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INVESTIGATION OF LANDFILL MINING FEASIBILITIES IN NORDIC AND BALTIC COUNTRIES: OVERVIEW OF PROJECT RESULTS

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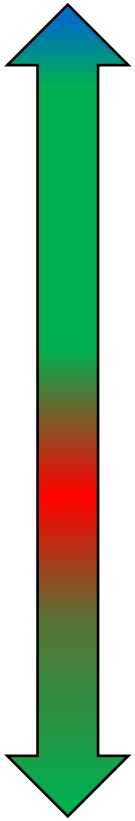
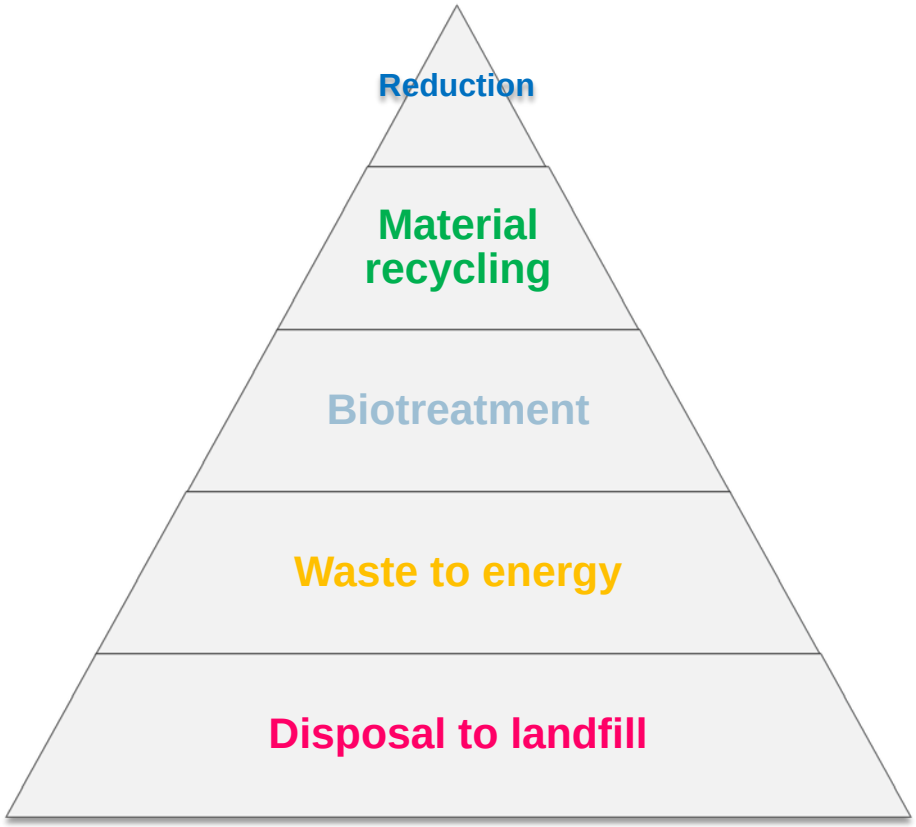
CYPRUS 2016 4th International Conference on Sustainable Solid Waste Management,
23rd - 25th June 2016 Limassol, Cyprus

MAIN PROCESSES IN WASTE MANAGEMENT SYSTEM

WASTE MANAGEMENT HIERARCHY!





1. INTRODUCTION (2)

CHARACTERISATION OF LANDFILLING

http://www.theguardian.com/sustainable-business/food-waste-energy-circular-economy

However for many countries landfilling remains still as oldest and least expensive waste disposal method...

CHARACTERISATION OF LANDFILLING (2)

https://www.theparliamentmagazine.eu/articles/sponsored_article/pm-landfill-ban-recyclable-materials-makes-economic-and-environmental

Landfilled materials contain the unused resources for products and energy.

1. INTRODUCTION (4)

TERM “LANDFILLING MINING”

- Excavation and removal of materials from an active or closed landfills for the purposes of recycling, use, reuse, sale, or composting means **landfill mining (LFM)**;

- **LFM includes**:

✓ processing of excavated material;
✓ recovery of soil masses;
✓ recovery of recyclable materials;
✓ making available new landfill volumes

EURELCO AND COST ORGANISATIONS

Currently many European academic institutions and authorities are in the closely cooperation regarding participation in various projects for investigation of landfill mining feasibilities.

