Policy Brief

NEW-MINE

EU TRAINING NETWORK FOR RESOURCE RECOVERY THROUGH ENHANCED LANDFILL MINING

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Joakim Krook
Peter Tom Jones
& Steven Van Passel

Why Enhanced Landfill Mining (ELFM) needs to be politically acknowledged to facilitate sustainable management of European landfills

Executive Summary:

- For a share of Europe's 500,000 landfills, Enhanced Landfill Mining (ELFM) could offer a more sustainable management option than conventional practices by combining remediation with recovery of dormant materials, energy carriers and land resources.
- Developing cost-efficient and societally-motivated ELFM practices relies on extensive investments in know-how and technology innovation, policy support and market interventions.
- Neglecting ELFM in EU policy and regulatory frameworks is not a neutral act but rather an effective way to lock-in suboptimal, conventional practices.
- In order to stimulate investments in the area and enable policy support and market interventions, ELFM needs to become institutionalised and recognised as a potential option for landfill management and recovery of natural resources

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EUROPEAN ENHANCED LANDFILL MINING CONSORTIUM

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1. Introduction

During the 20th century, Europe has placed massive amounts of obsolete materials in landfills. The majority of these by now 500,000 waste deposits constitutes non-sanitary municipal solid waste (MSW) landfills, predating the EU Landfill Directive (1999). Although these poorly equipped sites are associated with local, regional and global environmental impacts, as well as significant land use restrictions, Europe does not yet have any coherent strategy for their future management. When it comes to traditional remediation measures for avoiding environmental and health effects from these sites, the available public funding is also largely insufficient in the EU member states. For a share of all these landfills, Enhanced Landfill Mining (ELFM) could offer a more sustainable management option than traditional remediation and aftercare. ELFM is *"the integrated valorisation of landfilled waste streams as materials and energy, using innovative transformation and upcycling technologies and respecting the most stringent social and ecological criteria"* (Jones et al, Journal of Cleaner Production, 2013). The potential of this emerging concept lies in its integrated approach where remediation is combined with the excavation, processing and recovery of deposited materials and energy resources. Recent research shows that such a strategy could be a potential way to facilitate remediation of malfunctioning landfills, reclaim valuable urban land for purposes that are more sustainable and bring significant amounts of dormant metals, minerals and energy carriers back to use in society. Besides a few pilot trials, however, there is up till now a general lack of real-life, full-scale projects validating the feasibility of ELFM. The further development of the concept therefore circulates around the key challenge of how such projects could be executed cost-efficiently together with clear environmental and societal benefits..'

2. Is ELFM economically feasible?

As for most emerging environmental innovations, ELFM often experiences a hard time when exposed to current market conditions. However, whether or not ELFM could become an economically feasible option is reliant on multiple factors and on which objectives and values that are realised in such projects. So far, conducted economic assess-

