



Enhanced Landfill Mining in the EU-28: rationale, opportunities and challenges

Peter Tom Jones (General Co-ordinator EURELCO)
European Parliament, 20-10-2015





Scope

The landfill situation in EU-28

Enhanced Landfill Mining (ELFM): rationale and definition

The rise of the ELFM concept

Why EURELCO?

Conclusions

SNEAK PREVIEW: EURELCO Animation Film with Ray Cokes



The Landfill Situation in EU-28

– Problems and Opportunities

Landfills in EU-28 – Setting the scene

SUFALNET4EU
SUSTAINABLE USE OF FORMER
AND ABANDONED LANDFILLS FOR YOU



How many landfills in the EU-28?

- Sufalnet4EU: > 150,000 landfills
- Hogland et al, *Proc. ELFM I*, 2010: 350,000 – 500,000 landfills and dumps
- Bottom-up questionnaire EURELCO: 500,000 figure is most probably an underestimate (see infra)

Europe's landfills vary in size, depth, type

- Single Use USW Landfills, Mixed USW/IW Landfills, monolandfills containing one particular Industrial Waste residue
- Sanitary (managed) landfills (cf. Landfill Directive) versus unmanaged “non-sanitary” landfills and even waste dumps
- Publicly owned versus privately owned

Directive 1999/31/EC – Setting the scene

Objective Landfill Directive :

To prevent or reduce as far as possible negative effects on the environment, in particular on surface water, groundwater, soil, air, and on human health from the landfilling of waste by introducing stringent technical requirements for waste and landfills.

Landfill Directive defines different categories of waste and applies to all landfills, defined as waste disposal sites for the deposit of waste onto or into land.

Landfills are divided into three classes:

- Landfills for hazardous waste;
- Landfills for non-hazardous waste;
- Landfills for inert waste.

Landfill Directive - The EU Waste Hierarchy

EU Waste Management is governed by the EU Waste Hierarchy (Ladder of Lansink)

Key attention for climbing the ladder for freshly created Urban Solid Waste and Industrial Waste **FLOWS**, leading to:

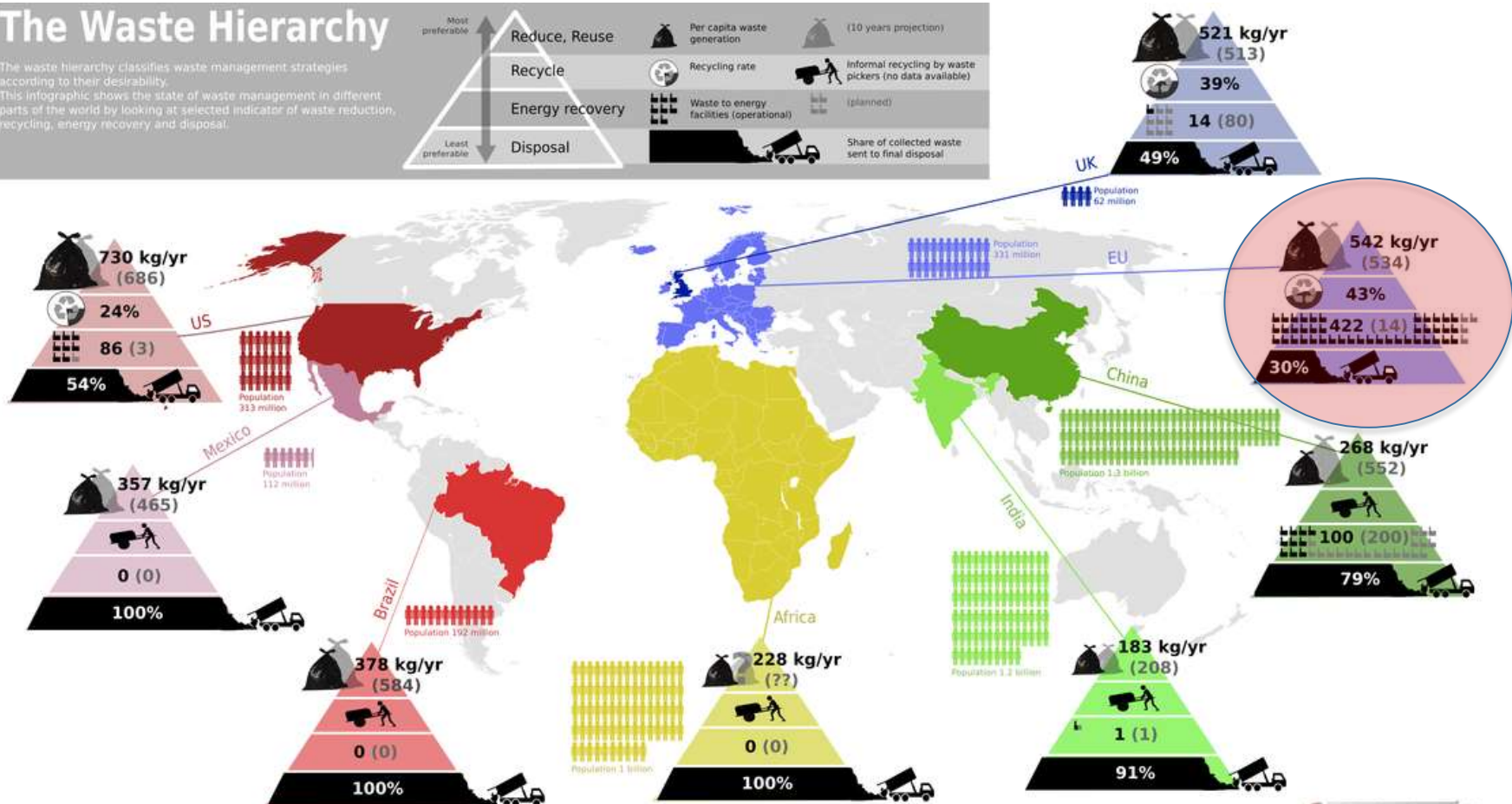
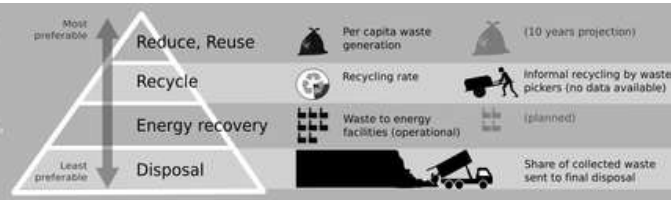
- Improved recycling technologies
- Incineration RUSW with energy recovery
- Phasing out landfilling
- Making sure that remaining landfilling is safe!



EU Waste Management – A global perspective: EU does well!