This activity is also expressed:

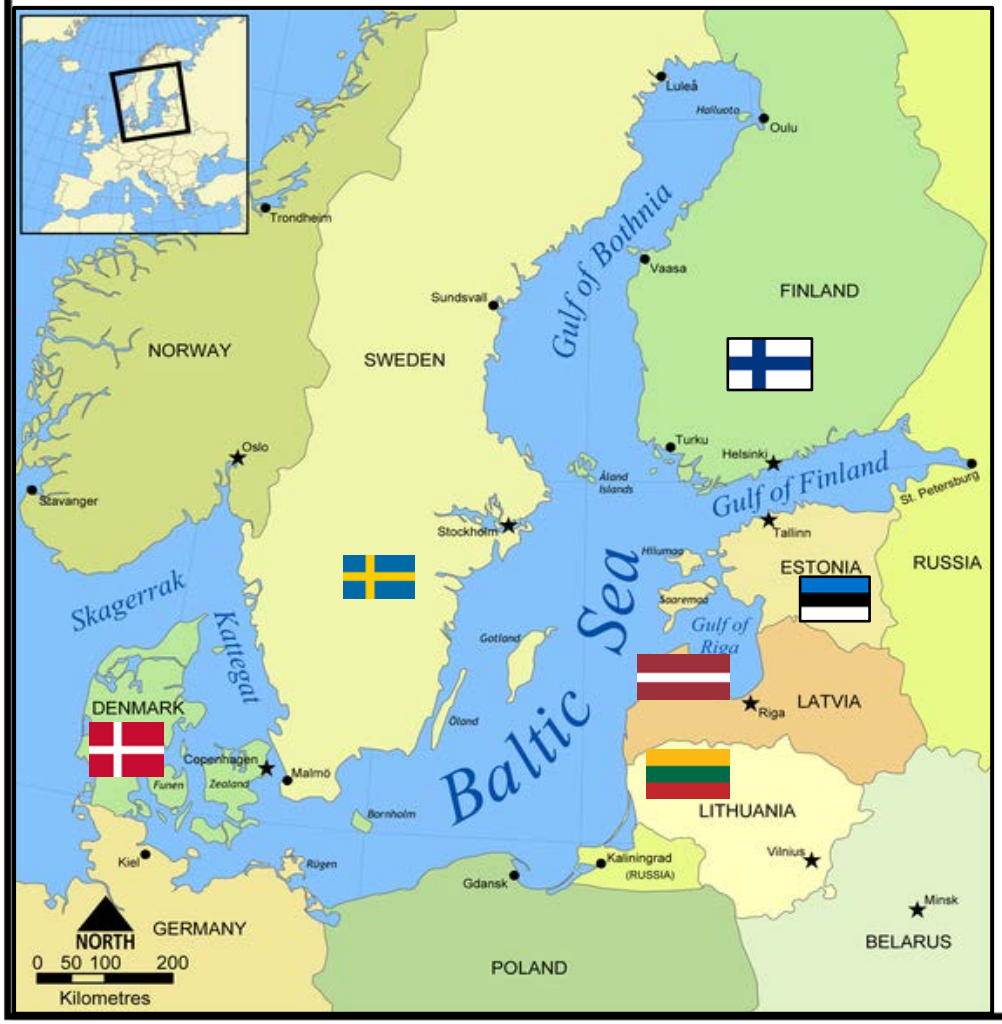
- ✓ by membership in EURELCO (European Enhanced Landfill Mining Consortium);
- ✓ by participation COST activity “Mining of European Anthroposhere” (MINEA).

EURELCO
EUROPEAN ENHANCED LANDFILL MINING CONSORTIUM

COST Countries

cost
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

International project SINDICATE



Project „**Closing the life cycle of landfills: landfill mining in the Baltic Sea region for future“ (SINDICATE, 2013)** have been funded by Swedish Institute

Partners: universities and SME in Sweden, Danemark, Finland, Estonia, Latvia and Lithuania