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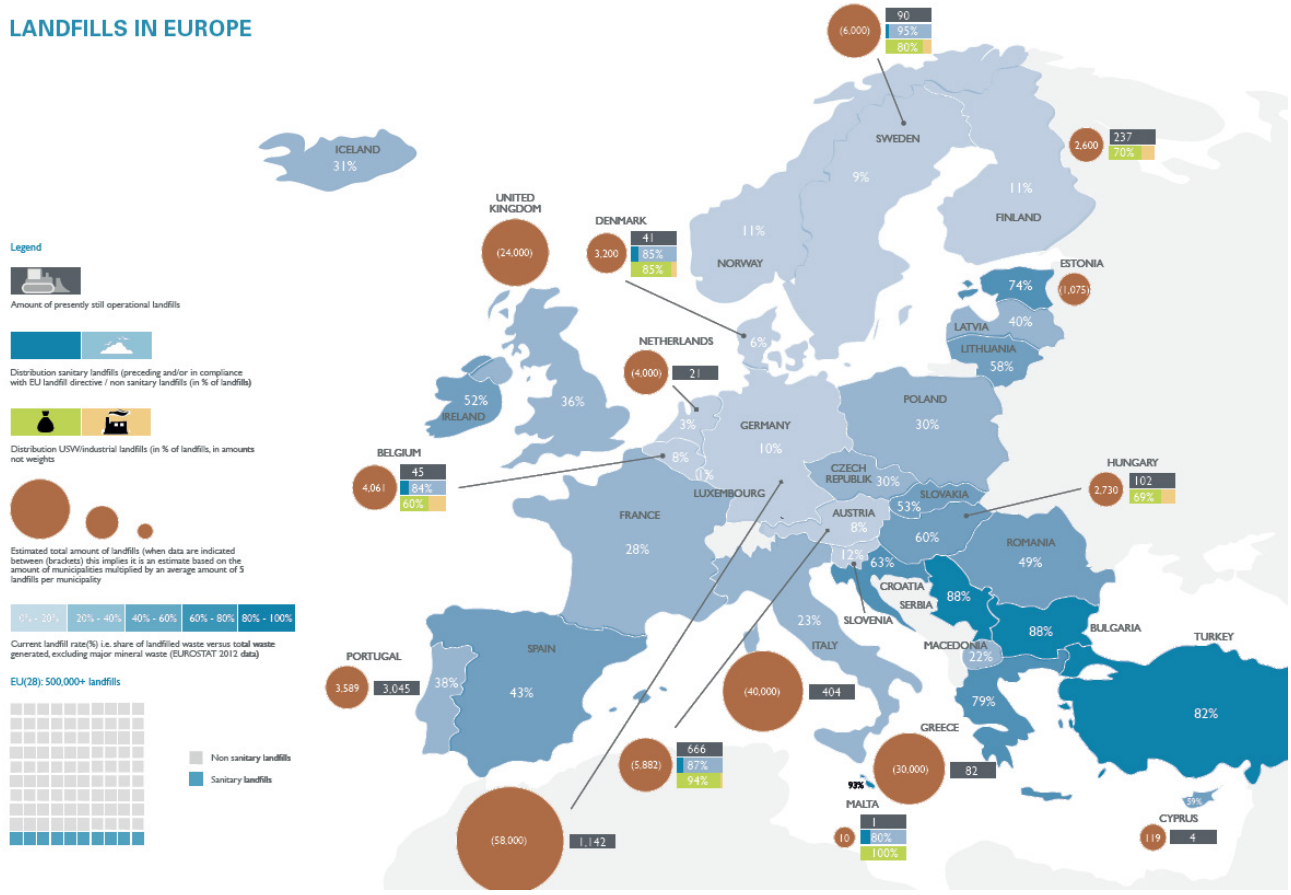
Landfills in Europe

