2nd ICoN-BEAT

Selamat sore! Tere päevast! ☺ July 28, 2021

Advanced studies of inert landfill fine fraction mass - hunting for values from waste

***Juris* Burlakovs**
Department of Environmental Science, University of Latvia, Jelgavas 1, LV-1004 Riga, Latvia

The annual growth rate of waste electric–electronic equipment (WEEE) is about 3–5%

This is the fastest growing waste stream in municipal wastes

The main contributing metals in such electronics applications are the rare earths (REE) and platinum group metals (PGE)

Strategic restriction by the supplier countries made the virtual hype in the global market and will negatively impact the EU's economy

There is growing technological potential for high metal recoveries by using mechanical, hydrometallurgical and bioleaching processes that are promising options for the treatment of WEEE

The EU Raw Materials Initiative

- Critical Raw Materials for the EU -

European Commission
Enterprise and Industry

Main challenges

EU highly dependent on imports of important raw materials (metals and industrial minerals) which are increasingly affected by **market distortions**


LMT
17:11
35 %
tradergo.luminor.lt
Charts
1W : 2Y
1W
US500.I
SMA 200
2,919.37
2,000.00
1,500.00
1,000.00
500.00
Monday, September 24, 2018
US500.I (Bid)
Open 2,921.74
High 2,923.99
Low 2,916.99
Close 2,919.37
SMA 200 2,307.70
US500.I RSI 14 Wilder
100.00
70.00
50.00
30.00
0.00
Indicative price
1985
1990
2000
2010
MARKET DATA PROVIDED BY SAXO BANK • DATA DISCLAIMER

LMT
17:11
34 %
tradergo.luminor.lt
Charts
1W : 2Y
1W
XPDUSD
SMA 200
1,054.20
750.00
500.00
250.00
Monday, September 24, 2018
XPDUSD (Bid)
Open 1,047.40
High 1,059.90
Low 1,038.80
Close 1,054.20
SMA 200 777.23
XPDUSD RSI 14 Wilder
100.00
70.00
50.00
30.00
0.00
Indicative price
1987
1990
2000
2010
MARKET DATA PROVIDED BY SAXO BANK • DATA DISCLAIMER

The Raw Materials Initiative

Integrated strategy

based on three pillars

Ensuring access
to raw materials from
International Markets

under the
same conditions as other
industrial competitors

Right
framework conditions
within the EU

in order to foster
sustainable supply
from European
sources

Boosting
resource efficiency
and recycling

to reduce the EU's
consumption of
primary raw materials

Efficiency & recycling

Huge potential of EU's Urban Mines

Tackle illegal shipment of waste to third countries through a more harmonised enforcement of Waste Shipment Regulation

Develop best practices in the area of collection and treatment of key waste streams

Develop eco-design measures aimed at fostering more efficient use of raw materials in products

Increase resource efficiency

The Commission published a Roadmap on how to move towards a resource efficient Europe by summer 2011

The roadmap set out specific resource efficiency objectives, and how to meet them, based on actions up to 2020 with a time perspective of up to 2050

Define critical raw materials

Methodology

41 raw materials analysed

Time horizon: 10 years

A pragmatic approach

Three main aggregated **indicators**

- **economic importance**
- **supply risks**
- **environmental country risks**

41 raw materials analysed

Aluminum	Antimony	Barytes	Bauxite
Bentonite	Beryllium	Borates	Chromium
Clays (incl. kaolin)	Cobalt	Copper	Diatomite
Feldspar	Fluorspar	Gallium	Germanium
Graphite	Gypsum	Indium	Iron ore
Limestone	Lithium	Magnesite	Magnesium
Manganese	Molybdenum	Nickel	Niobium
Perlite	Platinum Group Metals (PGMs)		
Rare earths (REE)	Rhenium	Silica sand	
Silver	Talc	Tantalum	
Tellurium	Titanium		
Tungsten	Vanadium		
Zinc			

Where we need all of this?

Importance for economic value chain and emerging (key) technologies

- **Renewable energy**:
  solar cells, wind turbines
- **Energy efficiency**:
  hybrid and electric cars, LED lighting, batteries
- **Electronics**:
  flat screens, mobile phones
- **Aerospace**:
  light weight alloys

Emerging technologies

Raw material	Production 2006 [t]	Demand emerging tech. 2006 [t]	Demand emerging tech. 2030 [t]	Demand/ prod. 2006	Demand/ prod. 2030	Factor
Gallium	152	28	603	0.18	3.97	22
Indium	581	234	1.911	0.40	3.29	8.2
Germanium	100	28	220	0.28	2.20	7.9
Neodymium	16.800	4.000	27.900	0.23	1.66	7.2
Platinum	255	very small	345	0	1.35	
Tantalum	1.384	551	1.410	0.40	1.02	2.5
Silver	19.051	5.342	15.823	0.28	0.83	2.9
Cobalt	62.279	12.820	26.860	0.21	0.43	2.1
Palladium	267	23	77	0.09	0.29	3.2
Titanium	7.211.000	15.397	58.148	0.08	0.29	3.6
Copper	15.093.000	1.410.000	3.696.070	0.09	0.24	2.7

Emerging technologies

(2)

Raw material	Emerging technologies
Antimony	Antimony-Tin-Oxide (~ In-Sn-O), micro capacitors
Cobalt	Li-ion batteries, synthetic fuels
Gallium	Semi-conductors, thin layer photovoltaics, IC, WLED
Germanium	Fibre optic cable, IR optical technology
Indium	Displays, thin layer photovoltaics
Platinum (PGM)	Fuel cells, catalysts
Palladium (PGM)	Catalysts, seawater desalination
Niobium	Micro capacitors, ferroalloys
Neodymium (REE)	Permanent magnets, laser technology
Tantalum	Micro capacitors, medical technology

Critical raw materials

High supply risks

High share of the worldwide production

- China (antimony, fluorspar, gallium, germanium, graphite, indium, magnesium, REE, tungsten)
- Russia (PGM)
- Congo (cobalt, tantalum)
- Brazil (niobium, tantalum)