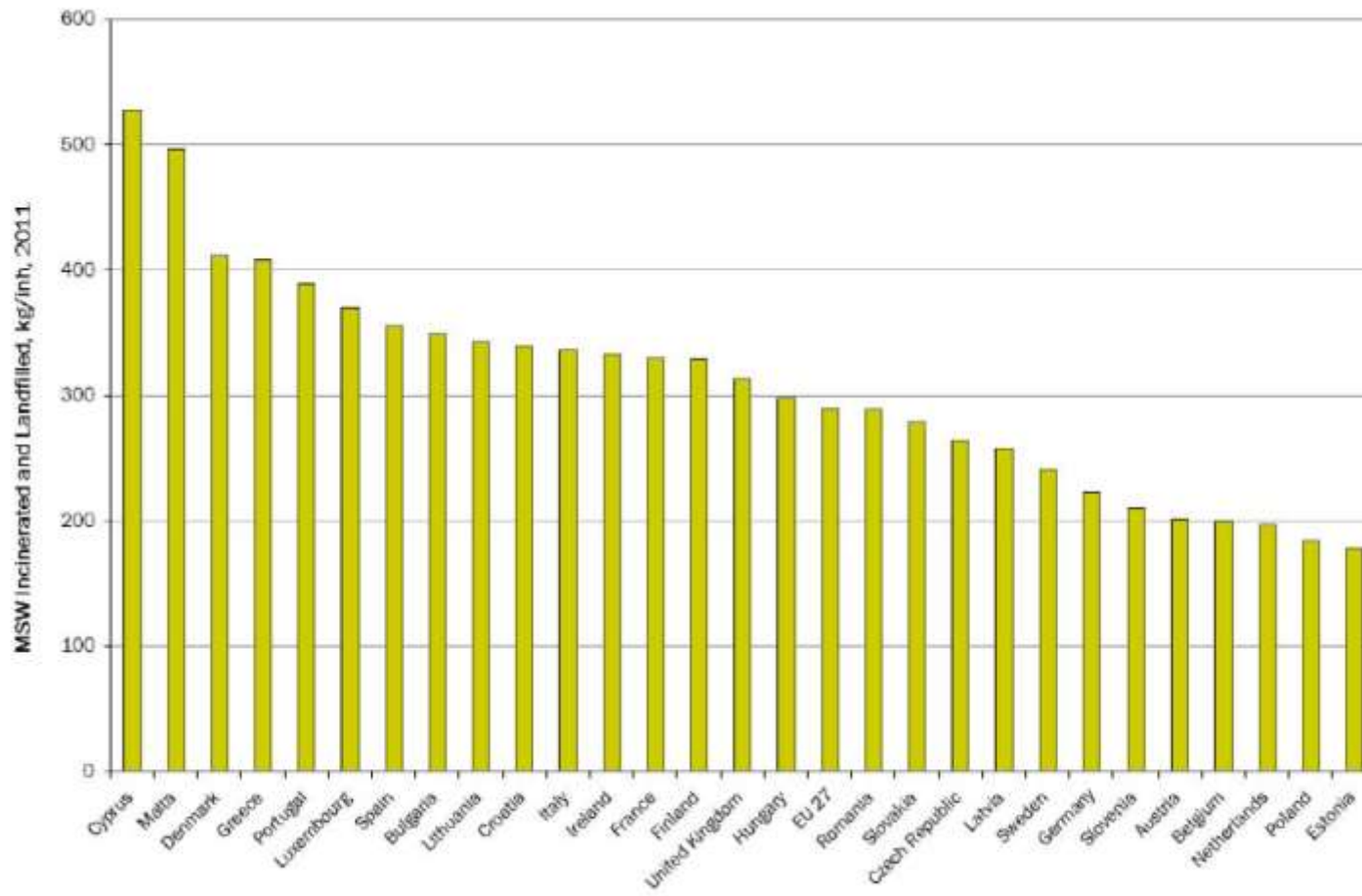
The Waste Hierarchy

The waste hierarchy classifies waste management strategies according to their desirability. This infographic shows the state of waste management in different parts of the world by looking at selected indicators of waste reduction, recycling, energy recovery and disposal.



EurEco Consultants 2012

Nevertheless... Landfilling & incineration in the EU-28 remain high



Landfill Directive has been instrumental in improving safety of landfilling for FRESHLY produced waste in many EU Member States

However, many questions remain:

- What about the historic legacy of landfills that were created prior to the Landfill Directive (1999)?
- Are these landfills safe?
- Is remediation required?
- What is the cost of remediation?
- Do they offer resource recovery opportunities?

Landfills in EU-28 - Parliamentary Question on Landfills in EU (18-5-2015)

EUROPEAN PARLIAMENT

EN

FORM FOR TABLING A QUESTION FOR WRITTEN ANSWER (Rule 130)

Select only one addressee:

PRESIDENT OF THE EUROPEAN COUNCIL

☐

COUNCIL

☐

VICE-PRESIDENT / HIGH REPRESENTATIVE

☐

COMMISSION

☒

Priority question

☐

AUTHOR(S): Hilde VAUTMANS

SUBJECT: Stimulating Enhanced Landfill Mining as part of the transition to a circular economy
(please specify)

Landfills in EU-28 - Parliamentary Question on Landfills in EU (18-5-2015)

- Many landfills pose major environmental and human health risks if left unaddressed. Member States will have to use taxpayers' money to remediate the most problematic sites. Has the Commission performed any calculations on the future remediation costs for the EU-28?
- Contrastingly, the EU's landfills contain significant amounts of base and critical metals, minerals, energy carriers etc. which can be recovered. Has the Commission performed a mapping of the resource potential of its 150,000 to 500,000 landfills?
- To be cost-effective for private companies, Enhanced Landfill Mining requires cutting-edge separation, transformation and upcycling technologies to deliver metals, materials, energy carriers and land. Does the Commission plan to support R&D and/or pilot activities, as well as demonstration projects, which explicitly address Enhanced Landfill Mining?

Landfills in EU-28 - Parliamentary Question on Landfills in EU (18-5-2015)

- Has the Commission performed any calculations on the future remediation costs for the EU-28? **NOT YET** [EC is confident that **Landfill Directive avoids health and environment risks**]
- Has the Commission performed a mapping of the resource potential of its 150,000 to 500,000 landfills? **NOT YET** [EC would like to receive these data but hasn't received them yet]
- Does the Commission plan to support R&D and/or pilot activities, as well as demonstration projects, which explicitly address Enhanced Landfill Mining? **NOT YET** [Although H2020 has many calls on circular economy topics]

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EURELCO – Bottom-up gathering of data (May-October 2015)

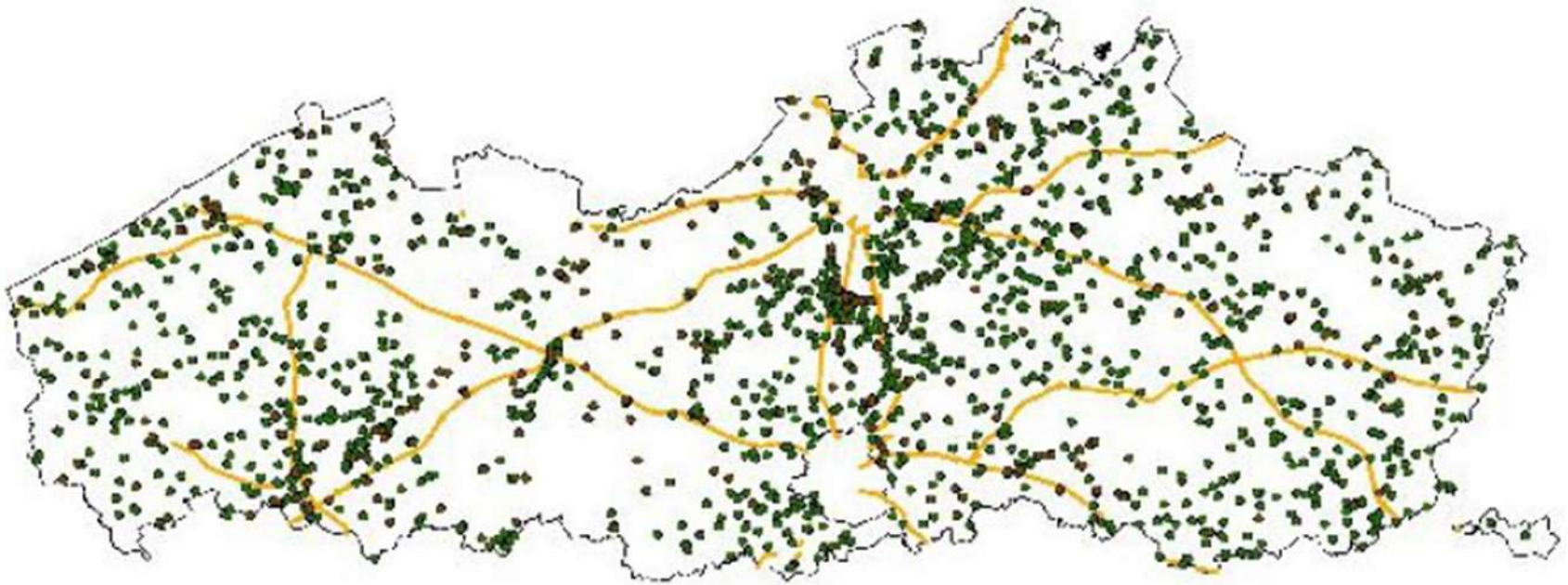
EURELCO Member States were contacted to provide data:

- Amount of presently still operational landfills
- Estimated total amount of landfills
- Distribution sanitary landfills (preceding and/or in compliance with EU Landfill Directive/ non-sanitary landfills (in % of landfills)
- Distribution USW/industrial landfills (in % of landfills, in amounts not weights)

Responses received from 13 EU Member States, combined with:

- Current landfill rate (%) taken from EUROSTAT 2012 data
- Definition: share of landfilled waste versus total waste generated, excluding major mineral waste,

EURELCO – Some Regions/Member States have accurate data, others don't



E.g. Landfill map for Region of Flanders: total number of inventorised landfills: 2,061 (87 km²); only 28 operational landfills in 2015.

EURELCO – Bottom-up gathering of data (May-October 2015)

Legend



Amount of presently still operational landfills



Distribution sanitary landfills (preceding and/or in compliance with EU landfill directive / non sanitary landfills (in % of landfills)



Distribution USW/industrial landfills (in % of landfills, in amounts not weights)



Estimated total amount of landfills (when data are indicated between (brackets) this implies it is an estimate based on the amount of municipalities multiplied by an average amount of 5 landfills per municipality)



Current landfill rate(%) i.e. share of landfilled waste versus total waste generated, excluding major mineral waste (EUROSTAT 2012 data)



LANDFILLS
IN EUROPE



Download here
the complete infographic

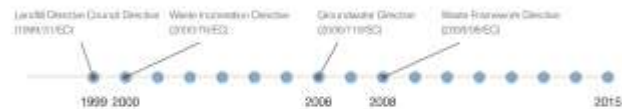


EURELCO – Infographic

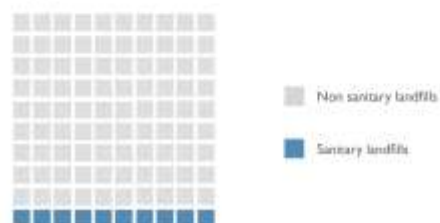


EUROPEAN ENHANCED LANDFILL MINING CONSORTIUM

Timeline of waste-related directives in Europe



EU(28): 500,000 landfills



Landfills in Europe



EURELCO – Bottom-up gathering of data (May-October 2015)

Key messages:

- 90% of EU's landfills are essentially “non-sanitary landfills”, preceding the Landfill Directive
- They will need remediation – estimated “classic remediation” cost for EU-28 is between 0,1 and 1 trillion euro (see infra)

BUT...