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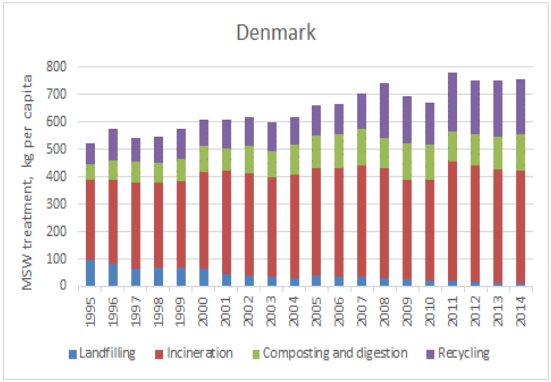
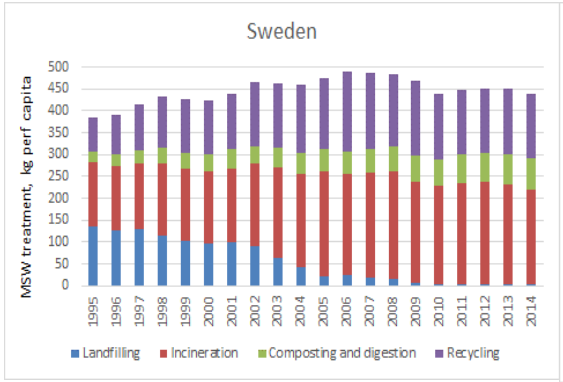
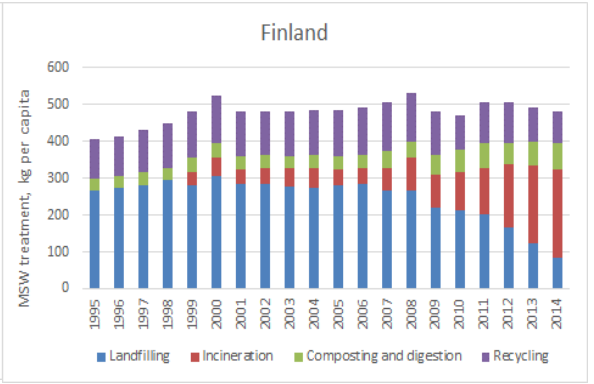
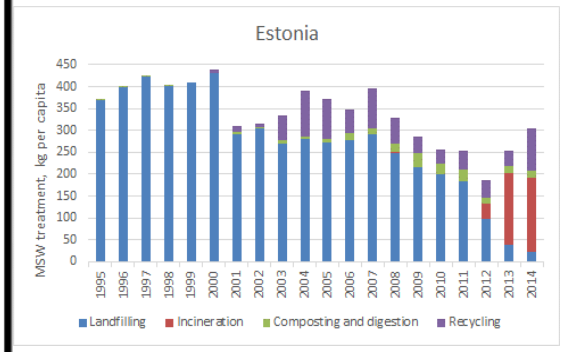
2. SITUATION FOR WASTE MANAGEMENT AND LANDFILLING IN TARGET COUNTRIES (3)

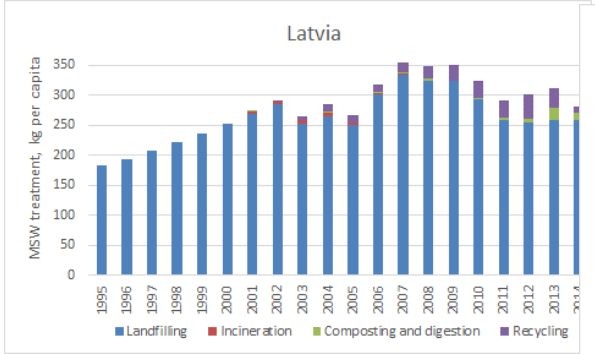
MSW generation and treatment in Nordic and Baltic countries in the periode of 1995 – 2014