Low substitutability

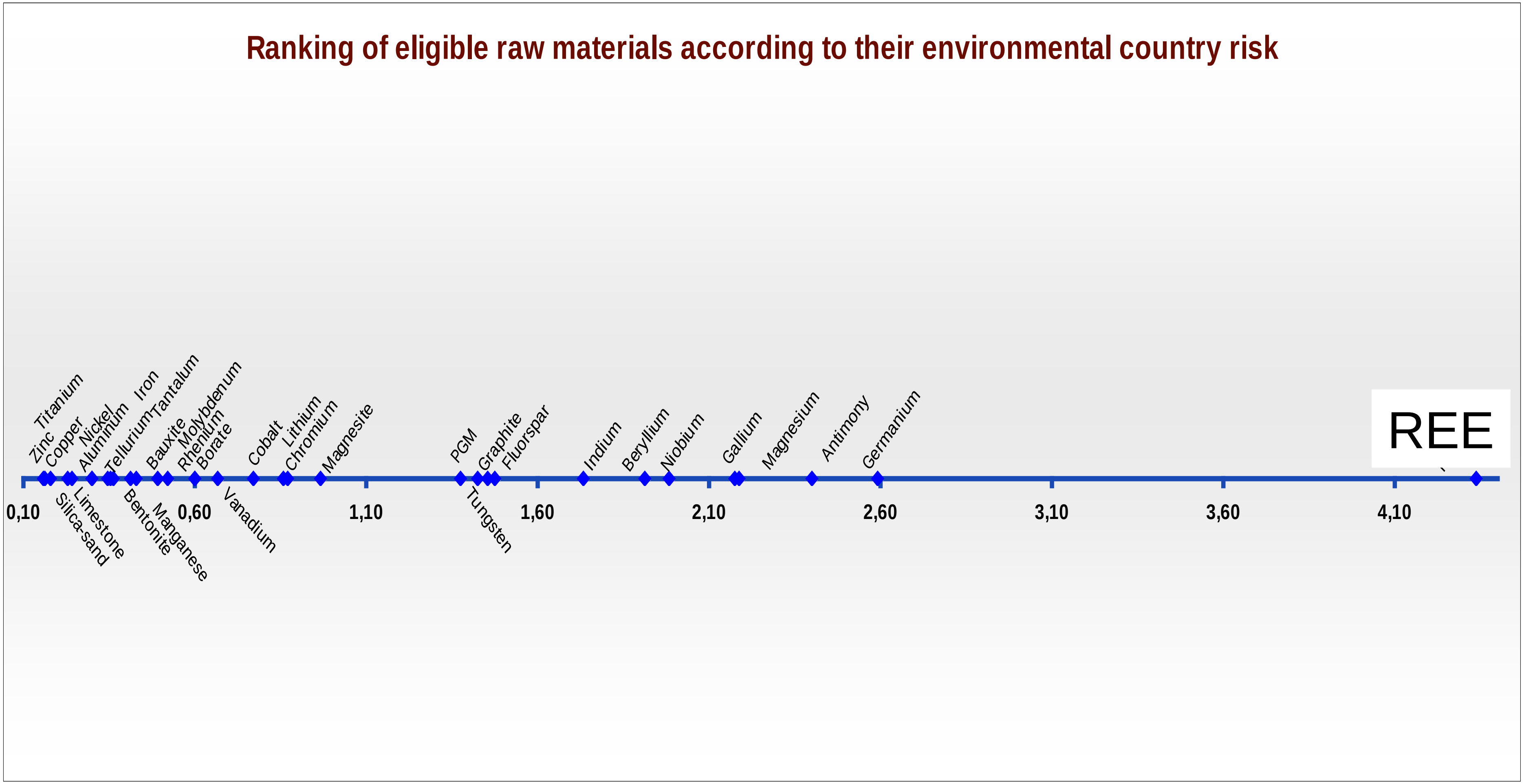
- REE, PGM

Low recycling rates

- When used in very low concentrations

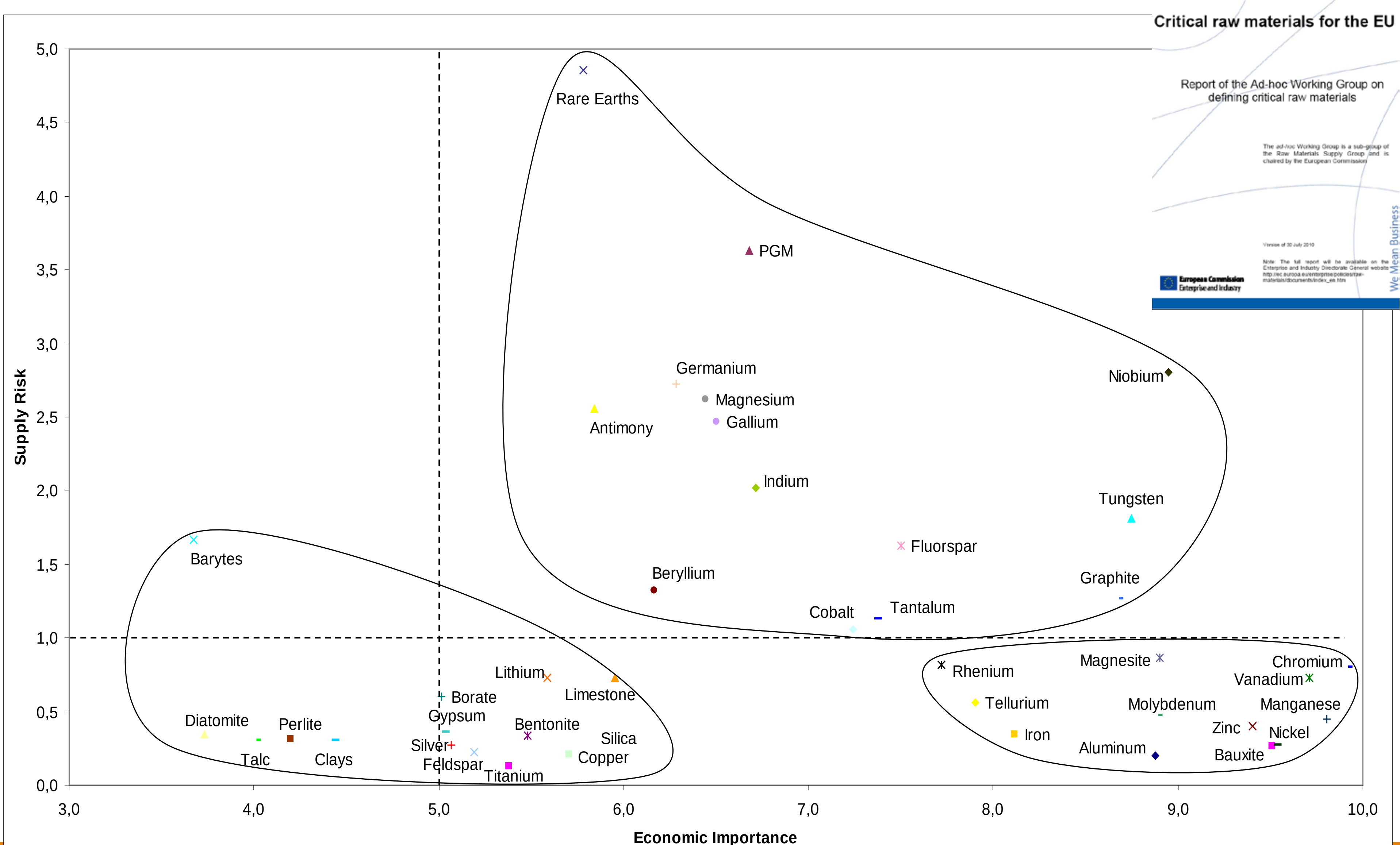
Environmental country risk

(adapted from Antje Wittenberg)



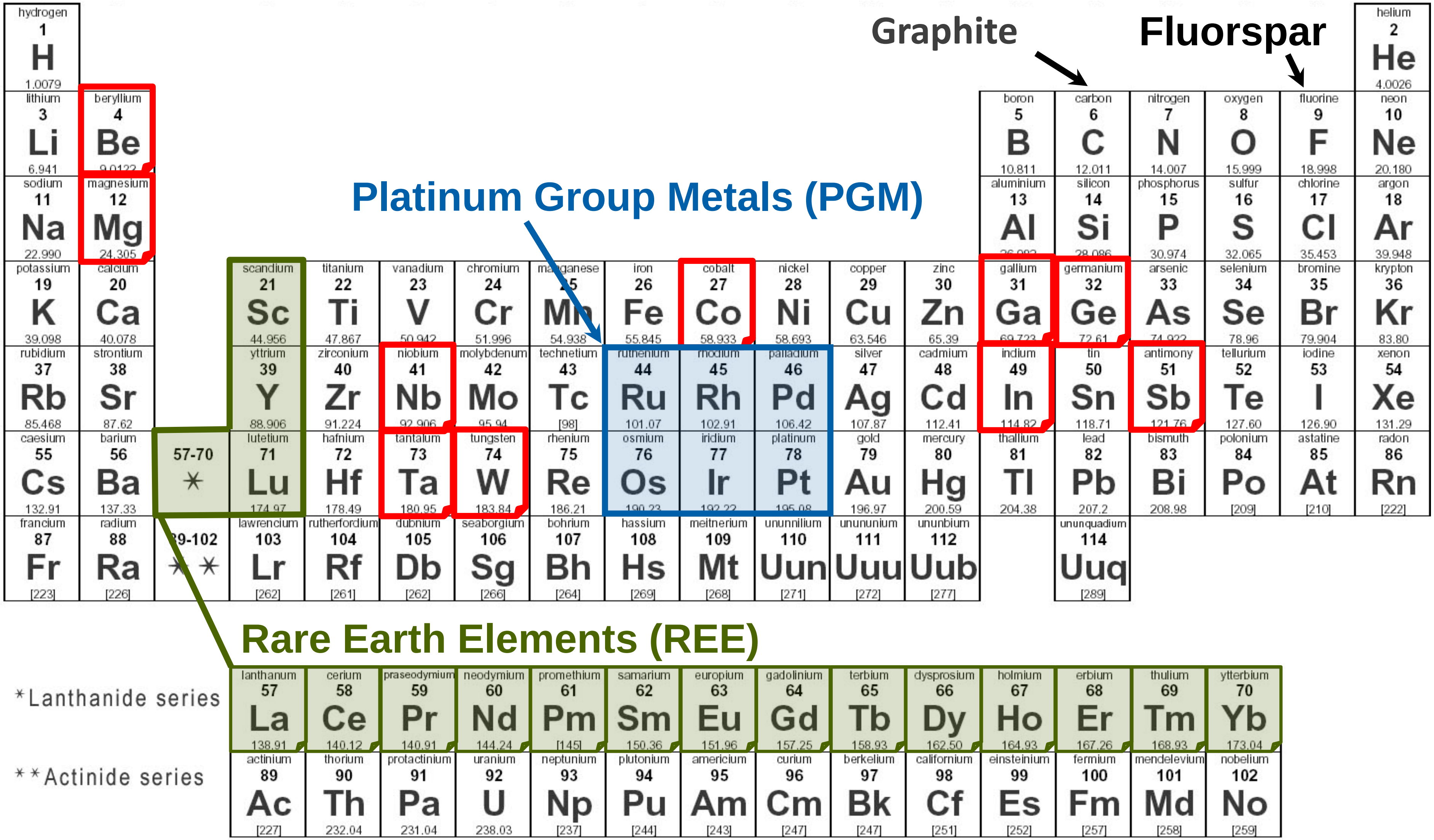
Critical raw materials

(adapted from Antje Wittenberg)



