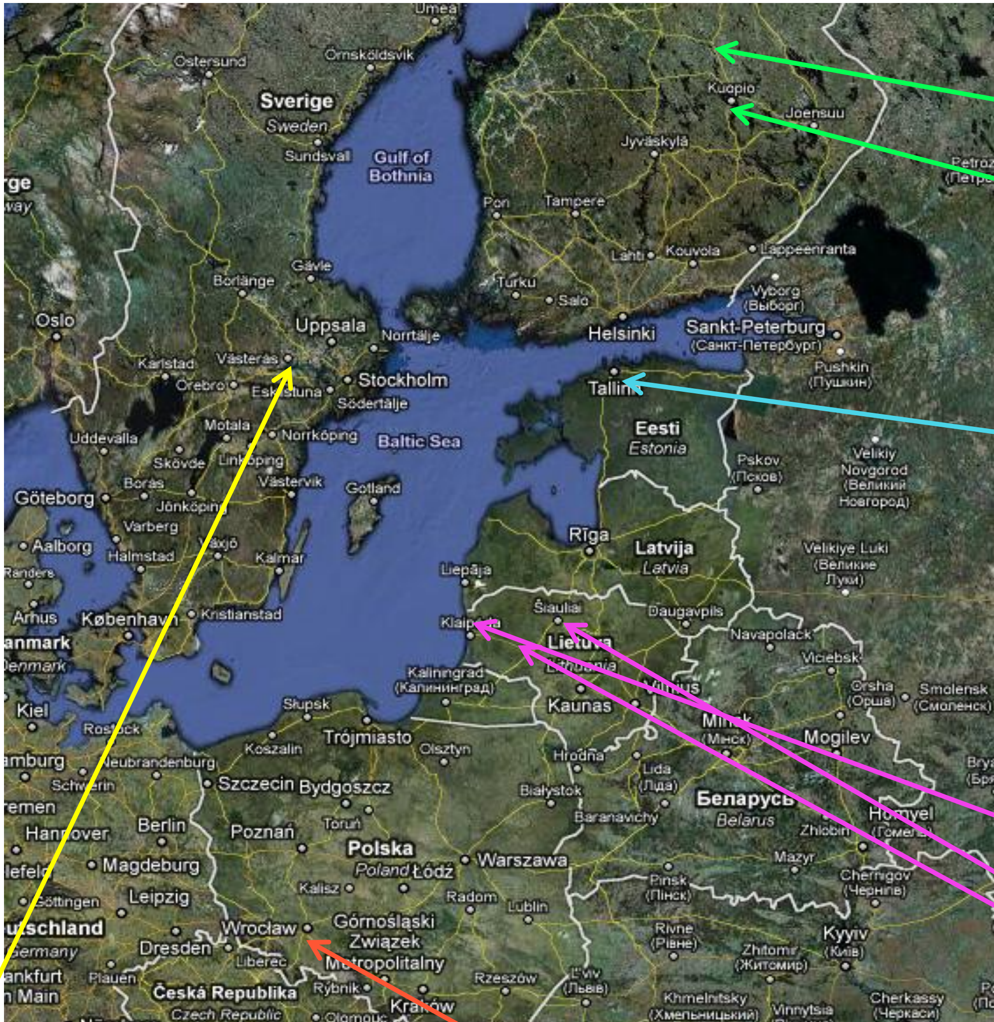
TASKS WITHIN REMOWE PROJECT

- biogas potential of different waste substrates and waste substrate mixtures including possible pre-treatment strategies

- report on biogas utilization strategies (including waste utilization, digestion technology and residue treatment) for each individual region - to be used by authorities and companies for decisions on investments in technology and systems and for policy making in the project

- contribute to the investigation of the current status in the whole chain of waste-to-energy utilization in each partner region and the current conditions and systems from which the development has to start

ORIGIN & KIND OF SUBSTRATES



Finland:
Iisalmi:
- hay silage (various ages)

Kuopio:
- municipal waste (30mm),
- unsorted organic waste
- manure and wood chips

Estonia, Tallinn:
edible fat
waste from grease traps
organic waste
brewers‘ grains
waste water
paper pulp