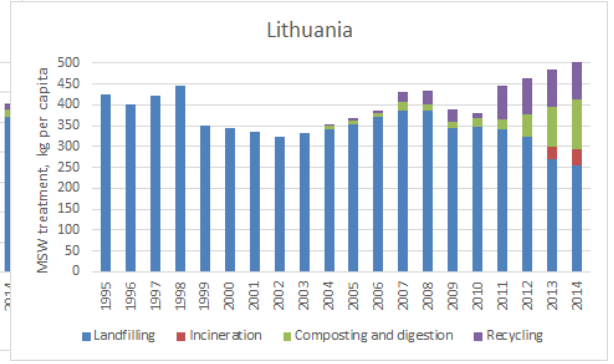








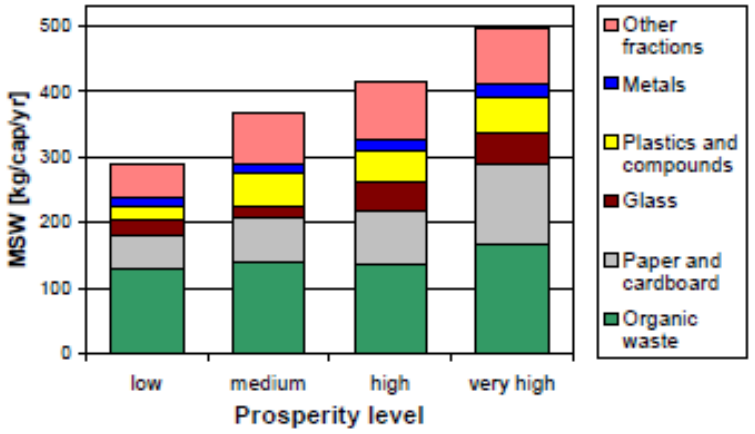




Reverse forecast for landfilled waste composition

- Firstly the average composition of landfilled MSW in each target country have been estimated theoretically;
- First step was the use the dependences of MSW fractions contents on common MSW waste generation per capita (it corresponds the prosperity level) have been estimated by use of information published by Beigl et all, 2004 [10].
- This dependence is characterized by simple linear equation, where both share of fraction and common MSW amount may be expressed in the same units:

$$MSW_{fraction} = a * MSW + b \qquad (1)$$



Municipal solid waste streams at different prosperity levels

3. THEORETICAL ESTIMATION OF LANDFILLED WASTE COMPOSITION (2)

Reverse forecast with respect to decay rate

After decay the remained amount of each MSW fraction in landfill is calculated with respect to retention time of landfilled materials and decay rate in the landfill [11]:

$$FRACTION\ j^{n}_{rem.} = \sum_{i=1}^{n} FRACTIONj^{i}_{land.} * exp[-k(n-i)] \quad , \quad (2)$$

where

$FRACTION\ j^{n}_{rem.}$ - total amount of MSW j fraction remained after landfilling and decomposing within n year periode;

$FRACTIONj^{n}_{land.}$ - within the year i landfilled MSW j fraction amount;

k – rate constant for waste fraction decay.

3. THEORETICAL ESTIMATION OF LANDFILLED WASTE COMPOSITION (4)

Reverse forecast with respect to decomposing rate (2)

- The amounts of coarse and fine fractions are estimated after consideration that coarse fraction includes remained paper, plastic, glass, metals and other fractions.
- Herewith the fine fraction includes the mineral part of all decayed waste fraction, remained biowaste in the form of humus and during landfilling attached ground – 20 % per landfilled MSW mass unit.
- In the landfills within *n* year formed coarse fraction is calculated as follow:

$$COARSE^{n}_{rem} = \Sigma FRACTION\ j^{n}_{rem.} - BIOWASTE^{n}_{rem}\ , \quad (3)$$