14 critical raw materials

(adapted from Antje Wittenberg)



Follow up and further support

Up-date the list every 5 years and enlarge the scope

Improve the availability and quality of statistical information and prepare a Yearbook

Carry out further studies, e.g. competition to land use, « cradle-to-grave » LCAs, emerging technologies

Establish a sub-group of the Raw Material Supply Group on criticality

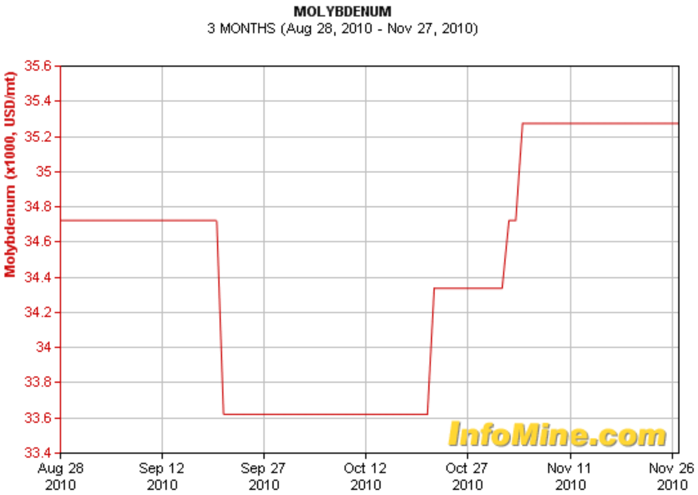
World Metal Price

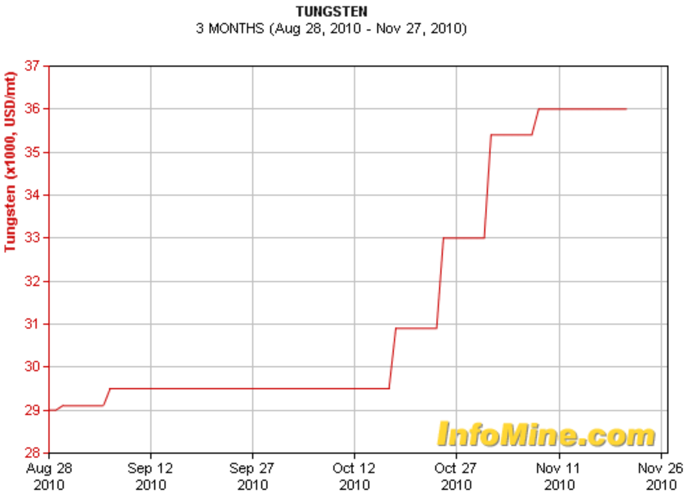
1995-2010

6.08.2010 accident in a small size Cu-mine, Chile

World Metal Price

1995-2010

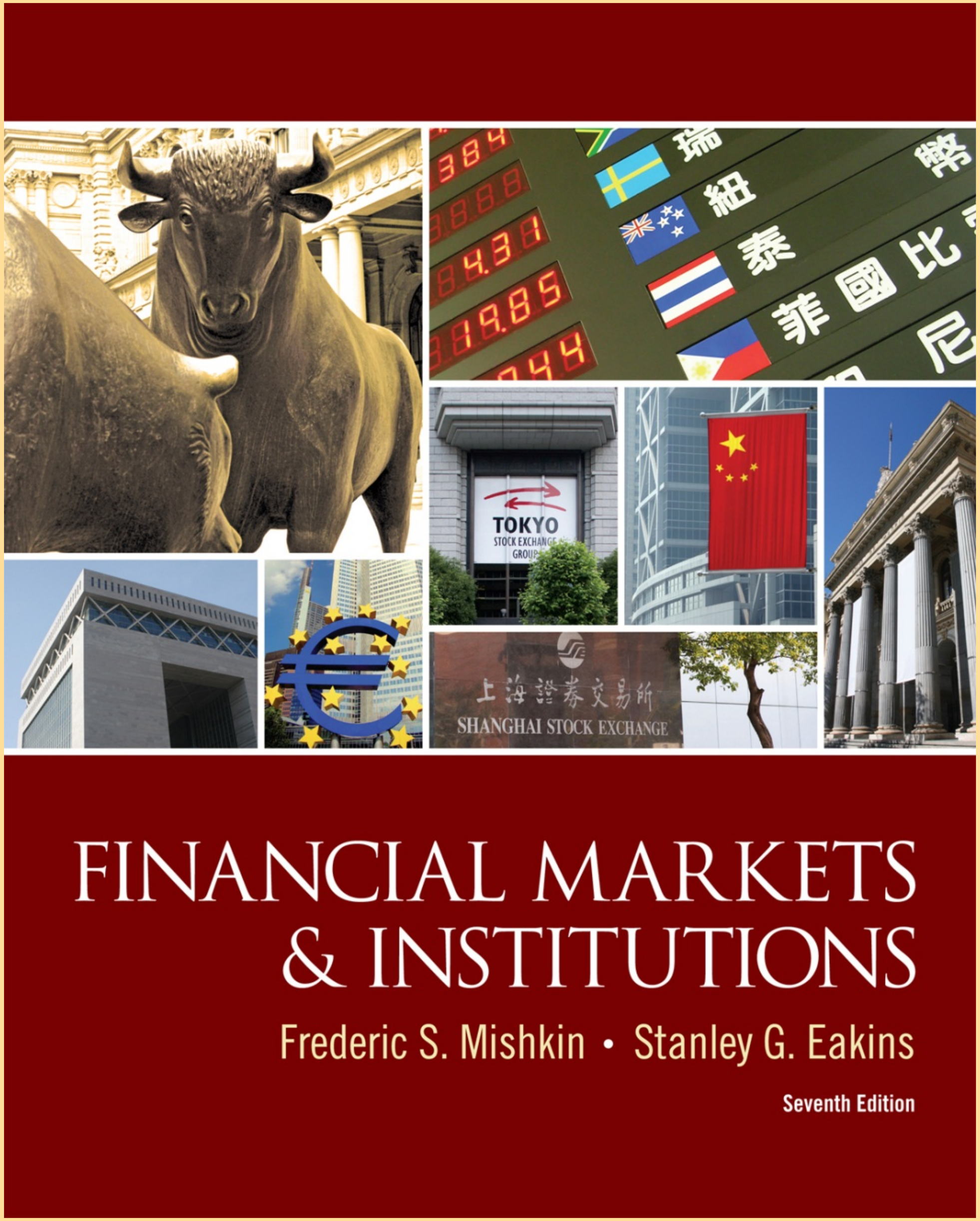





EXCHANGE CENTRE
20 BRIDGE STREET


Barclays
HSBC
Commodities
GOLD SPOT
SILVER SPOT
PALLADIUM SPOT
PLATINUM SPOT
ICE BRENT CRUDE
TLS TELSTRA
STO SANTOS LIMITED
S32 SOUTH32 LIMITED
FMG FORTESCUE
FXJ FAIRFAX
AWC ALUMINA LIMITED
MGR MIRVAC GROUP
QAN QANTAS AIRWAYS L