Lithuania:
Klaipeda, waste water sludge
Siauliu region, dump waste
Taurage region, dump waste
Plunges region, dump waste
Klaipeda, dump waste
Kretinga region, cow manure
palm oil, waste from spirit distillation, waste from screeners

Sweden, Västeras:
organic waste, ley crops silage
unsorted municipal waste

Poland, Gac:
municipal waste, fraction
<80 mm; <60 mm; 20-80 mm

VARIATION OF SUBSTRATES

dumped waste

waste water sludge

animal faeces

biowaste

agricultural (over)products

municipal household waste

industrial organic waste

DENIED SUBSTRATES FOR CONTINUOUS TESTS

dumped waste

waste water sludge

animal faeces

biowaste

agricultural (over)products

municipal household waste

industrial organic waste

Denied substrates for continuous tests

hay paper pulp	high ratio of non digestable material (e.g. lignin)
animal tissues	high health and safety at work effort
unsorted municipal waste	not suitable for wet fermentation

Procedure of Work Steps

- batch fermentation tests to gain maximum methane potential
- selection of suitable substrates or substrate mixtures for continuous tests also depending on needs for digestate disposal and

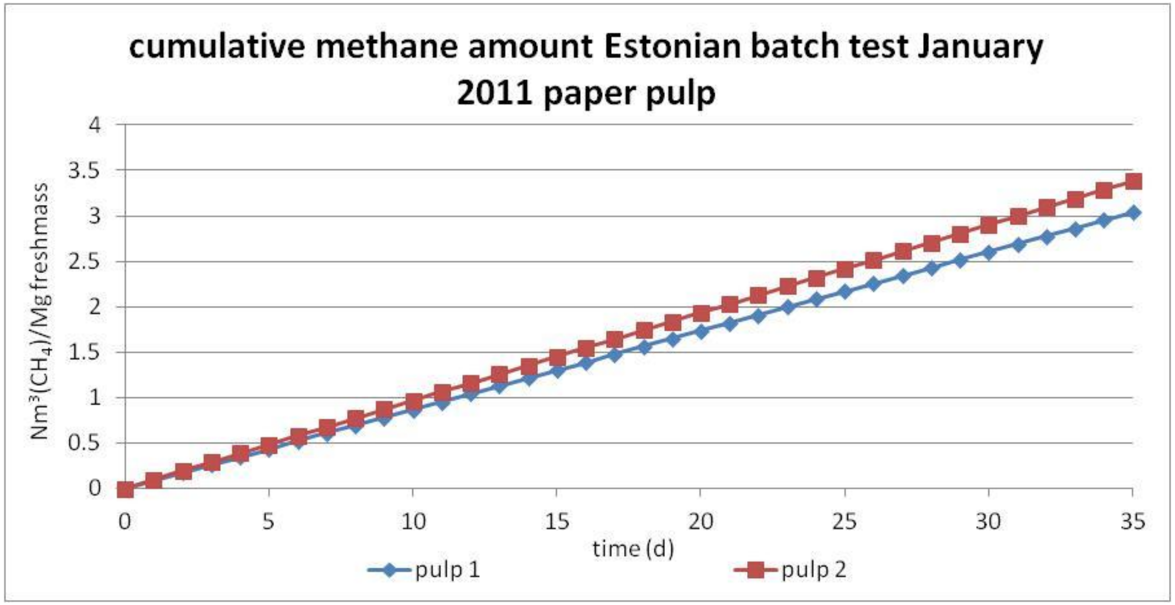
pre-sorting

sanitation

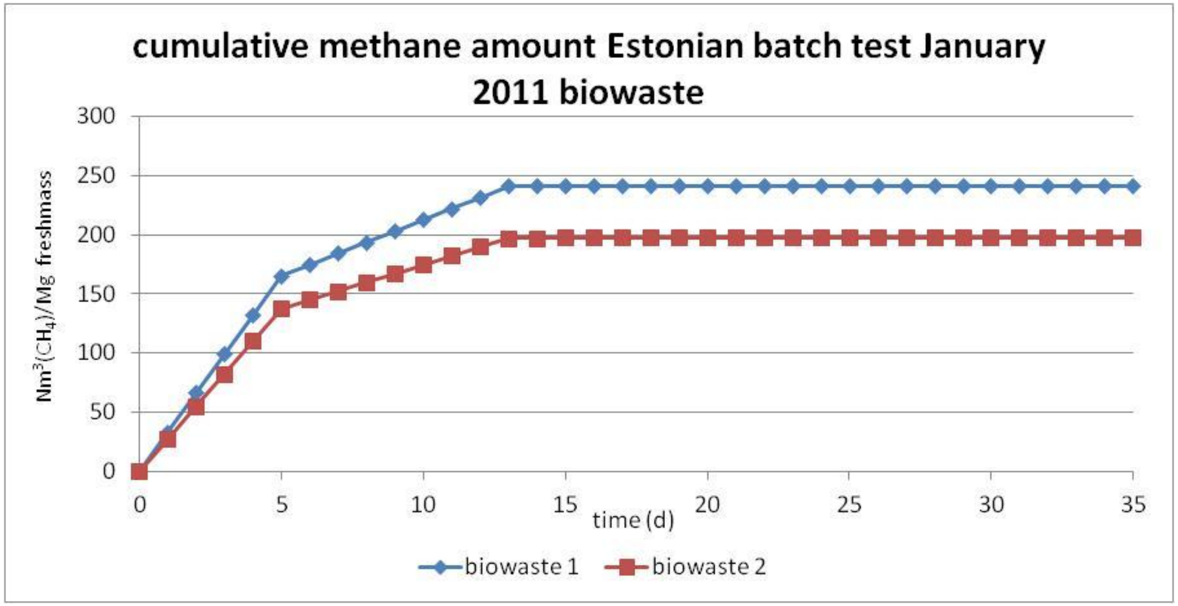
PROCEDURE OF WORK STEPS