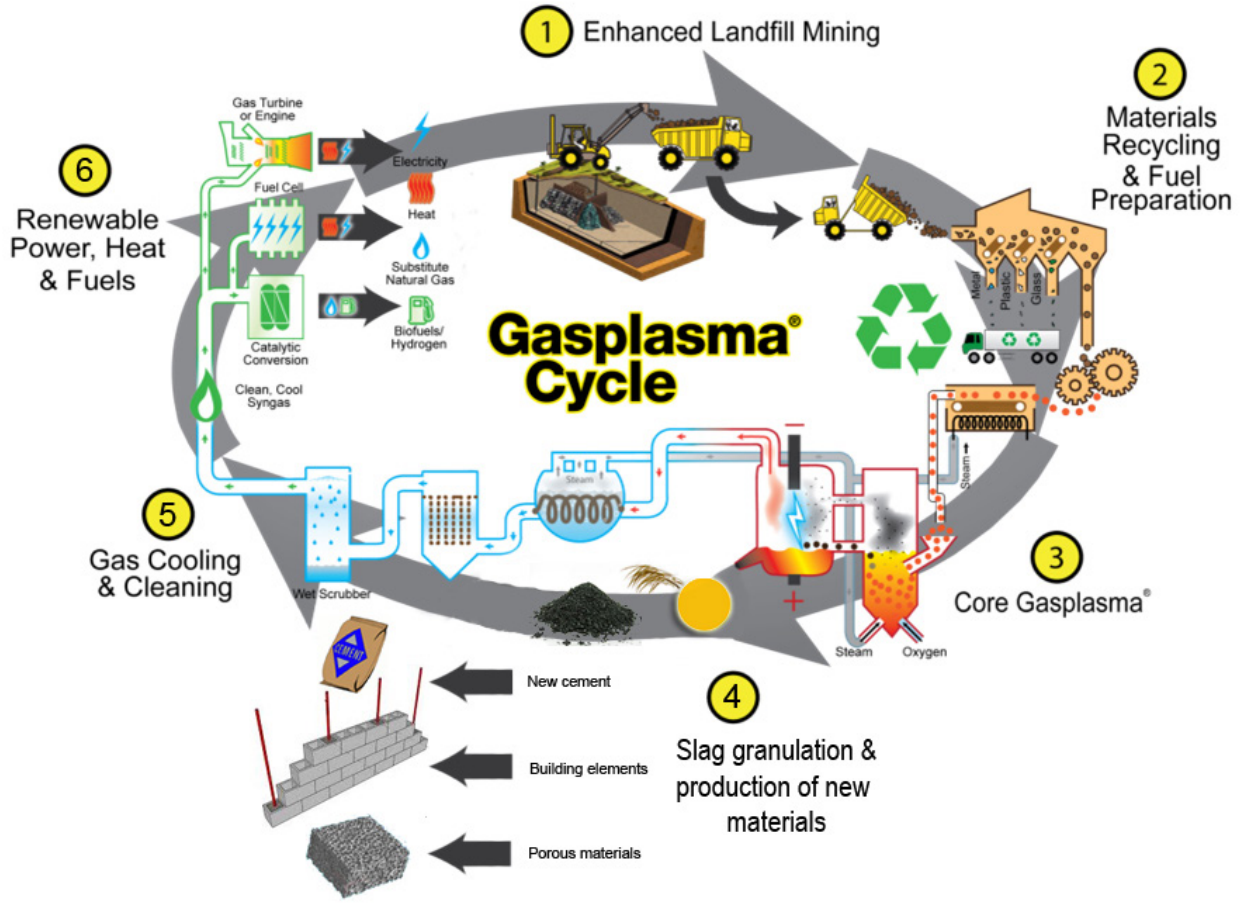


For the majority of Europe's landfills, having no or poor gas management systems in place, ELFM will virtually always result in net avoided climate emissions.

ments have mainly addressed the objective of resource recovery from landfills. Virtually all of these studies conclude that the process (e.g. investment and operational costs for the ELFM processing line) and material-flow-related (i.e. costs for transportation and disposal of exhumed materials) expenditures exceed the perceived revenues for recovered materials and energy carriers. A key challenge here is that in current waste markets only a minor share of the processed materials will generate any significant income (e.g. metals) while the remains will involve low revenues or disposal costs (e.g. aggregates, waste fuel and residues). In such a context, the economy of resource extraction from landfills mainly become a matter of regional cost settings for waste disposal while investing in improved sorting schemes to maximise metal revenues do not pay off. This is one prime reason for why the most recent ELFM research involves development of innovative technologies aiming to transform and upcycle the separated materials and energy carriers to more high-value commodities such as syngas, fuel-grade H_2 and low-carbon building materials (e.g. inorganic polymers).

Although technology innovation, increasing raw material prices and demands for secondary resources might change the conditions for resource recovery from landfills over time, this objective alone will presumably – in the short term – not provide sufficient economic incentives for ELFM implementation. Instead, research shows that obtaining cost-efficiency will also rely on the realisation of other objectives and values such as avoidance of high landfill remediation and aftercare costs as well as reclamation of valuable urban land or landfill void space. The current lack of economic incentives for ELFM is also partly related to EU waste policy, which directly influence market conditions for disposal, treatment and recycling practices. A denominator for this waste policy has been to re-direct (fresh) waste from landfills to more preferable recycling options by introducing bans, high costs and increasing disposal taxes. When it comes to ELFM, however, these very same instruments cause disincentives for recovery of deposited resources by inferring