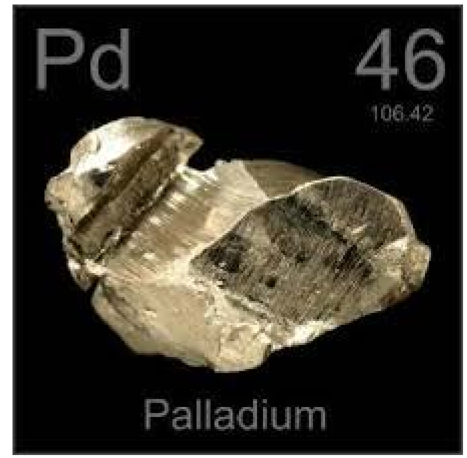

ASX
ASX
STOCK BID OFFER LAST VOL
STOCK BID OFFER LAST VOL
NETLINKZ
NETWEALTH GRO
NEUREN PHARMA
NEUROSCIENTIFIC
NEW AGE
NEW HOPE
NEWCREST
NEXTDC LIMITED
NGE CAPITAL
NIBHOLDING
NICK SCALI
NICKEL MINES
NINE ENT
CANADA

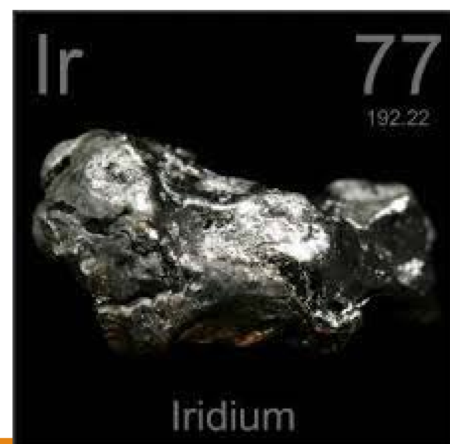


CHAPTER 8

Why Do Financial Crises Occur and Why Are They So Damaging to the Economy?

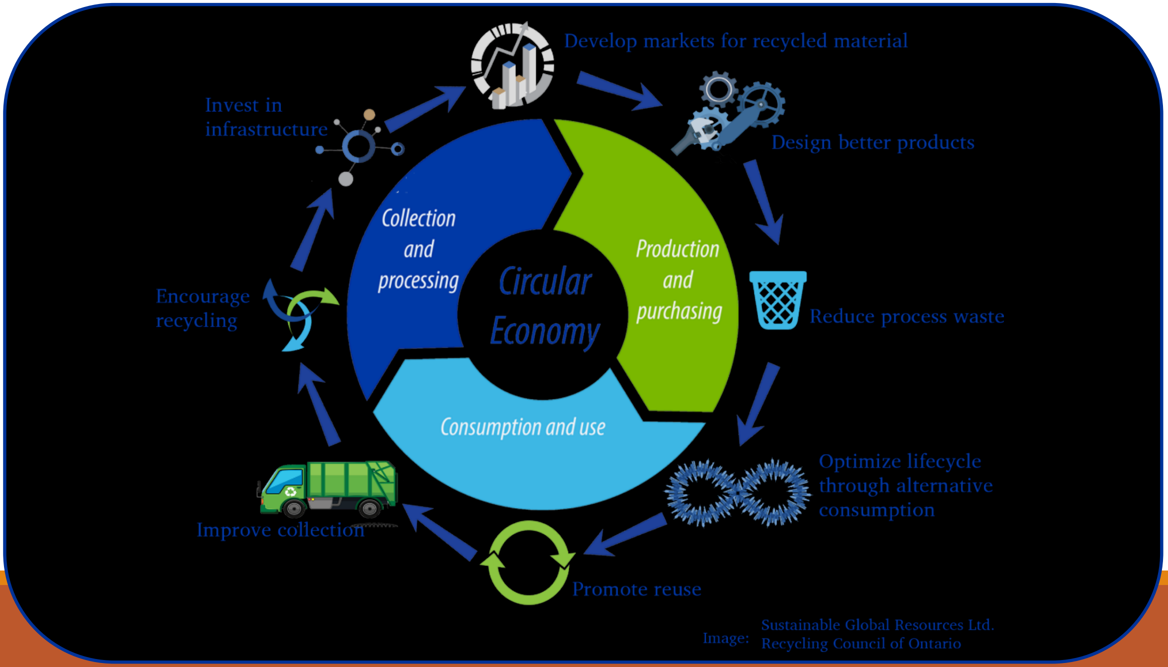
Platinum group elements (PGE_s)



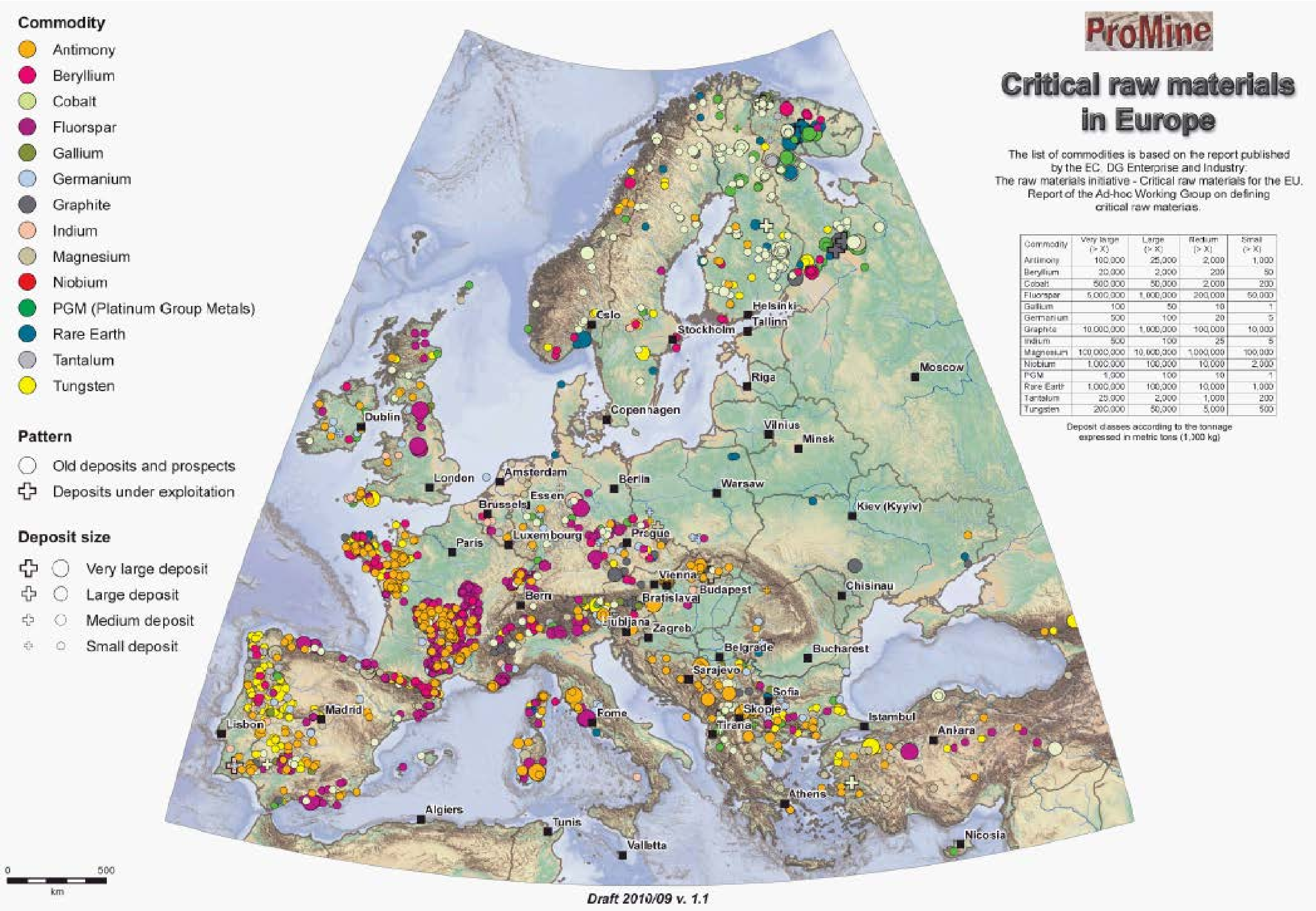


important notes

PGEs role as critical elements for industry in future will rise requiring sustainable exploration, mining and recycling in frame of circular economy