- starting of continuous fermentation tests (duration ~3 months)
- verifying methane potentials from batch tests
- detecting process problems (overfeeding, acidification, layer forming, clogging of process technology)
- comparison of methane potential with common agricultural substrates

RESULTS BATCH TESTS



paper pulp → nearly no methane production



biowaste → good methane production

RESULTS BATCH TESTS (EXTRACT)

Estonian substrates

date (2011)	sample	EWC code	temp. conditions	$Nm^3(CH_4)$/ Mg(fresh mass)	$Nm^3(CH_4)$/ Mg(oDM)	methane content in Vol-%
January	paper pulp 1	0303	mesophil	3.0	16.5	40.0
January	paper pulp 2	0303	mesophil	3.4	18.4	38.0
January	brewers' grains 1	0207	mesophil	88.4	420.3	61.9
January	brewers' grains 2	0207	mesophil	99.3	472.3	67.2
January	grease traps waste 1	190809	mesophil	323.3	680.3	68.4
January	grease traps waste 2	190809	mesophil	305.6	643.2	70.0
January	edible fat 1	200125	mesophil	652.0	652.5	63.8
January	edible fat 2	200125	mesophil	837.9	838.6	71.7
January	kitchen & canteen waste 1	200108	mesophil	241.3	571.5	67.9
January	kitchen & canteen waste 2	200108	mesophil	197.8	468.5	53.9
March	Estonian Mix 1	02 07, 19 08 09, 20 01 25, 20 01 08	mesophilic	266.6	637.6	74.8
March	Estonian Mix 2		mesophilic	253.0	605.1	74.7