ELFM flowsheet



Neglecting ELFM in EU policy and regulatory frameworks is, therefore, not a neutral act but rather an effective way to lock in conventional practices and lock out ELFM.

significant project costs for the inevitable re-deposition of unrecoverable material fractions. These policies have also contributed to market failure where, for instance, waste incinerators can charge significant gate fees for accepting high quality waste fuel. Given the large amounts of waste fuel contained in many MSW landfills, such market structures have a decisive negative impact on the economic motives for ELFM. Recent economic assessments of ELFM also conclude that there is a lack of economic policy instruments for internalising environmental externalities into the project economy. In practice, this means that remediation of malfunctioning landfills and re-circulation of previously abandoned materials and energy resources become a matter of contributing to the common good of the society rather than key business aspects.

3. ELFM & sustainability

The fact that ELFM involves several objectives and values adds complexity to the evaluation and governance of its contribution to sustainability. When it comes to the environmental consequences of such projects, the only impact that has been comprehensively studied is global warming. Here, recent findings conclude that the climate impact can vary considerably from case to case, ranging from large emission savings to significant net contributions to global warming. These variations in climate impact depend on if and to what extent ELFM contributes to avoided emissions from long-term landfill gas generation and replaced energy and material production. In principle, the potential for global warming mitigation is driven by projects on MSW landfills with poor landfill gas management that also are rich in organics (and metals). In order to obtain as much avoided climate emissions as possible, ELFM should also be executed by advanced technologies for separation and resource recovery, preferably in regions where the prevailing energy systems have a moderate to high fossil share. For the majority of Europe's landfills, having no or poor gas management systems in place, ELFM will virtually always result in net avoided climate emissions.

When it comes to other types of environmental impacts of ELFM, our knowledge is still limited. This deficit in understanding is problematic given that the realisation of such projects will presumably generate both positive and negative environmental consequences. Although the overall benefits of remediation of non-sanitary landfills and circulation of natural resources are well established, the excavation and processing of deposited masses will for instance cause temporary local environmental impacts and risks. In addition, pollution concerns related to various materials and energy recovery routes may emerge due to risks for co-recycling of hazardous substances contained in the landfill. If we then turn to the broader societal impacts of ELFM, a few studies outline several benefits such as improved regional material autonomy, liberation of valuable land resources and strengthened local economies through job creation and spillovers to other cleantech and recycling sectors. All current frag-

ELFM excavation at the Remo landfill site in Belgium, where the benchmark Closing the Circle ELFM project is developed

mented ELFM impact assessments are primarily focused on the environmental and/or techno-economic aspects, while social aspects are not yet considered. Given the lack of real-life projects, however, these benefits are only potentials and there is not yet any balanced and well-supported understanding of the positive and negative societal impacts of ELFM implementation.

4. Development of ELFM know-how and technology

Although ELFM displays a significant societal potential, developing cost-efficient and sustainable practices for such projects rely on extensive and long-term investments in know-how and technology innovation. According to recent research reviews, the following R&D topics are fundamental in this respect and address important knowledge deficits throughout the ELFM value chain:

- What site and local settings constitute landfills suitable for mining? So far, ELFM case studies have involved more or less randomly picked landfills. There is thus a need for systematic prospecting methods enabling a strategic selection of landfills suitable for mining. Such method development can departure from existing landfill surveys but needs to be complemented by additional landfill mapping efforts as well as the establishment of a systemic understanding of how different site and local settings jointly contribute to ELFM feasibility and performance.
- Which materials and energy resources can actually be recovered from deposited waste? In order to develop a sound understanding of what is technically and economically feasible to separate out and recover, there is no real alternative than to go from the often-seen laboratory studies and small-scale trials to practice. More specifically, there is a need for well-planned pilots in which the efficiency, capacity and performance of different separation, transformation and upcycling technologies and processing lines are assessed and continually improved in a scale comparable to real-life projects. Areas with restricted policy rules can support further development.
- What is the quality level and marketability of resources exhumed from landfills? Given its large impact on both the economic feasibility and societal motives for ELFM, the issue of resource quality and marketability of extracted materials and energy carriers from landfills needs to be more strongly emphasized in upcoming research. Worth noting is that this need is not just about performing detailed characterisation of the outputs from different separation, transformation and upcycling technologies. But in order to develop an increased understanding of viable recovery routes for such ELFM commodities, knowledge about existing market structures, supply and demand dynamics, competition and policy implications is of equal importance. Next, the development