R&D - preliminary findings



Commodity	Very large (> X)	Large (> X)	Medium (> X)	Small (> X)
Antimony	100,000	25,000	2,000	1,000
Beryllium	20,000	2,000	200	50
Cobalt	500,000	50,000	2,000	200
Fluorspar	5,000,000	1,000,000	200,000	50,000
Gallium	100	50	10	1
Germanium	500	100	20	5
Graphite	10,000,000	1,000,000	100,000	10,000
Indium	500	100	25	5
Magnesium	100,000,000	10,000,000	1,000,000	100,000
Niobium	1,000,000	100,000	10,000	2,000
PGM	1,000	100	10	1
Rare Earth	1,000,000	100,000	10,000	1,000
Tantalum	25,000	2,000	1,000	200
Tungsten	200,000	50,000	5,000	500

Hydrometallurgy

- Pre-treatment
- Leaching
- Recovery
- From lab-scale to full-scale applications
- Conclusions and research needs

Leaching

Acidolysis

Redoxolysis

Complexolysis

Bioleaching

Recovery

Adsorption

Complexation

Precipitation

Electrowinning

Selective recovery strategies (SX/IX)

Reduction/cementation

Microorganisms involved

Bioleaching microbes (Autotrophic and heterotrophic)

- Autotrophs (iron-and sulfur-oxidisers)
- Heterotrophs (acid and complexant producers)

Biorecovery microbes

- Reductive bioprecipitation microbes
- Biomineralization microbes
- Sulfate oxidisers (sulfidic precipitation)
- Biosorption microbes

Biochemical mechanisms

Bioleaching

- Acidolysis
- Redoxolysis
- Complexolysis

Hybrid approaches

- Chemical and biological combined approaches

Biorecovery

- Bioprecipitation
- Biomineralization
- Biosorption

From lab-scale to full-scale applications

Pilot & commercial applications HYDROWEEE – RELIGHT plant in Milano and one is on-going in Belgium or UMICORE – it is a combination process as hydro+pyro or similar

COST ES 1405 ReCrew on Recovery of Waste Electronics

Important research dimensions

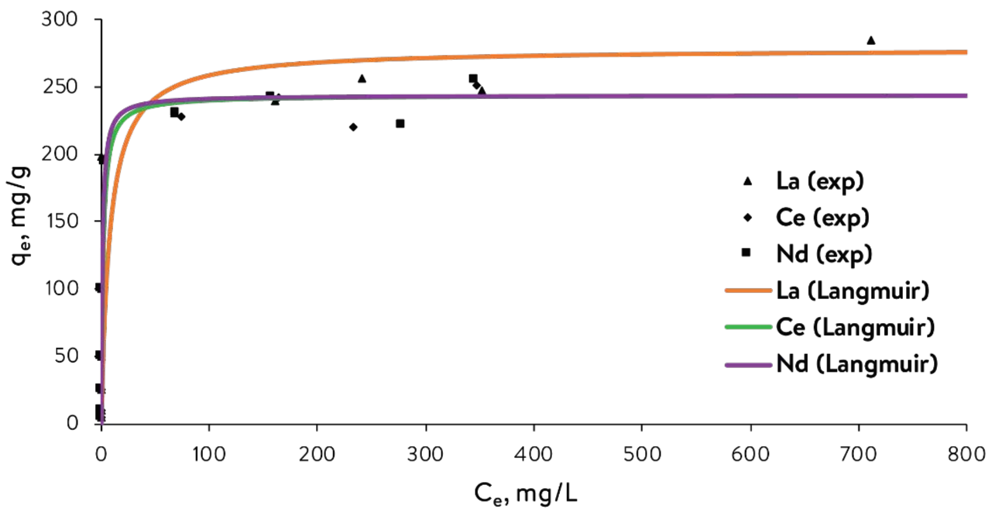
Better characterization of treated e-waste materials (total elemental composition, mineralogy)

Optimal pre-treatment strategy

Demonstration plant

Existing EU projects

Clay sorbents?



At 3rd Int. Symposium on Enhanced Landfill Mining, Lisboa, 8-10.2.2016

Metals and rare Earth’s elements in landfills: case studies

JURIS BURLAKOVS[1], MAIT KRIIPSALU[2], DACE ARINA[3], FABIO KACZALA[4], RUTA OZOLA[1], GINTARAS DENAFAS[5], MARIKA HOGLAND[4], VALERIY MYKHAYLENKO[6], YAHYA JANI[4], KAJA ORUPOLD[2], TSITSINO TURKADZE[7], VALDONE DAUGELAITE[5], ALGIMANTAS BUCINSKAS[5], VITA RUDOVICA[1], MIKA HORTTANAINEN[8], MARIS KLAVINS[1], WILLIAM HOGLAND [4]

[1] UNIVERSITY OF LATVIA; [2] ESTONIAN UNIVERSITY OF LIFE SCIENCES; [3] INSTITUTE OF PHYSICAL ENERGETICS, LATVIA; [4] LINNAEUS UNIVERSITY, SWEDEN; [5] KAUNAS UNIVERSITY OF TECHNOLOGY, LITHUANIA; [6] TARAS SHEVCHENKO NATIONAL UNIVERSITY OF KYIV, UKRAINE; [7] A. TSERETELI STATE UNIVERSITY, GEORGIA; [8] LAPPEENRANTA UNIVERSITY OF TECHNOLOGY, FINLAND

Background


Finland
VIKA
(Katrineholm)
Estonia
TORMA
KUDJAPE
Sweden
Latvia
RIGA
(BLB)
Baltic Sea
Lithuania
US Dept of State Geographer
© 2015 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
Google earth

Characterisation of sites: BLB, Riga, Latvia

Objectives

The aim of this study was to determine elemental content of colloidal, clayey and silty aggregates (very fine fraction) from excavated soil-like material in order to assess recovery potential of metals and REEs.

Why REEs, they were not the primary objective in any of the projects?

REEs strategic and expensive (up to 3-5 housand $/kg).

It is useful to know what do we have in 'stock'.

If we go for extracting major metals, perhaps we can get REEs too?

- Advanced leaching and bioextraction (approved technologies).

There is competence → Molycorp (Sillamäe, Estonia), is producing tantalum and niobium (loparite ore imported from the Kola Peninsula)

The aim is to find sustainable resources recovery potential for fine fraction of landfill waste with objectives

- **estimate recovery perspectives**
- **investigate interactions among remnant pollutants and organic matter in landfill fine fraction**
- **provide scientifically approved recommendations for land recovery and ecosystem revitalization in landfills in circular economy perspective**

Material Recovery

Since 2002 prices on minerals have grown substantially

Global demand for minerals will double next 25 years, scarce elements are depleted soon – landfill mining is recovery option

Landfill Mining

- ✓Is the materials and energy recovery (excavation) from historically dumped waste – it is Innovation
- ✓Reducing greenhouse gas emissions
- ✓Landscape restoration

New market


Over-production
Over-consumption
Fresh waste
Old waste and pollutionn
Well established market
Completely new market

Benefits from Landfill Mining

is material and valuables recovery

Perspectives in Baltic States:

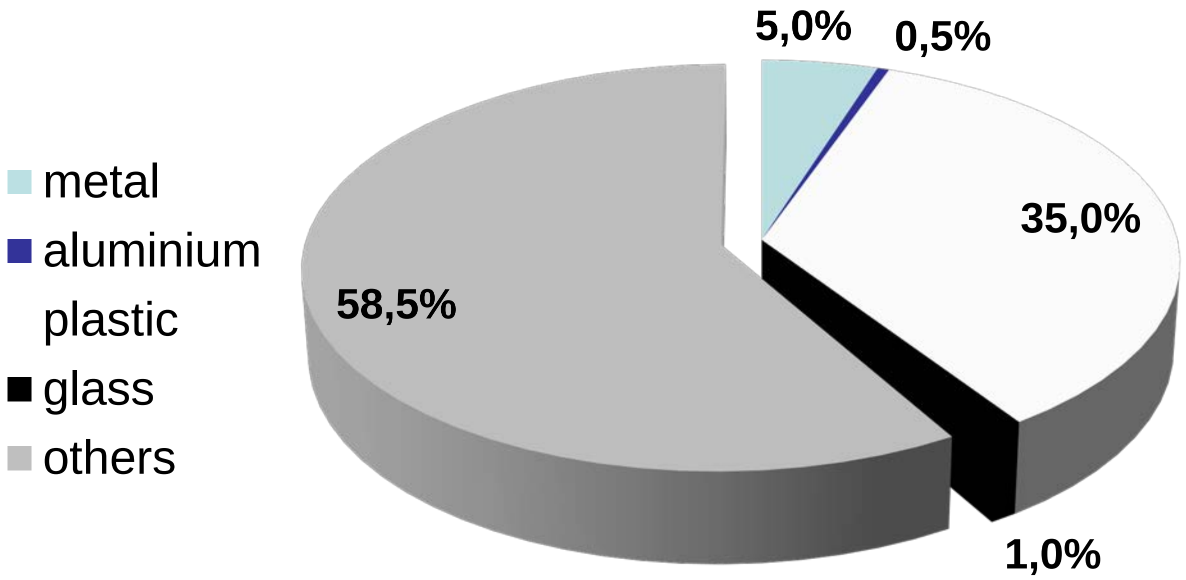
1700 closed landfills
2 million tons of refuse derived fuel
0.33 million tons of metals
140 000 kg of Rare Earth Elements