- These landfills constitute enormous resource stocks
- ELFM, combined with remediation, can deliver materials, energy and land, while drastically reducing remediation costs

The background of the slide is a screenshot of the EURELCO website. The website's header includes the URL 'www.eurelco.org' and the text 'EURELCO | European enhanced landfill mining'. The main navigation menu contains links for 'EURELCO COUNTRIES', 'PROJECTS', 'PARTNERS', 'CALENDAR', 'NEWS', and 'CONTACT'. A search bar is also visible. The main content area features a large photograph of a group of people standing outdoors. Overlaid on this image is the title 'What is Enhanced Landfill Mining – Rationale and Definition'. The words 'What is Enhanced Landfill Mining' are in white, while the subtitle '– Rationale and Definition' is in yellow.

What is Enhanced Landfill Mining

– Rationale and Definition

Definition ELFM – Flemish ELFM Consortium

Enhanced Landfill Mining =

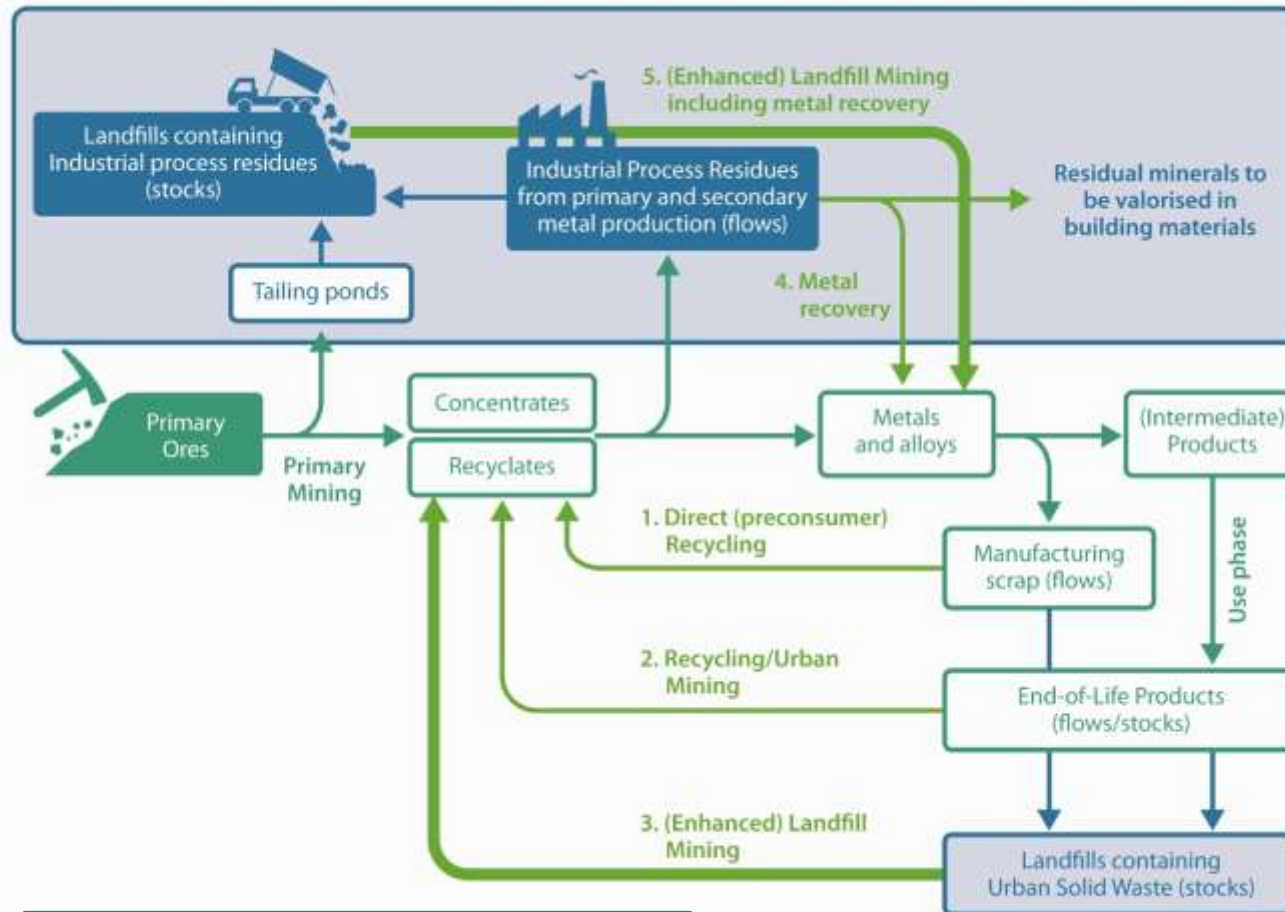
“the integrated valorisation of landfilled waste streams as both materials (Waste-to-Material) and energy (Waste-to-Energy), using innovative transformation technologies and respecting the most stringent social and ecological criteria.”



[Enhanced Landfill Mining in view of multiple resource recovery: a critical review \(Jones et al., JCLEPRO, 2013\)](#)



ELFM Definition relevant for MSW landfills and industrial residue landfills containing critical metals