The development of ELFM policy support and market interventions requires that authorities recognise such activities as societally-motivated.

ELFM IV closing debate video
From left to right: Victor Dries (moderator, Policy Advisor Flemish Government), Magnus Gislev (EC DG GROW), Derek Greedy (ISWA), Yves Tielemans (Group Machiels), Claudia Neculau (SpaQue, Interreg NEW RAW-FILL), Jan Frank Mars (RWS, Interreg Europe COCOON) and Mieke Quaghebeur (VITO): view here

Joakim Krook is Associate Professor in Industrial Ecology at the Division Environmental Technology and Management, Linköping University (Sweden). He is specialised in multidisciplinary systems analysis research on recycling strategies and landfill and urban mining. He is Steering Committee Member of EURELCO and editor of the special issue entitled "Urban and Landfill Mining: emerging global perspectives and approaches" in *Journal of Cleaner Production* (2013). He is Principal Investigator for Linköping University in the EU MSC-ETN NEW-MINE project.

of a wide range of new business cases can foster ELFM development. Beyond such practically oriented R&D, which address specific knowledge gaps along the ELFM value chain, there is also a need for developing a better systemic understanding of which site-specific factors, project settings and system conditions that are most critical for feasibility and performance. Apart from that such system-oriented research could constitute a powerful learning tool for facilitating development of applicable prospecting methods and tailored ELFM processing lines; it is also indispensable when it comes to specifying needs for policy and market interventions. In order to better support policy-making, however, broader assessment frameworks are needed covering local to global environmental impacts as well as the most relevant socio-economic consequences of ELFM.

5. The essential role of policy support and market interventions

By learning from the evolvement of other sustainability-driven innovations (e.g. renewable energy), the transformation of emerging concepts to conventional practices relies on a clear political direction and support. This is because existing policies, markets and governance structures are adjusted to the needs of established industries – conditions under which early stage environmental innovations are seldom competitive. Neglecting ELFM in EU policy and regulatory frameworks is, therefore, not a neutral act but rather an effective way to lock in conventional practices and lock out ELFM.

In order to stimulate investments in know-how and technology innovation and enable policy support and market interventions, ELFM needs to be institutionalised. In 2017 there was a first attempt to do so. The European Parliament adopted its Waste Package on March 14, 2017, which included "Article 5": *"The Commission shall further examine the feasibility of proposing a regulatory framework for enhanced landfill mining so as to permit the retrieval of secondary raw materials that are present in existing landfills. By 31 December 2025 Member States shall map existing landfills and indicate their potential for enhanced landfill mining and share information."* Unfortunately, this ELFM Amendment to the Landfill Directive was later blocked by the Council during the trilateral meeting. We consider this as a missed opportunity. A second attempt to institutionalise ELFM should be better explained in terms of the potential environmental, social and economic improvements that the ELFM concept can bring to Europe. A first step of such a process could be to legally define ELFM and provide this emerging concept with a clear regulatory framing. At present, authorities are ambivalent to how ELFM, with its multiple objectives (e.g. remediation and recycling), should be handled in relation to existing regulatory frameworks, which are developed for conventional activities and the realisation of one purpose at a time (e.g. remediation or recycling). For unconventional practices such as

Three years after the first ELFM Seminar in the European Parliament, a follow-up Seminar will take place on November 20, 2018, in the European Parliament (Brussels). The scope for the 2nd ELFM Seminar in the EP is broadened from landfill mining only to the development of a dynamic landfill management and mining strategy for Europe's 500,000+ landfills. An impressive programme has been developed. The event is a co-organisation of MEP Hilde Vautmans, SIM² KU Leuven, CTF, EURELCO and 3 EU-funded landfill management/ mining-related projects: NEW-MINE, COCOON and RAWFILL. More info here.