Market potential

- Potential of revenues total in Latvia:

Landfills content	Shares	Weight, t	Price, t	Amount
metal	5.0%	110 000	€ 189	**€ 20 790 000**
aluminium	0.5%	11 000	€ 1 000	**€ 11 000 000**
plastic	35.0%	770 000	€ 90	**€ 69 300 000**
glass	1.0%	22 000	€ -	**€ -**
others	58.5%	1 287 000	€ -	**€ -**
Total	**100.0%**	**2 200 000**		**€ 101 090 000**

Materials by type



Landfills content	Shares	Weight, t
metal	5.0%	110 000
aluminium	0.5%	11 000
plastic	35.0%	770 000
glass	1.0%	22 000
others	58.5%	1 287 000
Total	**100.0%**	**2 200 000**

Quality of Material from Landfill Mining

Challenges:

Innovative landfill mining includes extraction – plastic is wet and dirty; metallic elements mostly in residual bound with organics. Solutions: washing and drying plastic; separation of industrial waste from household waste. Latter is reject. For RDF production burnable fractions are plastic

Innovative landfill capping includes LFM, where fine fraction is used mixed with soil and vegetation to improve greenhouse gas (methane) degradation by natural means; most adequate recipe for new capping material is the challenge

Quantitative and qualitative studies will be performed with real case studies during the project

Case study: Kudjape

Kudjape landfill/dump, Saaremaa island, Estonia

In operation 40 years, most active during last 20 years

Estimated volume 200.000 m^3

Municipal waste

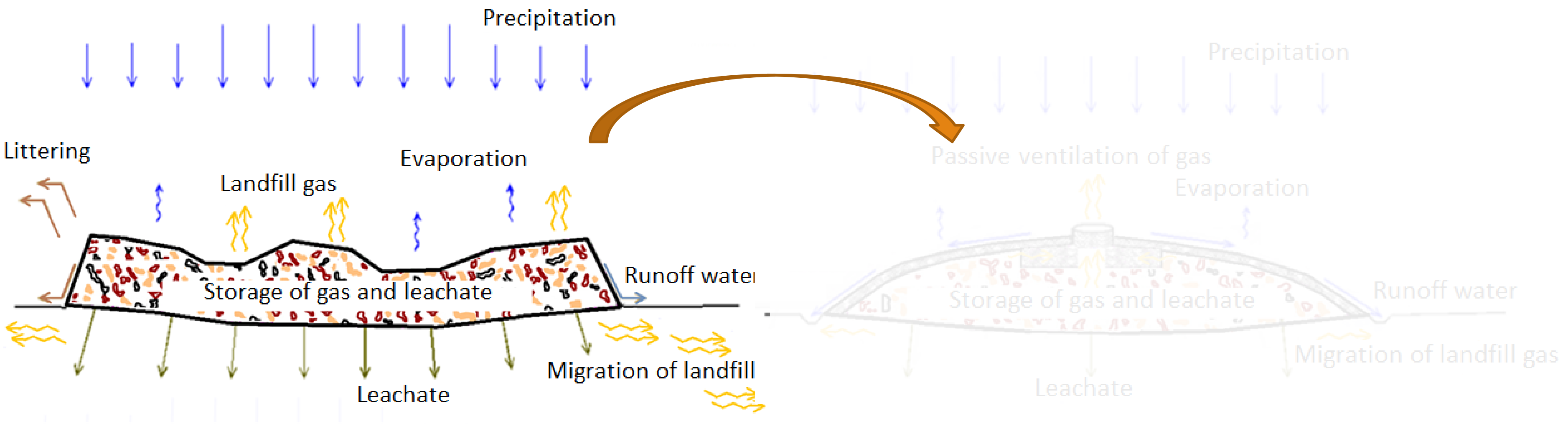
NO bottom liner

By law had to be capped 2013

Main issue: Landfill gas

- Gas collection? Passive ventilation?

Typical cover design in small dumpsites



Kudjape case was different

Simple closure design of a LF was **not agreed** by authority;

- Fear of gas → 1,5 m cover layer was prescribed;

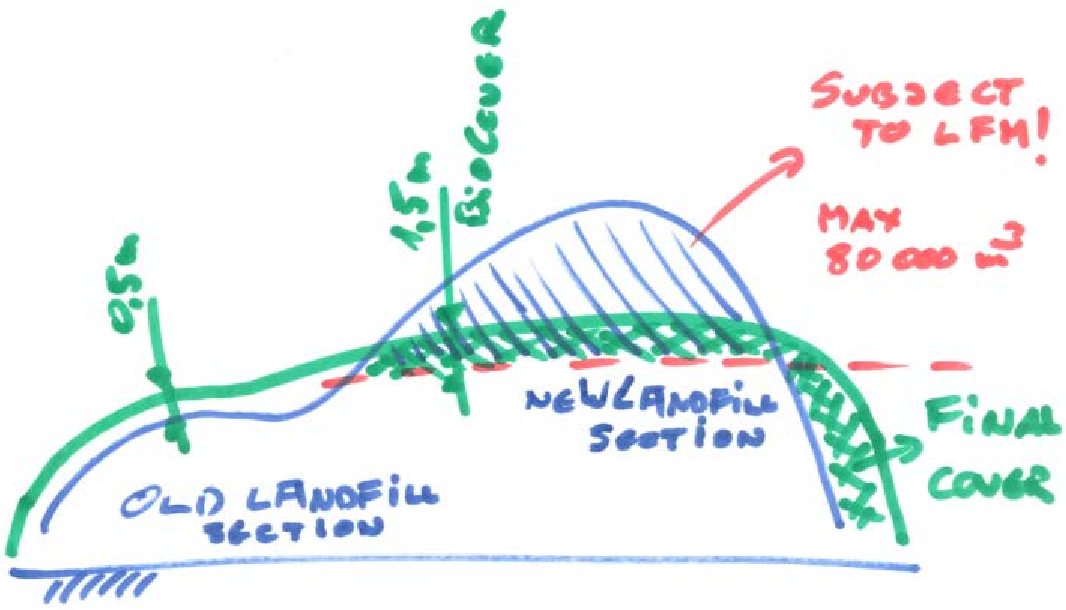
Cover material was not available.

- Cover material demand 60.000 t – locally not available
- To transport it from distances/overseas?
- Is it ethical to force LF using clean soil for covering waste?

What if we take cover material from the same landfill?