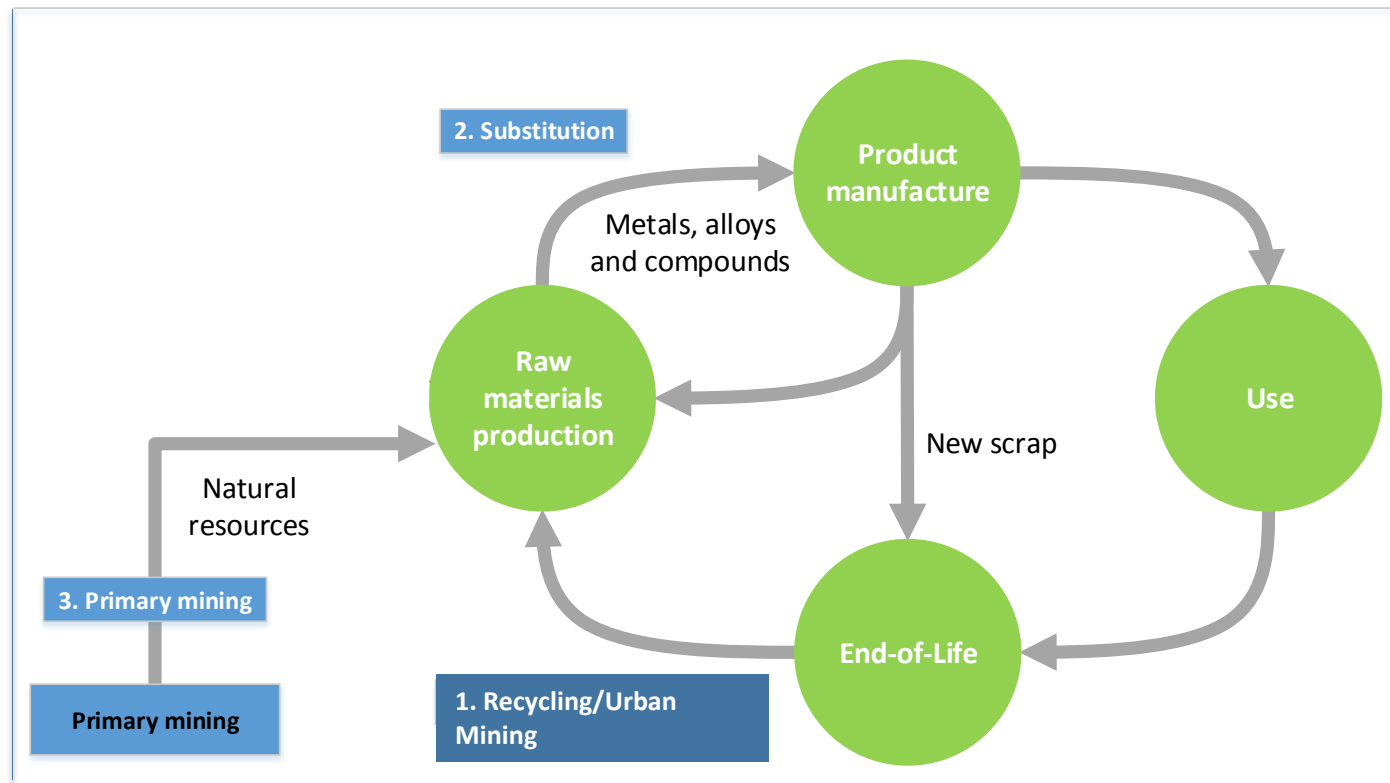


Source: Binnemans, Jones et al. , JCLEPRO, 2014

Keynote Prof.
Friedrich today

Keynote Yves
Tielemans today

ELFM – Complementary to recycling



ELFM – Complementary to recycling

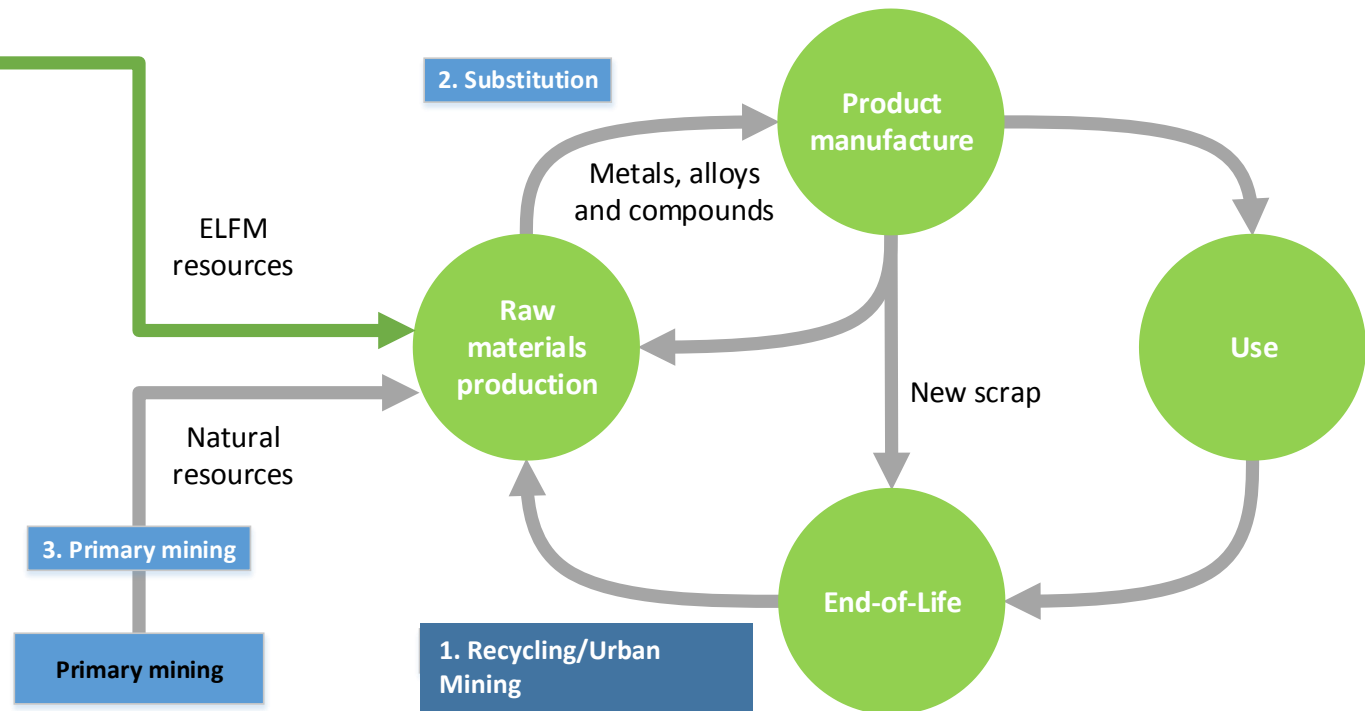
Enhanced landfill mining

150.000-500.000
Landfills in EU-28

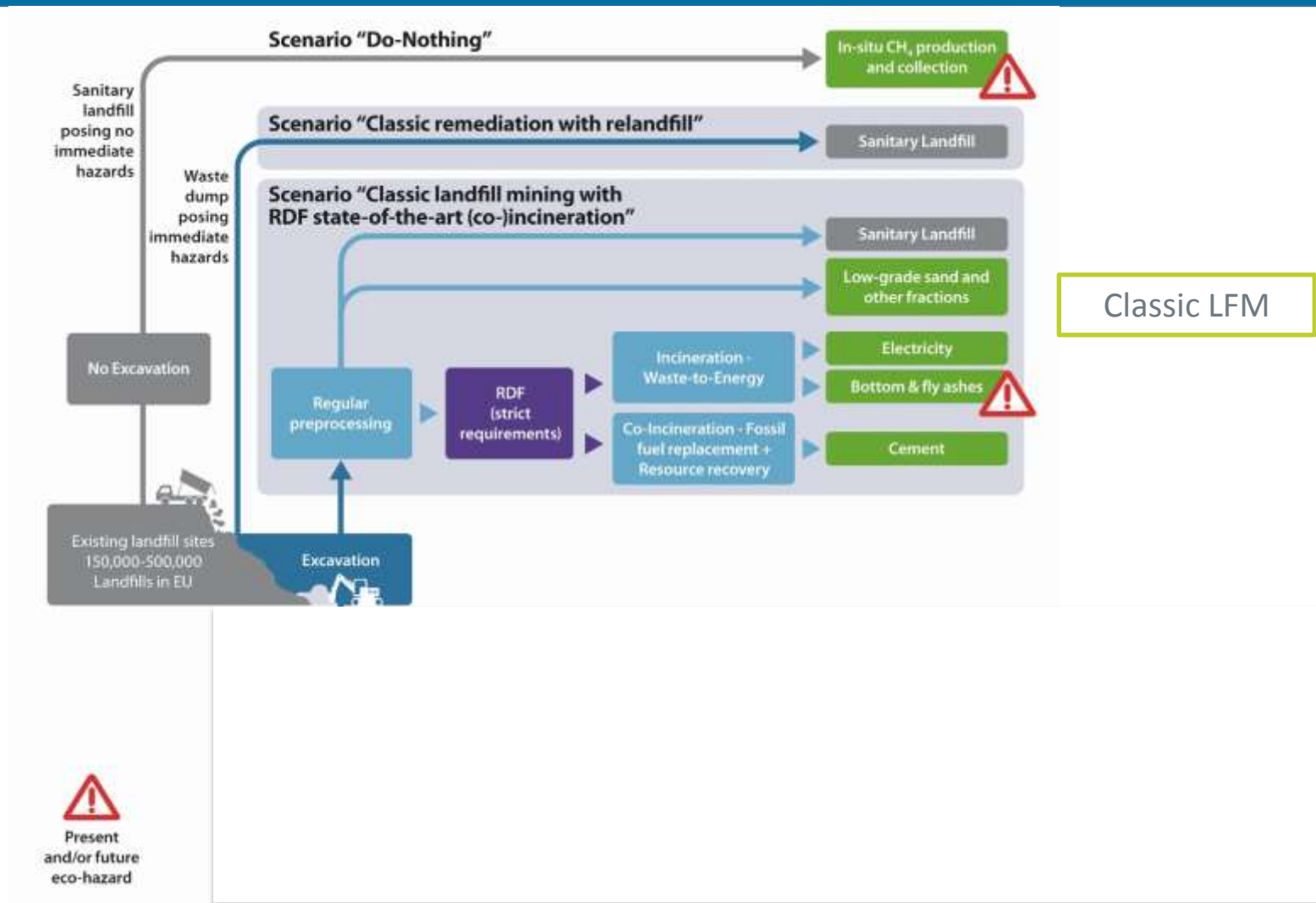
Single-use USW

Mixed USW/IW

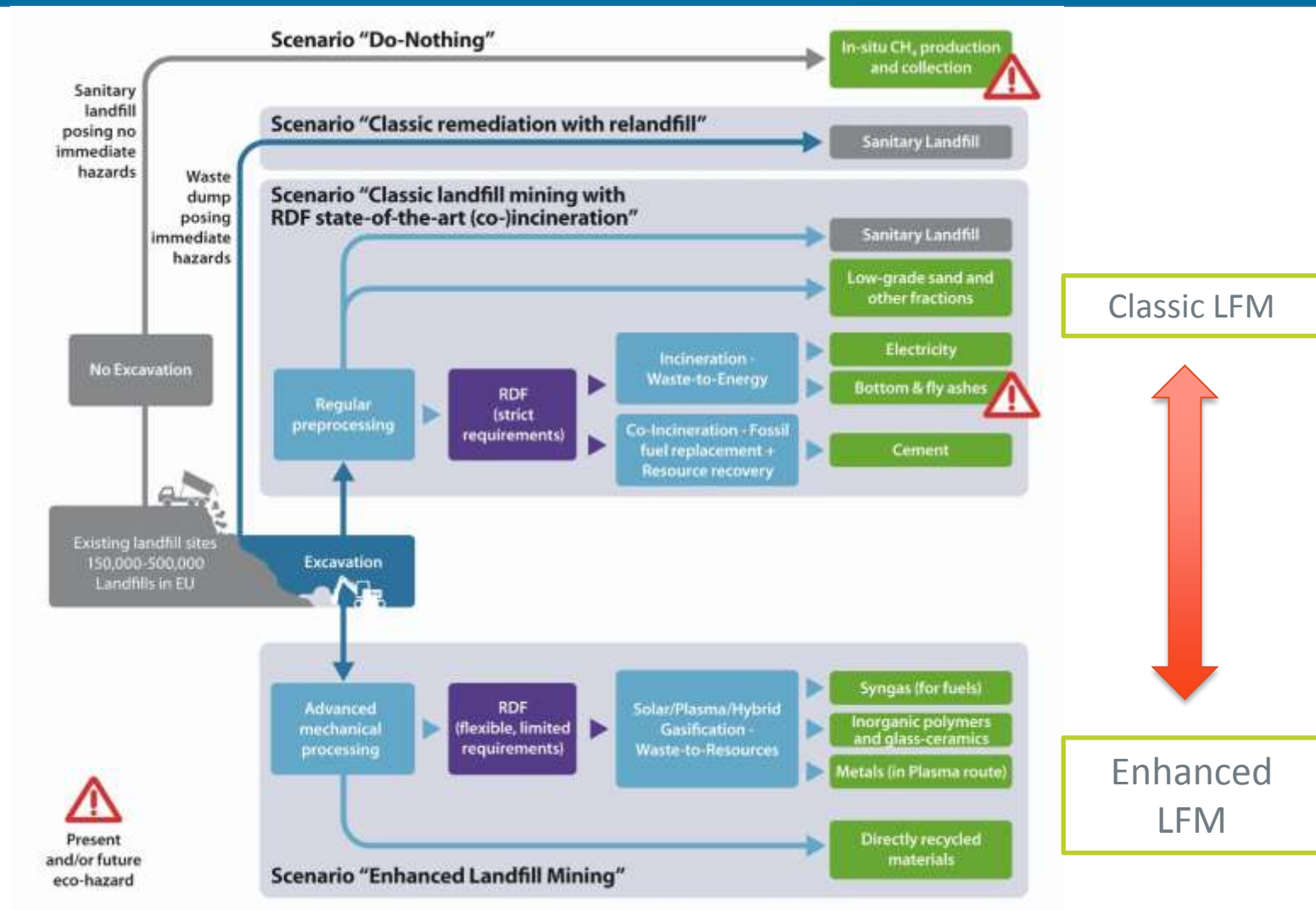
Monolandfills
containing industrial
residues