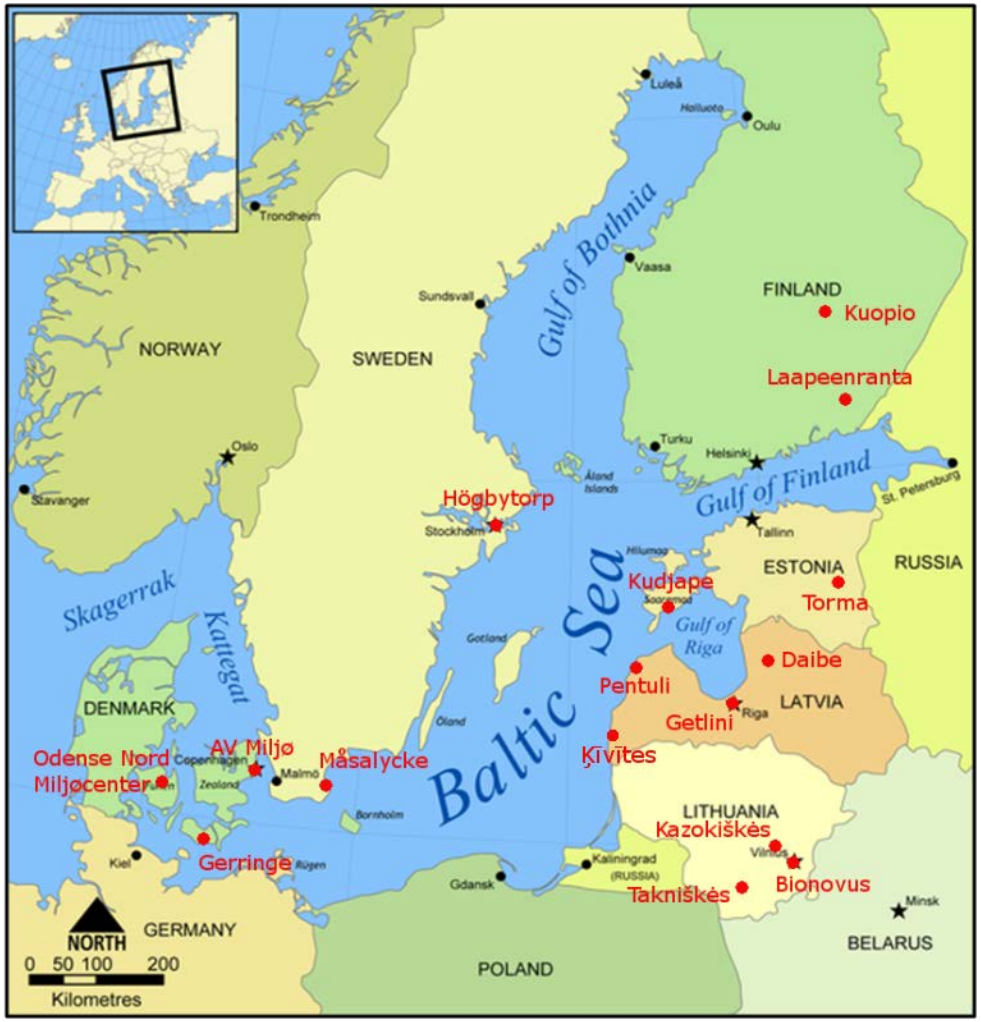
3. THEORETICAL ESTIMATION OF LANDFILLED WASTE COMPOSITION (5)

Reverse forecast with respect to decomposing rate (3)

Theoretically established average MSW composition and resources potential after landfilling and rotten in target Nordic and Baltic countries

Country	Denmark	Sweden	Finland	Estonia	Latvia	Lithuania
Number of existing landfills (exploited and closed in the period of 1995-2015)	~105	~ 300	~370	~370	~550	~ 840
Landfilled MSW amount at 1995-2915, kt	4 551	9 898	25 820	7 461	11 670	23 691
Possibly added ground at 1995-2915, kt	910	1 980	5 164	1 492	2 334	4 738
Waste amount in landfills with added ground after decomposing, kt, of which	4 353	9 049	24 526	7 979	10 661	22 391
fine fraction with added ground, kt	2 153	4 815	11 835	4 668	5 397	11 321
coarse fraction, kt	2 200	4 234	12 691	3 311	5 264	11 070
Established average landfills composition, %:						
fine fraction with added ground	49,46	53,21	48,25	58,50	50,62	50,56
coarse fraction, of which	50,54	46,79	51,75	41,50	49,38	49,44
combustible, of which	31,70	27,81	34,65	25,41	30,97	31,12
paper and cardboard	12,20	9,44	12,85	9,07	11,30	11,73
plastics	13,19	12,42	12,55	10,12	10,69	11,56
wood	0,33	0,34	0,58	0,33	0,44	0,39
textiles	4,78	4,41	7,67	4,72	6,94	6,02
rubber and leather	1,21	1,21	1,00	1,18	1,60	1,42
uncombustible, of which	18,84	18,98	17,09	16,08	18,41	18,32
glass	11,14	10,41	10,47	8,36	8,62	9,52
metals	3,14	3,60	3,48	3,35	4,41	3,83
inerts	4,56	4,97	3,13	4,38	5,37	4,96
Heat value, MJ/kg	23,36	23,92	22,63	23,17	22,38	22,73
Energetic potential for excavated RDF, PJ	32,24	60,18	192,32	46,98	73,91	158,41
Energetic potential for RDF pyrolisis oil, PJ	14,51	27,08	86,55	21,14	33,26	71,29

LOCATION OF INVESTIGATED LANDFILLS IN NORDIC AND BALTIC COUNTRIES



- During mentioned project the next type of closed or exploited landfills have been selected for field research in each target country. There are:
- ✓ three sites for landfilling of shredder residues in Denmark,
- ✓ by twos closed MSW landfills in Sweden and Finland,
- ✓ two closed MSW landfill in Estonia,
- ✓ four exploited MSW landfills in Latvia,
- ✓ two exploited MSW landfills and one closed landfill for construction and demolition waste in Lithuania.
- The morphological content of extracted samples has been established by sieving, manual sorting and weighting.