- This technology is called **Landfill Mining** (LFM)

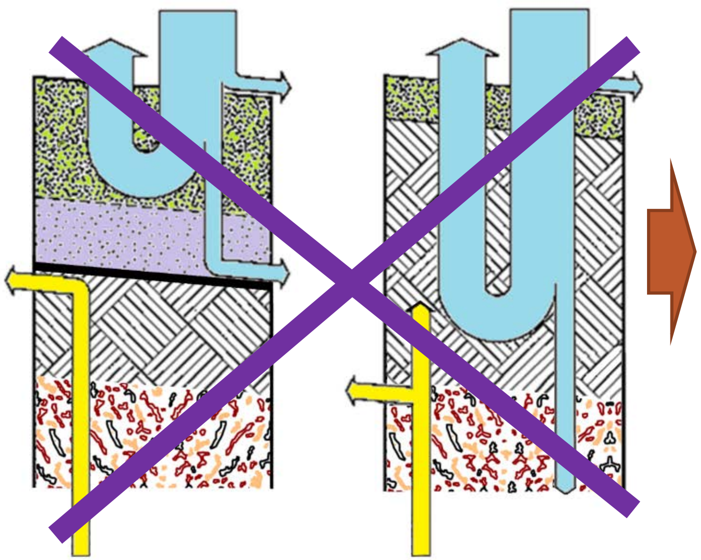
Master plan



BIOCOVER
1.5m
0.5m
SUBJECT TO LFM!
MAX 80 000 m3
NEW LANDFILL SECTION
FINAL COVER
OLD LANDFILL SECTION

Design of a cover layer

Impermeable cover layer



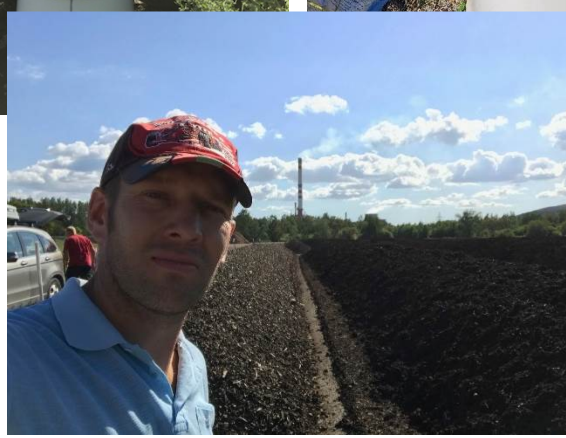
Semi-permeable cover layer

Methane degrades: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Excavation in progress

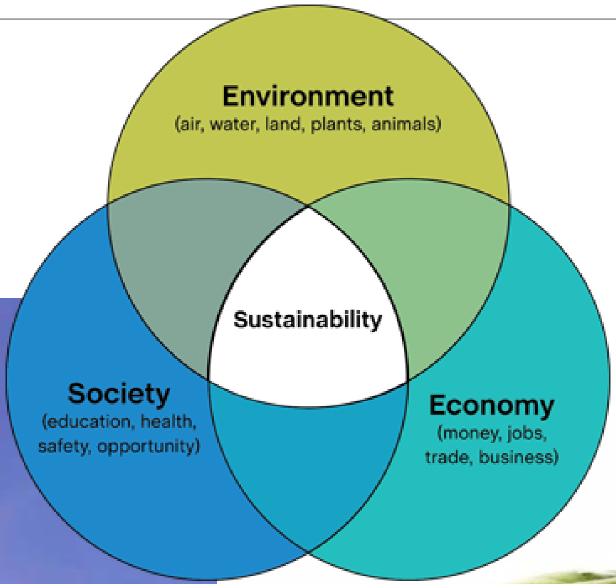
About 55.000 tons were excavated during one year.

Methane degradation and biowaste separation and valorization challenges



Separation of waste + Sustainable landfilling + + Sustainable closure = Clean Environment

the economy in the environment



The Spaceship Economy

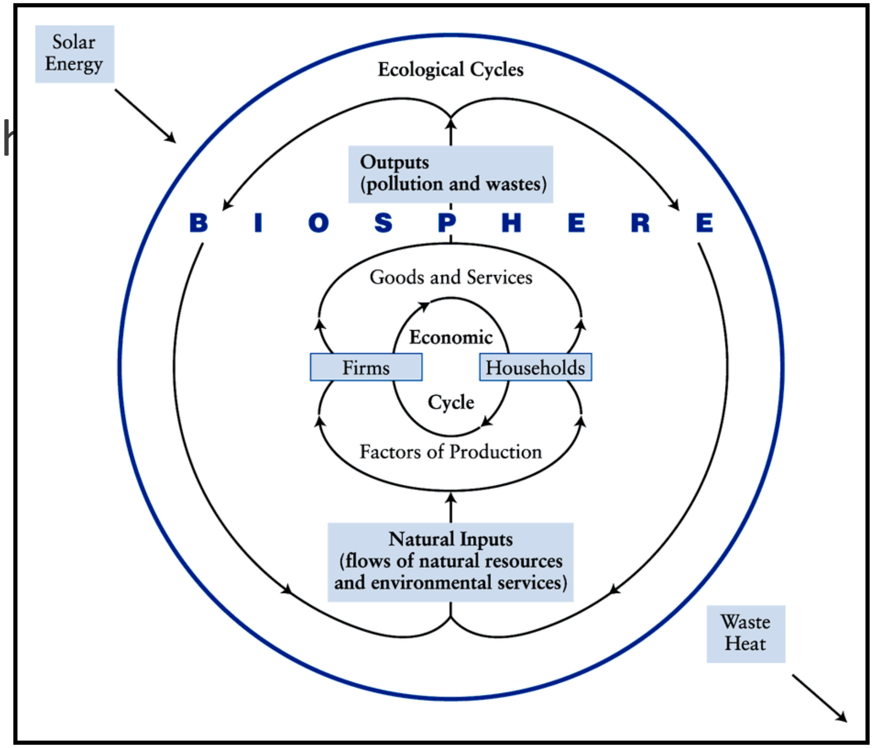
Expanding system boundaries

Limited reservoir of materials on earth

Economy uses inputs from the environment and emits waste

Must limit throughput

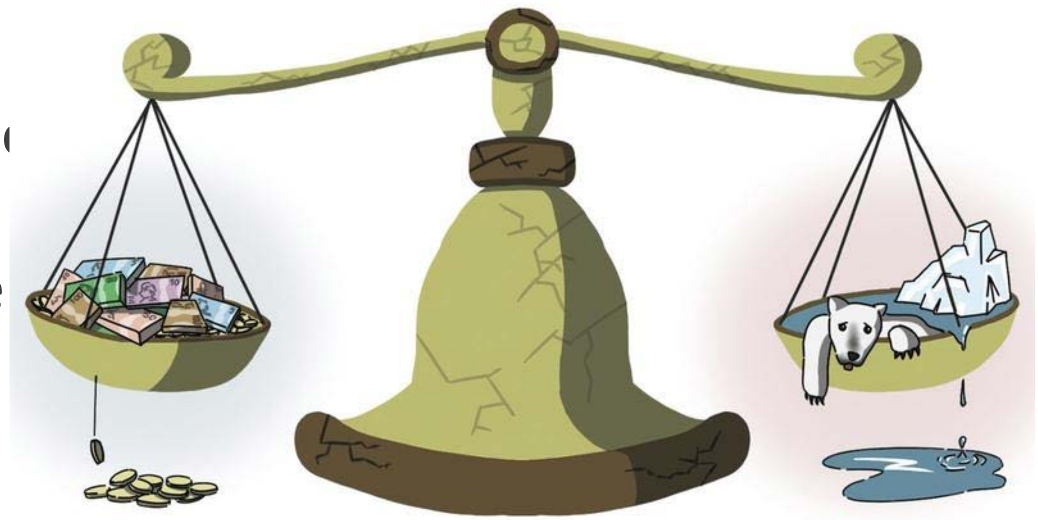
Limits to growth?