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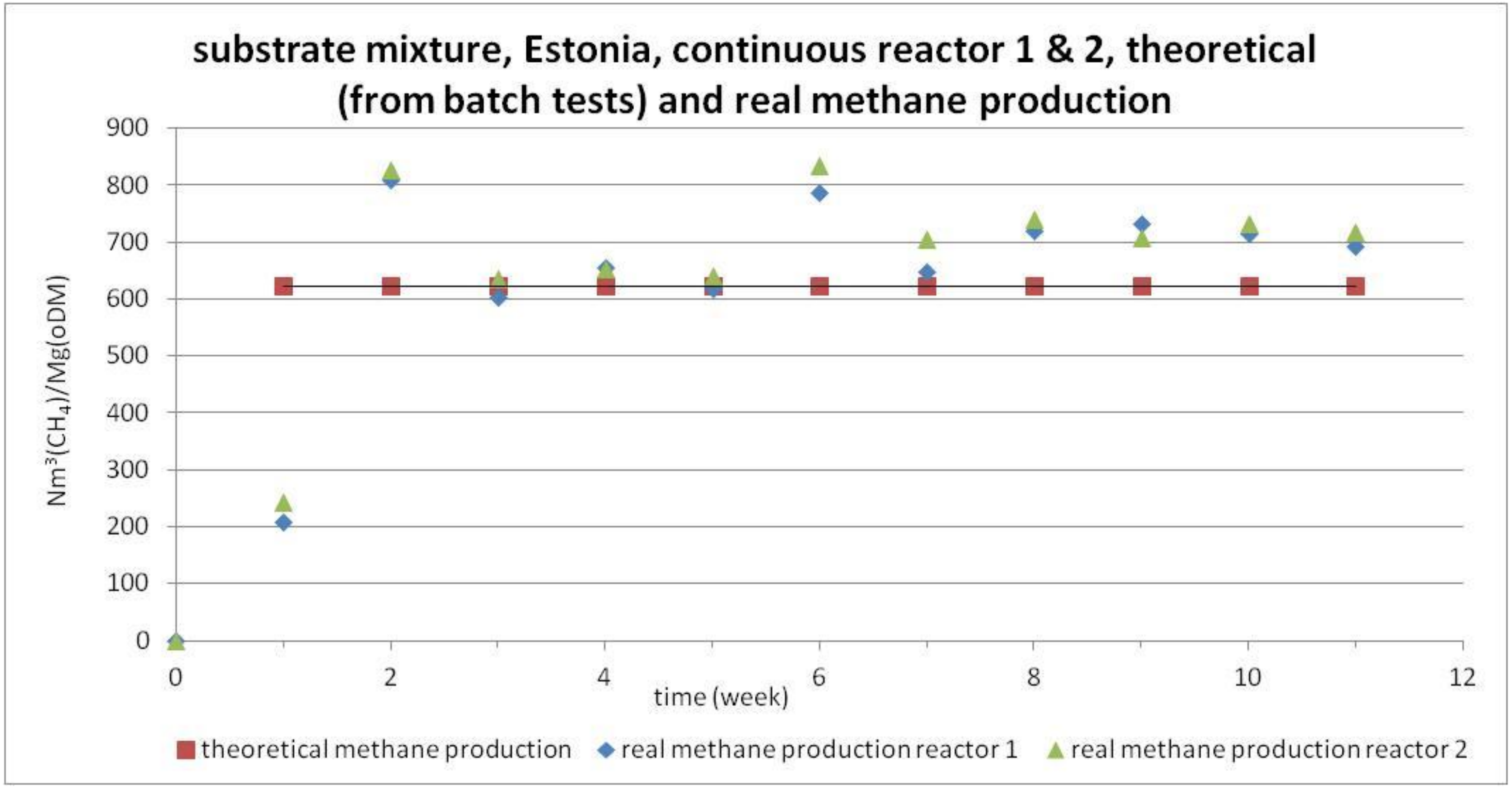
CONCLUSIONS CONCERNING BATCH TESTS

∑ 34 double tests performed

• dumped waste	high effort to be prepared, low methane output
• waste water sludge	high water content, on-site fermentation recommended
• animal faeces	recommended as co-substrate
• biowaste	compositions vary throughout seasons, good methane yield
• agricultural (over)products	methane yield depend on age of agricultural products
• municipal household waste	high effort to be prepared, outsourcing of disturbants, sanitation necessary
• industrial organic waste	high methane potential, high process attention necessary, suitable as co-substrate

RESULTS CONTINUOUS TESTS



Estonian substrates mixed for continuous tests

Results from continuous tests (extract)