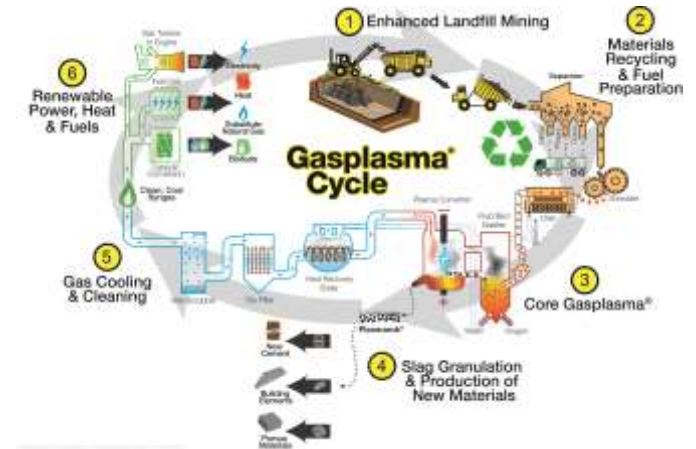
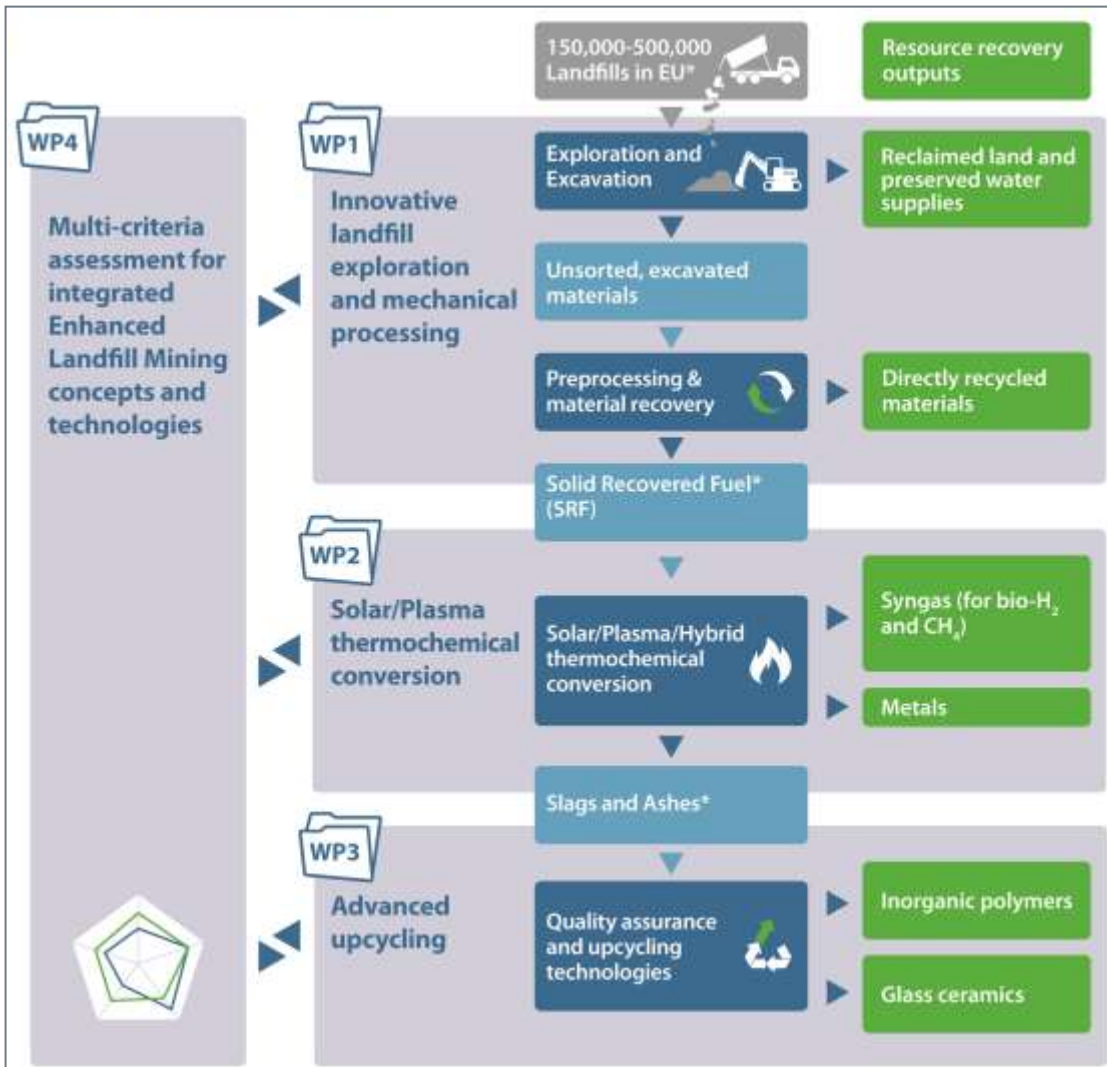
ELFM – With respect to other scenarios



ELFM – With respect to other scenarios



ELFM – A flow sheet for USW/MSW landfills

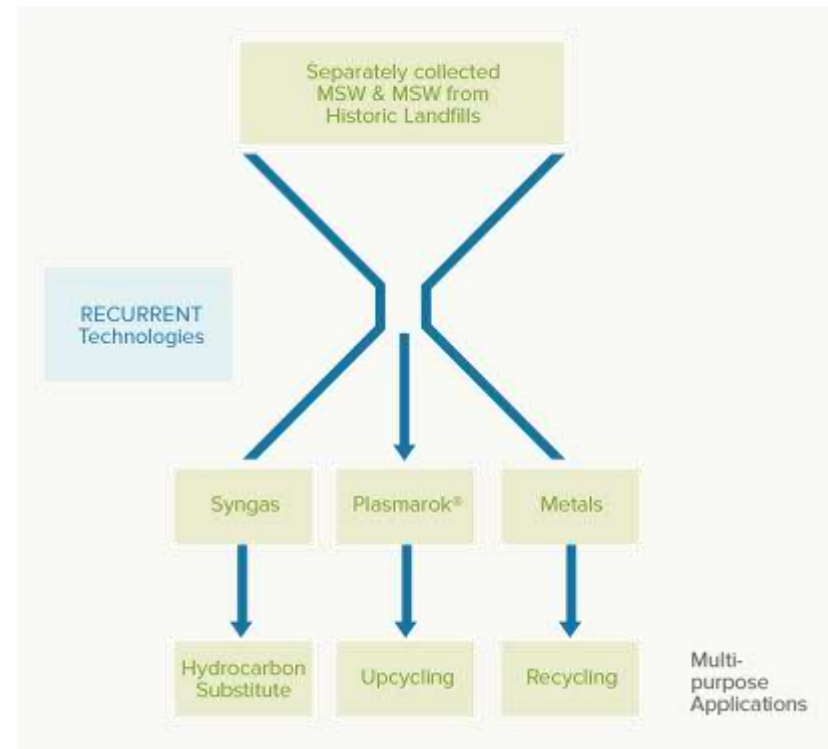
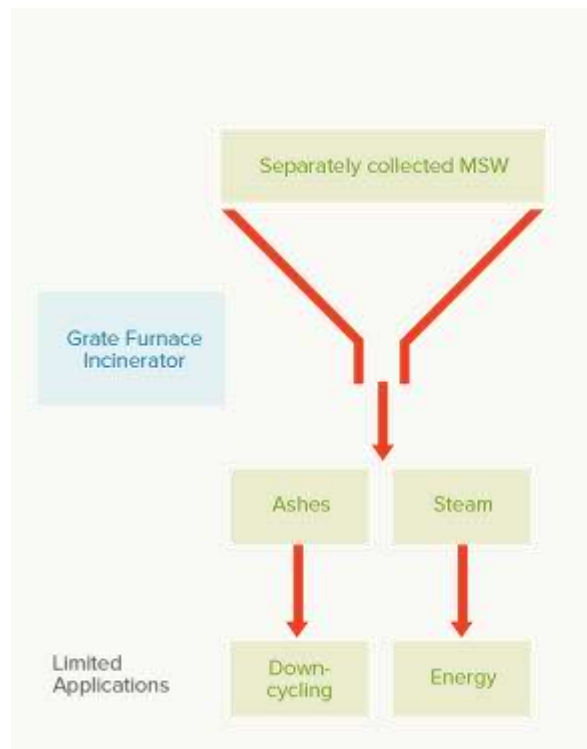
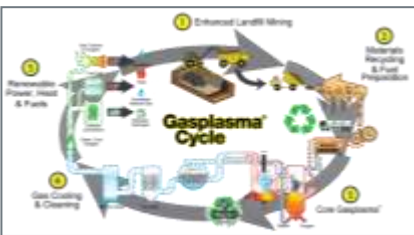