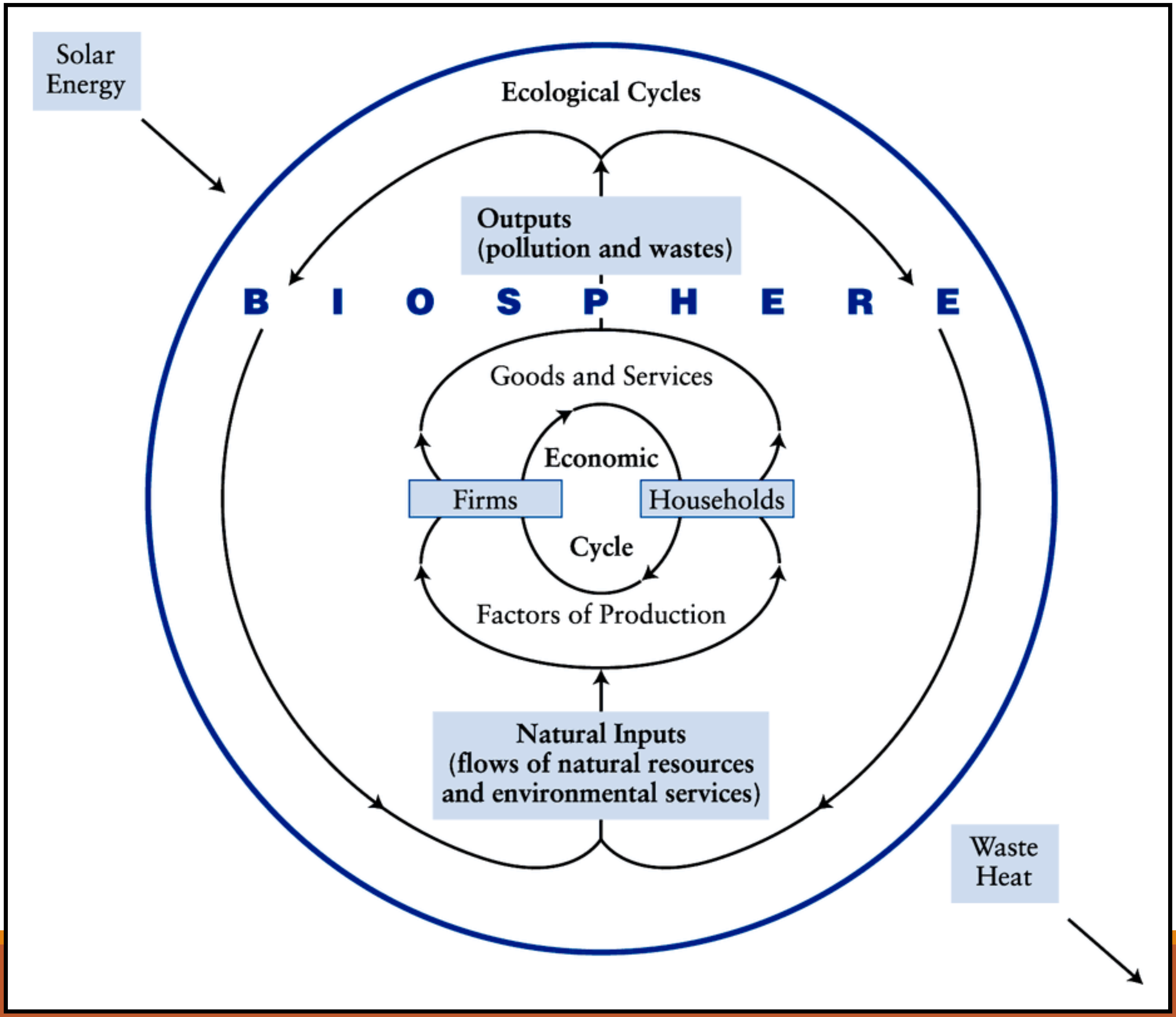
The Big Picture

Continually trying:

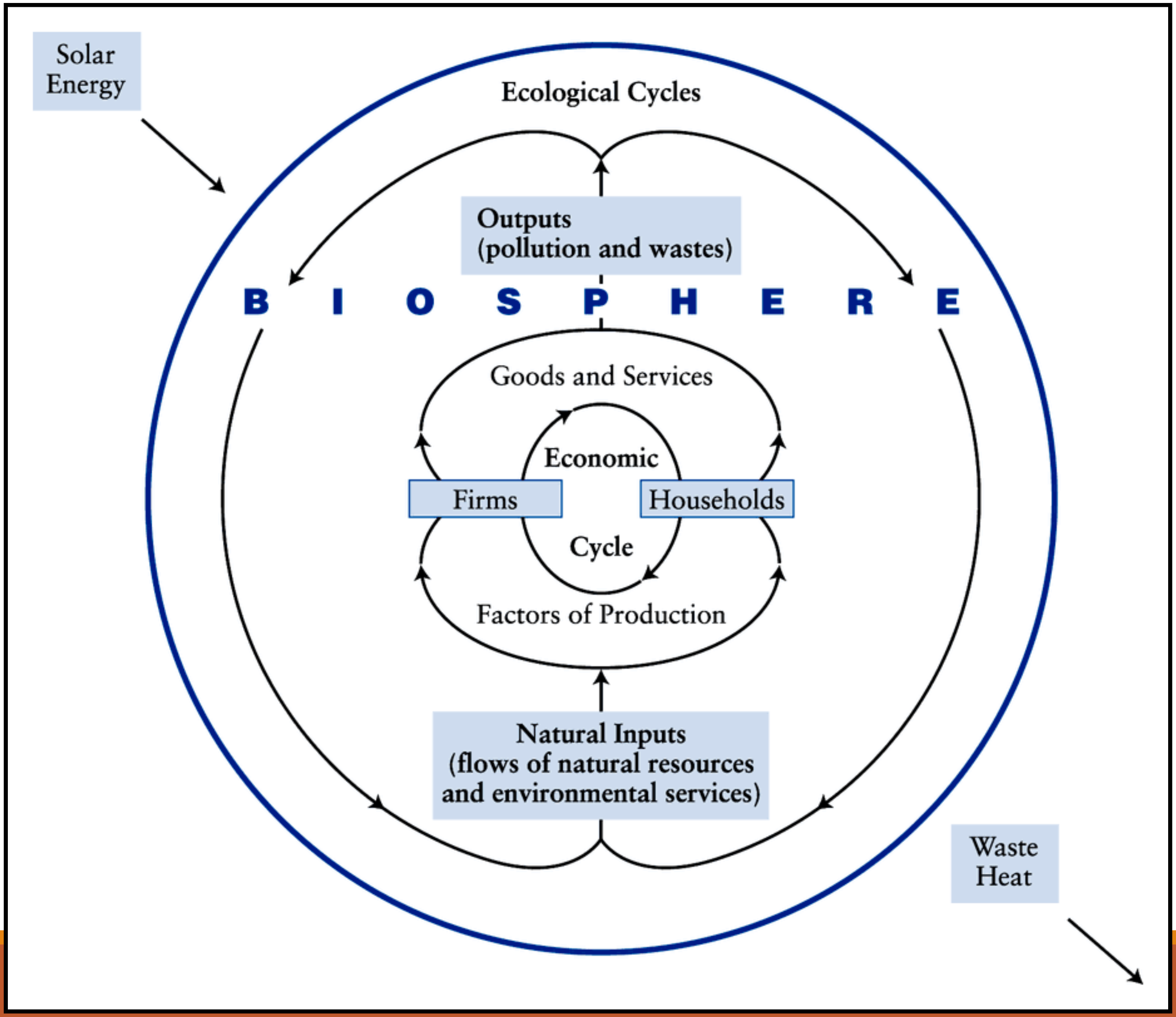
- Not to overwhelm regenerative capacity the environment
- Not to overwhelm the waste-assimilative capacity of the environment



Is the earth open or closed?



Is the economic system open or closed?



Conclusions

Sustainable closure of landfills is important for circular economy

Monitoring of soil, water, leachate and gasses are compulsory

Hydrogeology and modelling

Emissions assessment / calculations are recommended

Resources recovery estimates and technological challenges solutions should be discovered in future

Future of landfills is: logistics centres for recycled material and industrial / thematic parks through revitalization of degraded areas

Acknowledgements: teamwork!

Innovative technologies for stabilization of landfills- diminishing of environmental impact, and resources potential in frames of circular economy ***1.1.1.2/VIAA/3/19/531***

EMU, Dept of Water Management: MSc Enriko, Kaarel and Kaur-Mikk for hard work on site; Dept of Env and Agri: sup Kaja Orupõld, MSc Kertu and Allar for their work with fine fraction; sup Valdo Kuusemets and MSc Merilin for gas study; Dept of Land Surveying: Harli Jürgenson and BSc students, Dept of Forestry: Andres Jäärats and BSc Kati for survey of trees; University of Tartu: Marika Truu, Hiie Nõlvak and MSc Krista for 16S rRNA; Supervisors of undergraduates: Mari Ivask, Ülle Soom, Maie Meius

Mihkel Paljak and Valdo Liiv from Saaremaa Prügila Ltd, for innovative thinking and strong support;

RTS-Infra Ltd, Rein-Erik, Olavi and field staff for amazing daily effort;

Funding support: European Cohesion Fund and Estonian Environmental Investment Centre, Archimedes; EMU Basic funding 8P170055MIVE;

Swedish Institute (SI) for funding international research project ‘Closing the Life Cycle of Landfills - Landfill Mining in the Baltic Sea Region for future’.

COST Action programm CA15115 – Mining the European Anthroposphere (MINEA)

Prof William Hogland and Dr Fabio Kaczala, Linnaeus Uni, Sweden.

2nd ICoN-BEAT

TERIMA KASIH!

AITÄH!

JURIS.BURLAKOVS@EMU.EE