Waste sampling in the selected landfills

Location and technical characteristics of selected landfills in Nordic target countries

Country	Denmark			Sweden		Finland	
Region	Falster	Copenhagen	Odense	Stockholm	Simrishamn	South Karelia	Northern Savo
Landfill name	Gerringe	AV Miljø	Odense Nord Miljøcenter	Högbytorp	Måsalycke	Lappeenranta	Kuopio
Type of landfilled waste	MSW	MSW	Shredder residue	MSW and industrial wastes	MSW	MSW, C&D, landwaste	MSW
Year for starting of exploitation				1964	1975	1972	2001
Year of closure/end of exploitation	Still operating	Still operating	Still operating	Still operating	2008	2001	2011
Landfilled waste amount, kt	460 000	1 600 000	903177	35000		1 056	
Year for Investigation	2011	2016	2010	2014	2000	2012	2012
Project promoter	REFA I/S	AV MIljø	DHI, SDU	Ragn-Sells AB	SYSAV	LUT	VTT
Method of sampling/ investigation	Excavation	Excavation	Excavation	Excavation	Excavation	Sampling & examination prior to landfilling	Drilling
Maximal depth of investigated layers, m	14	4	22	4	8		31

Waste sampling in the selected landfills (2)

Table 3. Location and technical characteristics of selected landfills in Baltic target countries

Country	Estonia		Latvia				Lithuania				
Region	Torma	Saaremaa	Valmiera	Ventspils	Liepaja	Riga	Alytus	Vilnius	Vilnius		
Landfill name	Torma	Kudjape	Daibe	Pentuļi	Ķīvītes	Getliņi	Taknišk ės	"Bionovus"	Kazokiškės		
Type of landfilled waste	MSW	MSW	MSW	MSW	MSW	MSW	MSW	C&D	MSW		
Year for starting of exploitation	2000	1971	2004	2004	2004	2005	2009		2009		
Year of closure/end of exploitation	Still operating	2009	Still operating	Still operating	Still operating	Still operating	2012	2014	Still operating		
Landfilled waste amount, kt	300 000 t		367205	188734	526857	3199120	329				
Year for investigation	2015	2013	2015	2015	2015	2012	2014	2014	2014		
Project promoter	EMU, LNU	Saaremaa Prügila OÜ	RTU	RTU	RTU	"Getliņi EKO"	KTU	KTU	VGTU		
Method of sampling/ investigation	Excavation	Excavation	Sampling & examination prior to landfilling	Sampling & examination prior to landfilling	Sampling & examinatio n prior to landfilling	Sampling & examinatio n prior to landfilling	Drilling	Excavation	Excavation		
Maximal depth of investigated layers, m	5	5	-	-	-	-	10	1	1	10	20

EXAMPLE: EXCAVATION OF KUDJAPI LANDFILL IN ESTONIA

Excavation starting

EXAMPLE: EXCAVATION OF KUDJAPI LANDFILL IN ESTONIA (2)

EXAMPLE: EXCAVATION OF KUDJAPI LANDFILL IN ESTONIA (3)

Sorting actions...

EXAMPLE: DRILLINGS IN ALYTUS LANDFILL IN LITHUANIA

Drilling of holes and waste sampling, 2014

EXAMPLE: DRILLINGS IN ALYTUS LANDFILL IN LITHUANIA (2)

Sieving of fractions sampled in Alytus regional non-hazardous and inert waste landfill, 2014

Waste composition in the selected landfills

Morphological composition and resources potentials for selected landfills in Nordic target countries