	Estonia	Finland	Lithuania	Sweden
substrate	brewers' grains, edible fat, biowaste, grease trap waste	municipal household waste	cow manure, sewage sludge, screenings, waste from spirit distillation, palm oil	biodegradable kitchen & canteen waste
pre-sorting	-	√	-	-
testing period (d)	86	120	127	106
total substrate in (g)	3,160	9,813	11,508	9,216
total substrate out (g)	3,195	6,963	9,939	7,148
range of organic load	0.7-2.1	2.1-4.9	1.26-3.5	1.4-3.5
range weight of substrate (g)	20-60	81-176	83-227	65-161
effects through sanitation	-	√	√	√
ø final oDM of digestate (% of FM)	1.11	7.03	5.45	4.07
recommendation concerning dry fermentation	-	√	-	-
process stability	√	√	√	√
ø stable methane production (NL/h)	0.9875	0.5026	0.5725	1.2096

Conclusions concerning continuous tests

- all substrates tested in continuous reactors performed successfully
- digestion analyses have been performed
- recommendations concerning digestion suitability can be defined
- obstacles concerning digestion process could be defined

SUMMARY OF ENERGY POTENTIALS

- methane productivity from biogas processes
- heating value and energy from digestate through combustion

	Estonia	Finland	Lithuania	Sweden
	n.a. (**)			
Ø methane production from lab-scale (Nm³/t oDM)	718.078	275.47	406.85	453.83
annual substrate amount (t/a)	n.a.	20 000	606 894	14 000
substrate's oDM (%FM)	41.82	31.78	18.43	26.02
energy content CH_4 (kWh/m^3)	9.94	9.94	9.94	9.94
annual energy from biogas (MWh/a)	n.a.	**17 403**	**163 242**	**16 432**
annual digestate amount (*) (t/a)	n.a.	17 000	515 859	11 900
digestate's DM (%FM)	1.54	13.17	6.41	5.92
heating value (kWh/kg DM)	2.439	3.903	4.933	3.946
annual energy from digestate (MWh/a)	n.a.	**8 738**	**452 331**	**2 780**
percentage digestate energy of biogas energy (%)	n.a.	**50.2**	**36**	**17**

(**) digestate = 85 % of substrate amount (**) no information about yearly waste amounts

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RESULTS FROM DIGESTATE ANALYSES (EXTRACT)

heavy metal analyses (Estonian continuous tests)

	limit (mg/kg DM)	reactor 1	reactor 2
	(mg/kg DM)	(mg/kg DM)	(mg/kg DM)
chrome (Cr)	n.a. at the moment	10.0971	9.7087
copper (Cu)	1000-1750	209.7087	216.1812
nickel (Ni)	300-400	20.1942	11.7152
zinc (Zn)	2500-4000	559.2233	565.6958
cadmium (Cd)	20-40	0.5437	0.5437
lead (Pb)	750-1200	11.0032	26.9256
mercury (Hg)	16-25	0.4078	0.6667

ammonium results (Estonian continuous tests)

		inoculum	reactor 1	reactor 2	dairy cow manure (*)	sow manure (*)
NH_4	(g/L)	0.65	1.2	1.2	2.9	3.1
P	(g/kg)	0.89	1.0	0.85	0.872	1.396
N	(g/kg)	1.5	1.8	1.5	5.2	4.5

(*) (Chamber of Agriculture Lower Saxony, 2009)

concentration of impurities (Finnish continuous tests)

	reactor 1	reactor 2
top layer	20.03 %	15.11 %
middle layer	32.08 %	20.49 %
bottom layer	47.56 %	26.89 %
stirrer	79.35 %	65.56 %
average value	41.05 %	27.35 %

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CONCLUSIONS…

- most substrates are suitable for biogas (wet digestion)
- reliable data as basis for calculation available
- data basis for process upscaling
- by-products are usable

… AND OUTLOOK

- finding and discussion of implementation strategies
- calculation of degree of energy substitution for each region
- kind of utilization (biomethane, electricity, heat)
- discussion of side-effects (fertilizer/climate)

From Waste to Biogas

sewage sludge

fermentation batch test

weighing

sorting

waste

THANK YOU!!!

heating cabinet, 35 days, 40 C

daily shaking

gas measuring: volume and composition