(cf. Keynote Yves Tielemans, with focus on plasma gasification)

ELFM and advanced Thermochemical conversion – beyond incineration: from downcycling to upcycling

Improving the intrinsic business case of ELFM projects

Funnel and hourglass sand model



ELFM Industrial residue landfills (mostly privately owned)

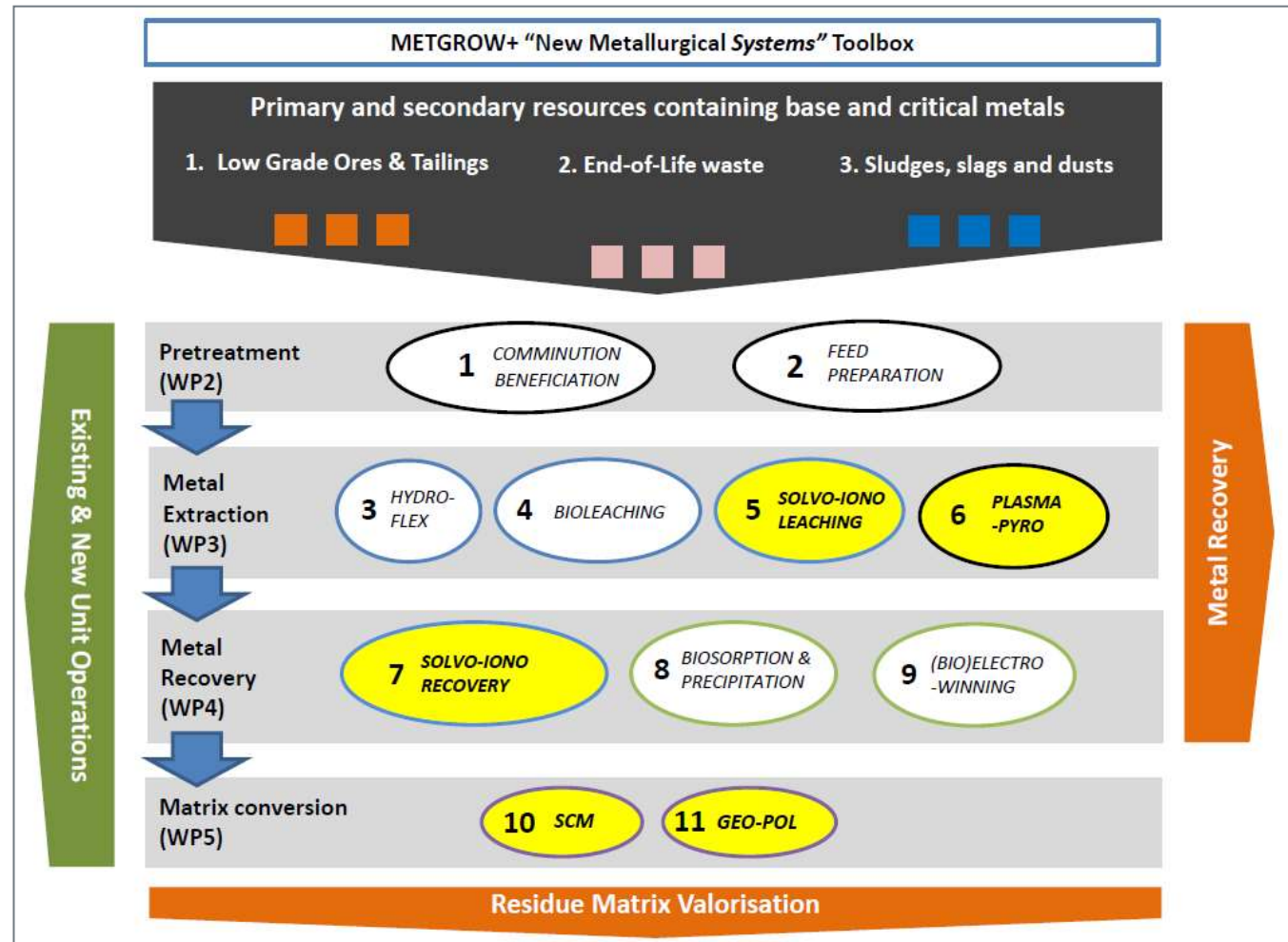


MaRes



(EIP) METGROW+

(cf. Keynote Prof.
Friedrich)

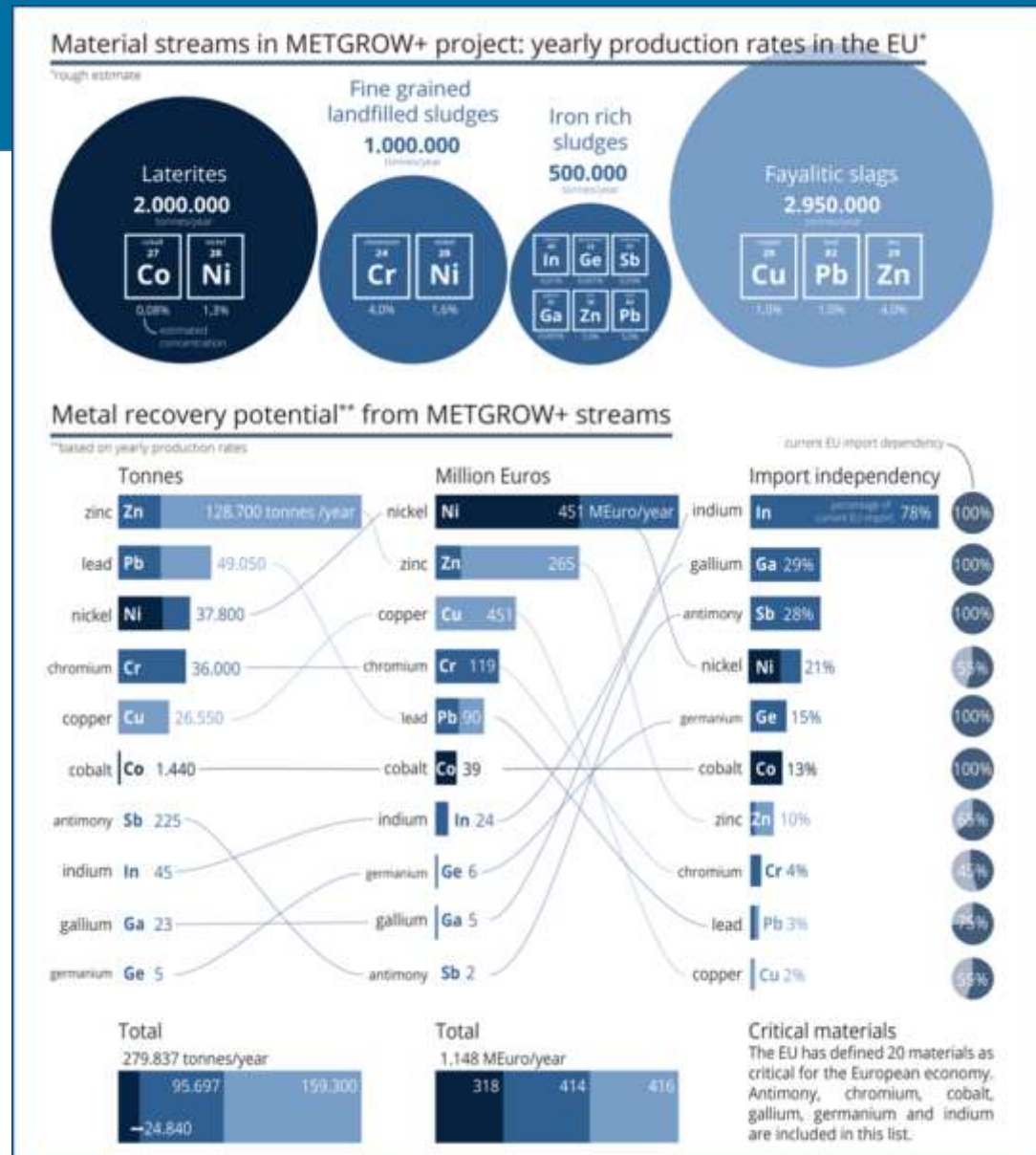


ELFM Industrial residue landfills

e.g. EU H2020
METGROW+ project
coordinated by VTT,
Finland

Relevance: bauxite
residue, goethite sludge,
non-ferrous fayalite slags,
tailings from Cu industry,
incineration ashes etc.