Country	Denmark			Sweden		Finland	
Landfill name	Gerringe	AV Miljø	Odense Nord Miljøcenter	Högbytorp	Måsalycke [12]	Lappeenranta	Kuopio [13]
Established common waste content, %:							
coarse fraction	49,1	44	12	24	54	100,0	48,0
fine fraction	50,9	56	88	76	46	-	52,0
Size of coarse fraction, mm	>25	>25	>45	>40	> 50	-	> 20
Coarse fraction content, %							
combustible, of which	41,9	43,0	70,1	7,2	15,1	10,2	43,0
paper	-	3	-	1,1	5,2	10,2	6,0
plastics	-	-	41,9	1,8	2,6	-	24,0
other combustible, of which	-	40	28,2	4,3	7,2	0,0	13,0
wood	-	-	7,1	3,6	5,3	-	6,0
nappies, san. towels	-	-			0,3	-	-
textiles	-	-	0,5	0,6	1,2	-	7,0
rubber	4,1	-	20,6	0,05	0,3	-	-
leather	-	-	-	-	-		-
biowaste, of which	-	-	-	-	-	32,9	0
food waste	-	-	-	-	0,3	-	-
garden waste	-	-	-	-	0,6	-	-
uncombustible, of which	-	-	-	-	-	13,5	5,0
glass, ceramics	-	-	0,25	1,4	0,2	5,0	
metal	0,8	1	17,6	0,2	0,9	3,2	4,0
stones, etc.	2,3	-	5	6,8	7,4	-	-
other, of which	-	-	-	-	-	1,3	0
electronics	-	-	0,25	-	0,0	-	-
hazardous waste	-	-	-	-	0,1	1,3	-
miscellaneous•	-	-	6,8	8,4	29,4	-	-

Waste composition in the selected landfills (2)

Morphological composition and resources potentials for selected landfills in Baltic target countries

Country	Estonia		Latvia				Lithuania [14,15]				
Landfill name	Torma	Kudjape	Daibe	Pentuļi	Ķīvītes	Getliņi	Takniškės	Bionovus	Kazokiškės		
Established common waste content, %:											
coarse fraction	46,0	NDA*	NDA*	NDA*	85,2	53,8	46,0		NDA*		
fine fraction	54,0	NDA*	NDA*	NDA*	14,8	46,2	54,0		NDA*		
Size of coarse fraction, mm	> 40				>40	> 20	> 40		>20		
Coarse fraction content, %											
combustible, of which	26,2	22,4	25,2	21,0	31,6	47,1	64,0	26,8	74,1	48,9	26,2
paper	3,2	5,6	8,0	5,7	16,2	1,0	15,3	0,0	0,0	3,8	3,2
plastics	8,3	11,0	11,8	4,7	11,8	21,0	7,1	22,9	50,6	21,6	8,3
other combustible, of which	14,7	5,8	5,4	10,6	3,6	25,1	41,7	3,9	23,5	23,5	14,7
wood	3,7	0,5	3,2	2,0		0,5	20,0	0,2	1,6	5,5	3,7
nappies, san. towels											
textiles	9,2					2,9	24,6	4,2	2,3	20,2	18,0
rubber	1,8		5,3	2,2	8,6	0,7		2,5	1,4	1,8	0,0
leather											
biowaste, of which			64,96	51,7	51,9	36,5	0	0,0	60,6	22,7	49,2
food waste						29,5					
garden waste						7,0					
uncombustible, of which	9,1	11,0	12,7	23,1	27,1	14,5	6,7	36,0	12,6	3,2	1,9
glass, ceramics	1,3	0,5	9,7	18,9	23,3	8,2	0,3		8,9	1,7	1,9
metal	5,2	0,5	3,0	4,2	3,8	3,2	3,6	6,0			
stones, etc.	2,0	10,1				3,1		30,0	3,7	1,5	0,0
other, of which		6,44				17,4	0,06	0,0			
electronics							0,02				
hazardous waste	0,7	0,5				0,2	0,04				
miscellaneous•		6,0				17,2					

Fine fraction – methan degradation layer

LFM-fine fraction must be mixed with soil and sludge compost to adjust its properties.

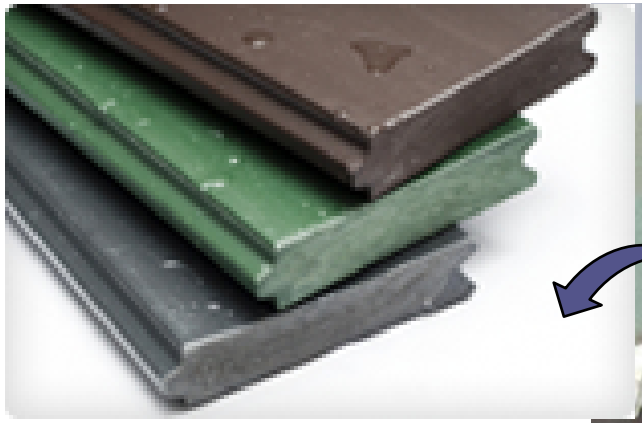
RDF for energy generation

Washing ⇨

	Before washing	After washing	Comment
Net calorific value MJ/kg	9,6	27,0	≥16, best quality RDF.
Moisture %	40,3	1,9	<15, super
Ash %	29,8	23,4	<15, too much.