ELFM, such conditions for governance create uncertainties regarding the playing rules especially so since remediation and recycling activities involve significantly different regulatory frameworks. This situation makes it difficult for actors to foresee the outcome of their investments – something that effectively constrain their will to engage in the area. The lack of market advantage means that the success of environmentally-driven innovations depends on political support and interventions, at least initially. Such inducement mechanisms could take many different forms such as investment support, governmental grants and loans and tax anomalies. When it comes to ELFM, investment support or specific research grants for establishing costly large-scale pilot and demonstration projects would be particularly important at this stage. So would funding of regional landfill surveys and mapping exercises that specifically address the resource aspects of such deposits.

However, it needs to be said that just supporting development of know-how and technology innovation is not enough for establishing cost-efficient and sustainable ELFM practices. Correcting current market failures is most likely also required, thereby enabling adequate revenues for extracted materials and energy carriers and avoiding high re-deposition costs and taxes for the share of the residual waste fractions that cannot be recovered. Economic instruments that internalise positive and negative ELFM externalities into the project economy is another example of potential policy interventions that would change economic boundary conditions and stimulate societally-motivated practices. Obviously, the development of ELFM policy support and market interventions requires that authorities recognise such activities as societally-motivated. Given the early stage of development, such recognition could be challenging to obtain due to significant uncertainties and needs to capture the multiple objectives of ELFM (e.g. various materials recycling, recovery of energy carriers, remediation of malfunctioning landfills and land reclamation). A recent government commission in Sweden reveals that existing authorities lack institutional capacity for governing such complexity and uncertainties of emerging innovations. By more or less considering only one objective of ELFM, i.e. metals recycling, the Swedish EPA concluded that political support is not societally justified and stated that *"The EPA believes that the important remediation work shall not be jeopardised by uncertain possibilities for recycling of disposed resources"*. To facilitate emergence of ELFM as well as other circular economy innovations, institutional change, breaking up current structures, might therefore be needed because at present such multi-value concepts do not seem to have an institutional affiliation capable of governing their emergence in a complex and uncertain world.

What evolutionary economics tells us is that it is often hard to foresee which innovations that in the end will prove most viable. From a policy perspective, this means that there needs to be an openness for allowing and supporting the emergence of several options. Given the lack of coherent strategies for how Europe should manage its 500,000 landfills as well as how a circular economy could be established, we therefore urge politicians and authorities to also consider ELFM as a potential future business line.

Want to react? Send your comments to peter.jones@kuleuven.be.

Peter Tom Jones is a KU Leuven IOF (Industrial Research Fund) Senior Research Manager in the field of Urban/Landfill Mining and Sustainable Metallurgy (SIM² KU Leuven). He is coordinator and/or valorisation officer of a number of KU Leuven, Flemish and EU-wide projects and consortia in the field of recycling, metallurgy and Urban/Landfill Mining. He is the General Coordinator for the European Enhanced Landfill Mining Consortium (EURELCO). Jones coordinates the EU H2020 MSCA-ETN NEW-MINE project on ELFM.

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Steven Van Passel is Professor Environmental Economics at the University of Antwerp. His research concentrates on the economic and sustainability assessment of micro-systems (e.g., firm level or system level). As an ecological and environmental economist, he is specialised in conceptual and methodological aspects of assessing sustainability, clean technologies and climate change. He is Principal Investigator for the University of Antwerp in the EU MSC-ETN NEW-MINE project.