(cf. Keynote Prof.
Friedrich)



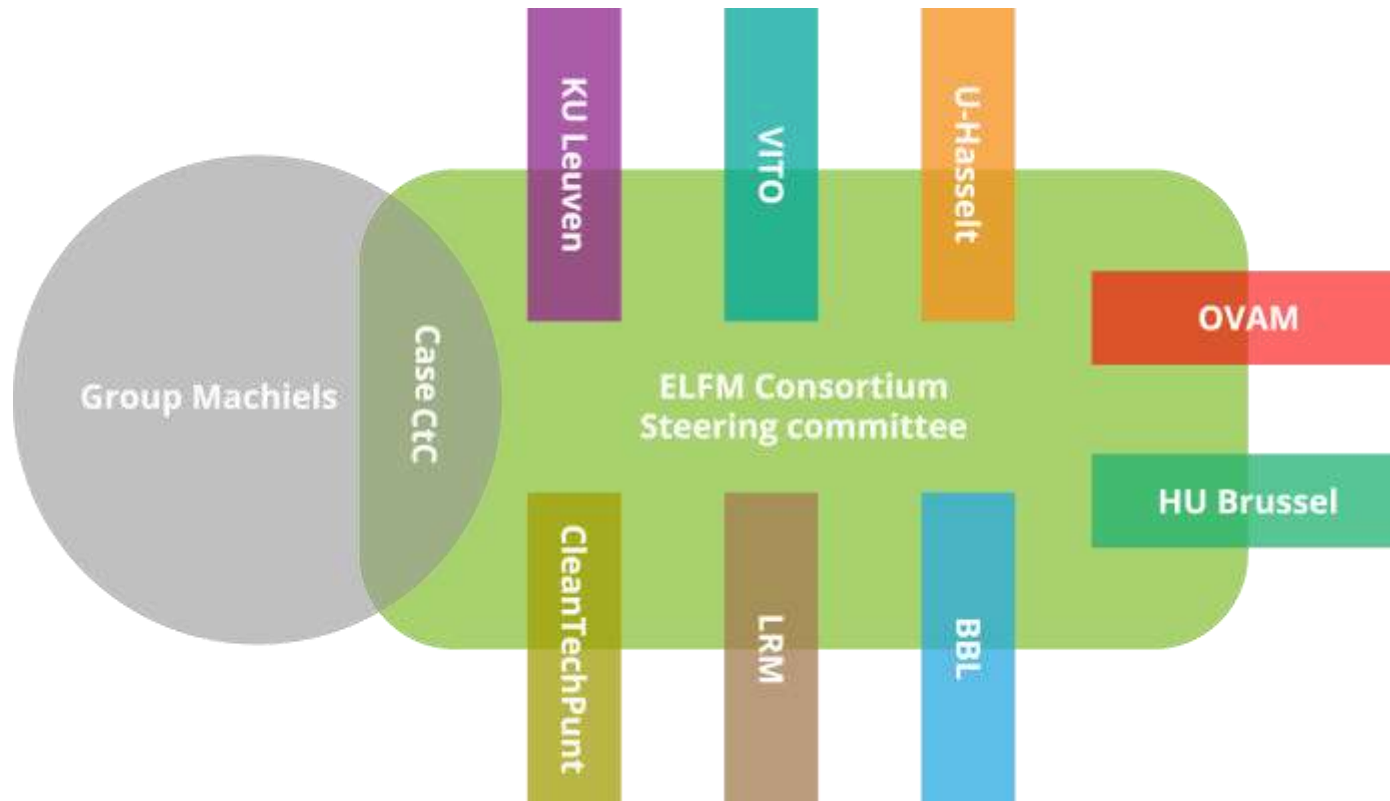
The rise of the ELFM concept — Achievements

Enhanced Landfill Mining (ELFM) has gradually obtained more coverage and credibility in the EU:

- Flanders: Multi-actor research consortium since 2008
www.elfm.eu



ELFM Consortium Governance model



Enhanced Landfill Mining (ELFM) has gradually obtained more coverage and credibility in the EU:

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www.elfm.eu
- Several national research projects are running



ELFM Nationally funded R&D projects

Name Project (website)	Funding Agency (Budget)	Partners	Which landfill? (location) - owner, size, type	Timing
Closing the Circle [http://www.elfm.eu/CTC.aspx]	Flemish Government + Private Funding (JMR) (6 M€ for IWT O&O ELFM + 1 M€ for MIP ICON PLASMAT)	NEW-MINE: KU Leuven, JMR, UA Others: VITO, U Hasselt	Remo landfill (Houthalen-Helchteren, Flanders/Belgium) - JMR, 16,5 Mtonne, mainly MSW)	2011-2016
LAMIS [http://avaw.unileoben.ac.at/en/forschung-ag_deponie_altlast_schlacke-landfill_mining/]	Austrian Research Promotion Agency (FFG) (Budget: 0,57 M€)	NEW-MINE: MUL Others: More than 20 partners	Halbenrain Landfill (Styria, Austria) - AVW Mürzverband, 10 ha, MBT-treated MSW	2013-2016
:metabolon [http://www.metabolon.de]		NEW-MINE: BAV, RWTH Aachen Others: around 20 other partners	Leppe Landfill (Leverkusen, Germany) – BAV, 45 ha, MSW and organic waste	2011 - 2016
MINERVE [http://greenwinminerve.com] (cf. MSCA ETN ATBEST)	Wallonian Government (Marshall Plan) + Private Funding (5 M€ budget)	NEW-MINE: Shanks Others: Holcim, Uliège, CTP, UCL et al.	Mont-Saint-Guibert landfill (Wallonia) – Shanks, 30 ha, > 10 Mtonne MSW	2011-2016
Landfill Mining 2.0	Funder: Swedish Innovation Agency (VINNOVA) (0,23 M€ subsidy)	NEW-MINE: LIU, Stena Others: Nordvästra Skånes Renhållnings, Tekniska Verken	Gärstad landfill (Linköping, Sweden) – Tekniska Verken, 4 Mtonne MSW and other [2 other landfills are in this project as well]	2015-2017

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▶ www.elfm.eu
- Several national research projects are running
- Erection EUROPEAN ENHANCED LANDFILL MINING Consortium in march 2014 www.eurelco.org
- EURELCO received EIP RMC Status



Mission. To be a an **open, quadruple helix network** that supports the required **technological, legal, social, economic, environmental and organisational** innovation with respect to Enhanced Landfill Mining within the context of a transition to a **circular, low carbon** economy.



EIP RMC status **EURELCO**

- An RMC is a joint undertaking by several partners, who commit to activities aimed at achieving the EIP's objectives between 2014 and 2020
- Early 2014 the High Level Steering Group of the EIP confirmed that 80 commitments fulfilled the required criteria.
- EURELCO was one of the 80 commitments that were given the official status of “EIP RMC, thereby corroborating the EU-wide relevance of the vision and mission of EURELCO.
- The EURELCO RMC was initially signed by KU Leuven, VITO, Group Machiels (Belgium), Stena Metall & Linköping University (Sweden) and VTT (Finland).

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- ELFM is key part of new EIT KIC Raw Materials



EIT Raw Materials Integrates ELFM at the highest level

Western co-location centre, hosted at KU Leuven, unites industrial and research core partners from Belgium, Germany and the Netherlands.

Main areas of innovation will be:

- Recycling of complex End-of-Life products and urban mining;
- Recovery of valuable RM from industrial residues and landfill mining;
- Circular economy;

Also “Eastern” CLC with MUL works on this item of ELFM



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- ELFM is key part of new EIT KIC Raw Materials
- EURELCO developed Interreg Europe COCOON network



Rationale

- Objective: “to develop, integrate and improve relevant ELFM² policy instruments, while increasing subsidies through operational programmes (OPs) for these resource efficiency projects.”
- 8 targeted policy instruments include (a) ELFM² policy in Flanders (BE), Styria (AT), the Netherlands and Veneto region (IT) and (b) funding of ELFM² projects through the OPs in Cyprus, Eastern Macedonia and Thrace (GR)), Hungary and Malta.

Participation of relevant Public Bodies from 9 EU Regions corroborates growing interest for ELFM amongst governmental actors

The background image shows a landfill site with heavy machinery, including a large truck and an excavator, operating on a pile of waste. In the background, there is a dense forest of tall, thin trees. The entire image is overlaid with a semi-transparent blue filter.

Why EURELCO ?