4. PRACTICAL INVESTIGATIONS (13)

Landfill plastic to plastic product?



Pyrolisis oil from LFM plastic

41,901 MJ/kg, S – 0,16 %

4. PRACTICAL INVESTIGATIONS (15)

Obtained recreational area

Conclusions

- Nordic and Baltic EU countries are closely related by cooperation in solving of environmental issues, including waste management.
- The experiences of Nordic countries are successfully transfered to Baltic countries, so currently almost all in Estonia generated MSW are stopped for landfilling due increased incineration and recycling.
- Despite noticeable progress in field of recycling and incineration, landfilling remains still the main MSW disposal method in Latvia and Lithuania.
- On the other many academic and industrial partners from Nordic and Baltic EU countries started to collaborate in the several projects regarding establishment of landfill mining feasibilities with resource recovery target.
- Theoretically obtained composition of landfilled and decomposed waste remains similar in all target countries, but practical investigations in selected landfills are different and even contradictory.
- However in all cases obtained potential for solid recovered fuel, glass and metals seems realistic and suitable for extraction.

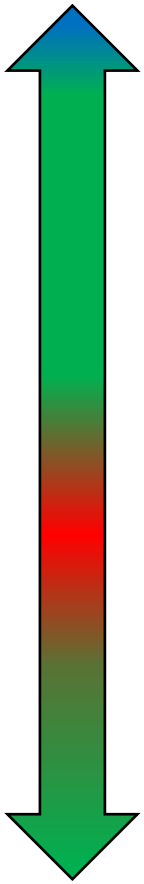
5. CONCLUSIONS (2)

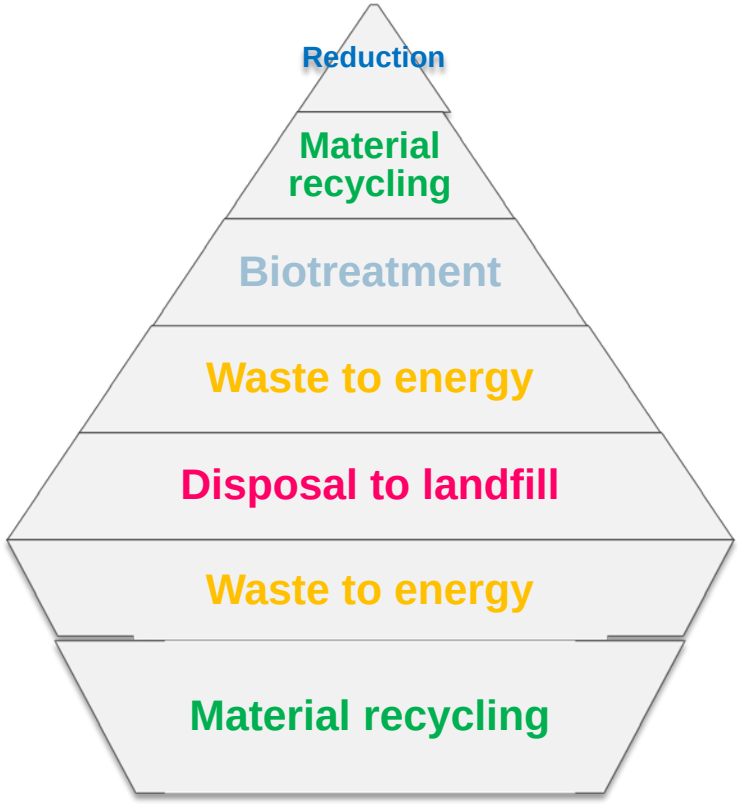
WASTE MANAGEMENT HIERARCHY!

?

Herewith landfilling:

- ✓ can be cease to be the last waste management priority and in fact becomes a function of waste temporary storage and noticeable element of circular economy due to growing of interests for urban and landfill mining with materials and energy recovering.





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Thank you for your attention ☺