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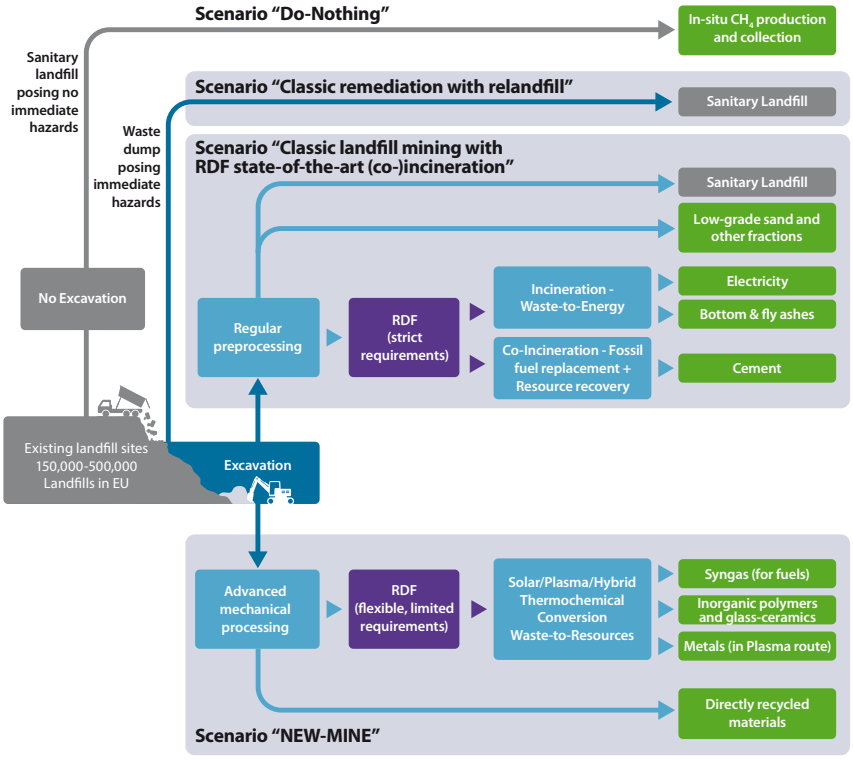
Key project information:
Project type: H2020 MSCA-ETN
Project duration: 4 years (01/09/2016 to 31/08/2020)
Website: http://new-mine.eu/
EU contribution: €3.85 m
Coordination: KU Leuven

Europe has somewhere between 150,000 and 500,000 landfill sites, with an estimated 90% of them being "non-sanitary" landfills, predating the EU Landfill Directive of 1999. These older landfills tend to be filled wth municipal solid waste and often lack any environmental protection technology. In order to avoid future environmental and health problems, many of these landfills will soon require expensive remediation measures. This situation might appear bleak, but it does present us with an exciting opportunity for a combined resource-recovery and remediation strategy, which will drastically reduce future remediation costs, reclaim valuable land, while at the same time unlocking valuable resources. However, the widespread adoption of Enhanced Landfill Mining (ELFM) in the EU, as envisaged by NEW-MINE, urgently requires skilled scientists, engineers, economists and policy makers who can develop cost-effective, environmentally friendly ELFM practices and regulatory frameworks. All this demands a European commitment to concerted, inter- and transdisciplinary research and innovation. NEW-MINE trains 15 early-stage researchers (ESRs) in all aspects of landfill mining, in terms of both technological innovation and multi-criteria assessments. The technological innovation follows a value-chain approach, from advanced landfill exploration, mechanical processing, plasma/solar/hybrid thermochemical conversion and upcycling, while the multi-criteria assessment methods allow to compare combined resource-recovery/remediation ELFM methods with the "Do-Nothing", "Classic remediation" and "Classic landfill mining with (co-) incineration" scenarios. By training the ESRs in scientific, technical and soft skills, they become highly sought-after scientists and engineers for the rapidly emerging landfill-mining and broader raw-materials industries of Europe.



EURELCO is an open, quadruple helix network that supports the required technological, legal, social, economic, environmental and organizational innovation with respect to Enhanced Landfill Mining within the context of a transition to a resource efficient, circular, low-carbon economy. Are you a relevant actor working on ELFM? More information on how to become a EURELCO Member can be found here: https://eurelco.org/become-a-partner/

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