Nevertheless, acceptance of the concept and commercial breakthrough of ELFM less straightforward than for urban mining of critical metals

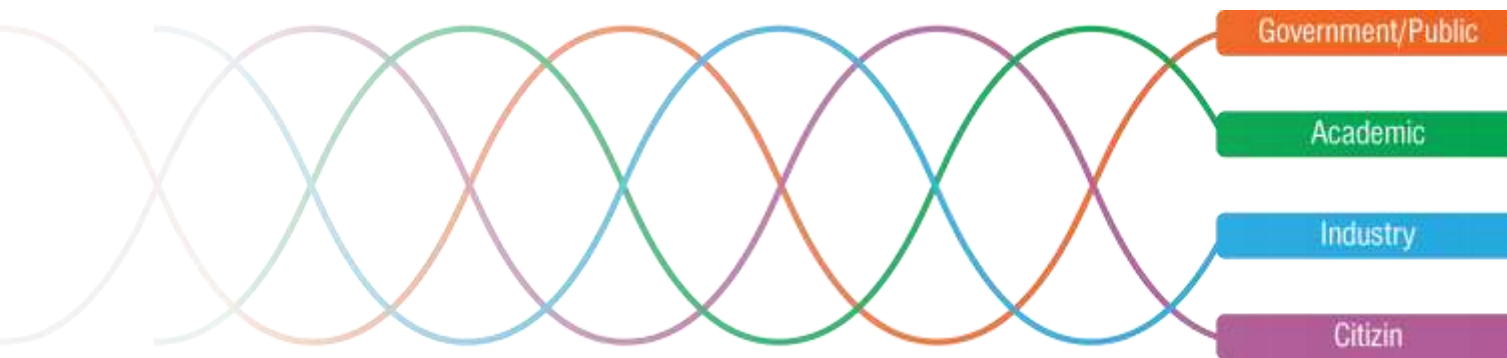
Non-technical barriers are manifest:

- Social acceptance (NIMBYISM)
- Legal (e.g. Landfill Directive & Waste Framework Directive)
- Economics (public versus private benefits)



Quadruple Helix Innovation

- Government, Academia, Industry and Citizens collaborating together to drive structural changes far beyond the scope of any one organisation could achieve on it's own
- Involve all stakeholders in quadruple helix to innovate and experiment in real world settings, in creating frictionless ecosystems



The landfill is stuck in a dump regime

- EU Landfill Directive strongly advocates isolation, control, final closure and post-monitoring
- This perception of landfills as hazardous, end stations for obsolete materials displays clear signs of path-dependency and lock-in
- The fact that ELFM is not part of EU policy and regulatory frameworks causes multiple challenges and uncertainties
- Such uncertainties regarding the market rules (e.g. landfill tax for fractions that need to be relenadfilled) make it difficult for actors to foresee the outcome of their investments
- Most of the benefits of landfill mining only occur on the societal level = key policy challenge → *coupling ELFM with remediation needs can offer a way forward!*

Examples of policy and regulatory implications

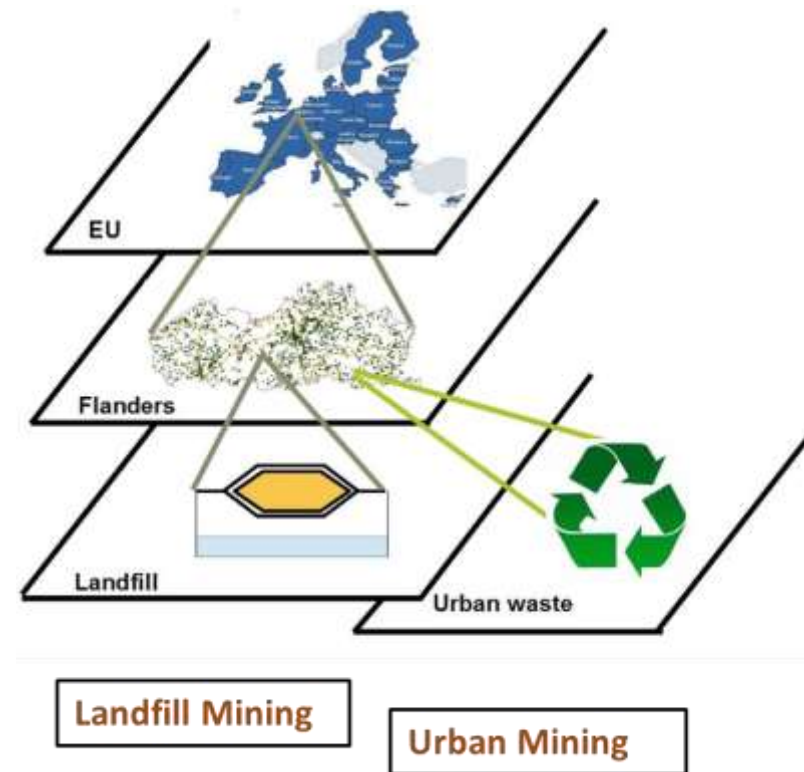
- Landfill prohibitions and taxes impose potential waste disposal problems and high additional costs for landfill mining projects
- A resource-effective and cyclical use of the extracted materials could also be prevented by strict guiding values on heavy metals
- Current landfill and waste regulations have contributed to unfavourable markets for energy carriers recovered from landfills (i.e. gate fees)

Opportunities for ELFM – Policy aspects ELFM [credits to OVAM]

Focus on ELFM in broader context of circular economy. Landfill = dynamic stock of resources versus static, eternal disposal

The challenge is to combine the top-down public perspective with a bottom-up private perspective (companies willing to perform ELFM projects)

Coupling ELFM + remediation is the way forward



Conclusions

Conclusions – Let's turn the landfill problem into an opportunity

**90% of Europe's 500,000 + landfills
are non-sanitary landfills for
which the Landfill Directive does
not offer a solution**

**Dedicated inventory exercises based
on log books, geophysical
studies, drillings and economic
assessments are required in
order to obtain better data for
EU-28**

Conclusions – Let's turn the landfill problem into an opportunity

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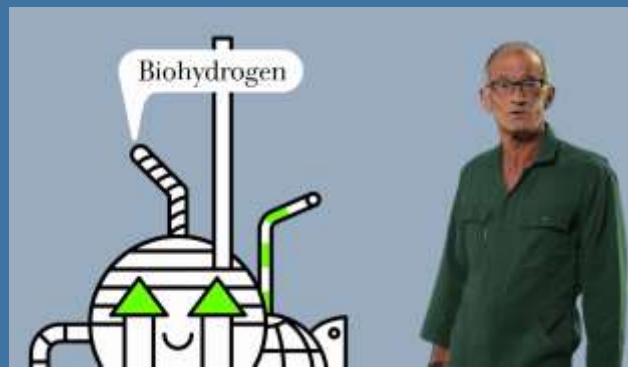
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ELFM requires a paradigm shift: landfills need to be taken out of the dump regime → to be re-considered as “resource reservoirs awaiting valorisation”

ELFM can be combined with remediation, drastically lowering overall costs

ELFM triggers technological innovation (circular economy framework) and leads to local job creation

Private businesses are ready but need stable frameworks



Thank you for your attention – Enjoy “The benefits of landfill mining”





Third International
Academic Symposium
on Enhanced Landfill Mining

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ELFM potential - Appendix

Economic benefits

- Avoidance of landfill remediation costs:
0,1-1 trillion € (if ELFM concept is used for all EU-landfills)
 - A new resource recovery economy, with significant short, medium and long term potential for EU SMEs in EU-27 and in the rest of the world: CH₄ extraction (*in situ*); Organic based materials (WtM or WtE) (*ex situ*); Metals (*ex situ* and/or *in situ*); Materials for building and construction (*ex situ*)
- Recovery of valuable land (*in situ* or *ex situ*)



Impact of ELFM on a EU-scale (see Jones et al., 2013)

Strategic benefits through resource recovery

- Improve EU's *materials autonomy* :
 - Reducing pressure on primary raw materials (fossil fuels and non-energy raw materials)
 - Fostering the use of secondary raw materials:
 - Aggregate figure: **~5% of the current DMC/year** for EU-27, for 25 years
 - Plasmator slag (a.o. replacement for cement clinker): **250–840 Mtonne** for 25 years
 - (Critical) Metal recovery from, especially, industrial process residue landfills; tailings, sludges, slags and ashes (see review Binnemans et al., 2015): metal recovery potential substantial (detailed mapping of potential on-going in WG1 EURELCO)
- Improve EU's *energy autonomy* :
 - Contributing to EU's renewable energy target through accelerated CH₄ uptake through *in situ* LFM: **7 million TOE ~3% of the EU-27 renewable energy target for 2020)**
 - Contributing to EU's renewable energy target (WtE from SRF (mixed organic) from *ex situ* LFM: **an additional 0,4-1,1 million TOE)**

Health and environment



- Lower the EU's carbon footprint (benchmark with direct **EU CO₂(eq) emissions: 4600 Mtonne CO₂(eq)/year**):
 - Avoided CO₂(eq) emissions due to *in situ* CH₄ mining of **112 – 139 Mtonne/year**;
 - Avoided CO₂(eq) emissions due to net carbon balance, from a full EU-27 ex situ LFM approach (versus *in situ* only approach, for 150.000-500.000 landfills): **extra 15 - 75 Mtonne CO₂(eq)/year**
 - Plasmarok slag replacing cement clinker: **3-11 Mtonne CO₂(eq)/year**
 - Use of CO₂ in horticulture
- Land reclamation (**>2800 - 6000 km²**, nature-urban-industrial purposes)
- Avoiding future human health and environmental issues due to landfill pollution problems
- Reducing environmental & health impact associated with primary mining of energy and non-energy materials

Social benefits

- Creation of new jobs associated with the start-up of new, SME-driven markets:
 - Up to 300 FTE new jobs for the Remo landfill site (ex situ mining)
 - Up to 240.000-800.000 new jobs in EU-27 (for full implementation of ELFM framework)

