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# ENHANCED LANDFILL MINING AT THE REMO SITE: ASSESSING STAKEHOLDERS' PERSPECTIVES FOR IMPLEMENTATION

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## Introduction

The resource potential as well as environmental and societal risks and impacts of landfills and Landfill Mining (LFM) have been discussed in literature.<sup>1-3</sup> Different objectives can drive LFM projects and can range from sanitation purposes, conservation of landfill space or reclamation of land to resource recovery and energy generation.<sup>4,5</sup> For taking economic pressure from sanitation projects or even developing business models, the concept of LFM further developed into Enhanced Landfill Mining (ELFM). ELFM aims to valorise urban waste streams as materials (Waste-to-Material, WtM) and energy (Waste-to-Energy, WtE) using innovative technology in an integrated, environmentally and socially sound way.<sup>2</sup> Along with this development, the concept of landfills, as some kind of eternal disposal site, also shifted towards the idea of temporary storage.<sup>6-8</sup> Hence, environmental risks and impacts of landfills as well as ELFM activities have received of growing interest in the past years<sup>9-11</sup> along with economic and societal evaluations of ELFM projects.<sup>7,12-14</sup> While the benefits in these studies usually focus on the mitigation of risks or the reclamation of land, it remains unclear how different stakeholders approach ELFM and on which risks and benefits they focus. The importance of economic and societal drivers and barriers to stakeholders has to be assessed. This will help to mitigate risks and develop effective communication strategies and policy guidelines. Moreover, it should be identified which key stakeholders should be involved in an ELFM project. Krook, Svensson & Eklund conclude in a review paper that further investigations on stakeholder perceptions with societal actors are “essential for understanding the capacity of technology and conditions for realisation” of ELFM projects. This will help, for example, to identify the recyclable share of resources deposited in landfills or the effects of current policies on ELFM.<sup>1</sup>

## Method

To investigate how different stakeholders perceive ELM activities, semi-structured interviews were conducted. The interviews were recorded and consequently transcribed. From an initial review of the relevant literature, five major themes were identified. These included (i) 'perspectives on landfills and their management', (ii) 'economic drivers and barriers of ELM', (iii) 'environmental benefits and risks of ELM', (iv) 'societal challenges for the implementation of ELM projects' and (v) 'the role and responsibilities of institutions and other stakeholders involved in the realisation of ELM activities'. While the first theme (i) was chosen to identify the general approach of participants to landfills, the second, third and fourth theme (ii-iv) aim at determining the perceived sustainability of ELM. The last theme (v) was chosen to describe how different stakeholders are involved in ELM projects and where they are able to influence processes along the way of realisation. Furthermore, four major stakeholder groups have been identified by applying the logic of the quadruple helix, being (i) local community members, (ii) institutional actors, in this case governmental bodies, (iii) scientists and (iv) business actors. During the analysis, the software NVivo was used and statements of the interviewees were assigned to the themes to carve out differences in perspectives according to the different stakeholder groups involved. In a first step, interviewees were assigned to one of the four stakeholder groups. To interpret responses, a structure of topics and subtopics was derived, based on the interview guide and a first screening of the interviews. Consequently, statements of participants were categorised according to themes by assigning them to the structured topics and subtopics as well as stakeholder groups. This made it possible to identify relations as well as emerging patterns and ideas. If a statement was relevant for multiple topics or subtopics, it was possible to assign the response multiple times.

## Case-study and sampling

To get relevant results from the interviews, an active engagement of the interviewees in an ELM project was considered important.<sup>15-17</sup> A case was needed where operations had either already started or were planned to start within a considerable timeframe. Authorities and the local community also needed to be involved. The REMO landfill, located in the Flemish region of Belgium, provided such a stakeholder environment and was additionally subject to prior scientific investigations.<sup>5,12,18</sup> Interviews were taken with individual participants and interviewees included (i) two members of the residential area around the landfill organised in a group called 'De Locals'. This group seeks to gather information about the planned ELM activities at REMO and inform residents. Also included were three members from (ii) relevant authorities as OVAM, the Flemish waste, material and soil agency and the European Commission as well as one (iii) scientist and (iv) two managers from the operating

company of the landfill site, Group Machiels. To select interviewees the quadruple helix framework was further subcategorised and subcategories were prioritised according to their relevance to the REMO case. For example, business actors were split into operators, technology providers, purchasers and financiers or institutional actors into governmental and non-governmental bodies to identify potential participants. The main criteria for the selection of interviewees were (i) their affiliation to a prioritised subcategory of the quadruple helix, (ii) their level of involvement in the REMO case or research, and (iii) an approximate evenly distributed share of participants over the quadruple helix framework. In total eight interviews were conducted and analysed.

It has to be mentioned that some participants were biased towards the REMO project. Operators, of course, have already committed to the projects by making investments and want the realisation to move forward. The local community members interviewed were part of a specific group concerned with the development of the REMO landfill. They have been working closely with the operators and are represented within EURELCO, the European Enhanced Landfill Mining Consortium, an organisation with a positive attitude towards ELFM. Community members who publically oppose the REMO project were not interviewed.

## **Results**

The results show differences and similarities of various stakeholder groups. The individual themes will be presented hereafter.

### **Approach to landfills**

There are differences and similarities in how each stakeholder group approaches landfills in general. Topics like “Safety of a landfill” or “Disadvantages of a landfill” are understood differently between stakeholder groups. Associations with the REMO site are mostly positive and most critique came from the operating company itself.

All stakeholder groups primarily perceive the function of a landfill as temporary storage of waste and resources. Landfilling is considered the least favourable waste treatment option but was also identified as being necessary by all interviewees. The operating company emphasises the offered service of waste disposal for its customers, whereas the scientific side also mentioned landfills as a source of pollution and land occupation. Furthermore, institutional participants make an explicit distinction between “dump sites” that pre-date the European Landfill Directive from 1999 and “(sanitary) landfills” that comply with the EU Landfill Directive. While “dump sites” were less regulated regarding materials to be landfilled and were more considered to serve as an eternal storage of waste, “landfills” under

the EU Landfill Directive take environmental aspects into consideration and implement a clear hierarchy to the waste being disposed. This could partly explain a change in the institutional perception of landfills from a final storage towards a resource reservoir. Moreover, one participant from the institutional side made it clear that extractive waste from traditional mining processes does not fall under the *EU Landfill Directive* but, instead, under the *Extractive Waste Directive* and is, therefore, not part of landfills in their understanding.

An overarching agreement on the safety of landfills can be found considering modern landfills. Overall, all stakeholder groups consider those rather safe. Nevertheless, differences in perceptions are situated in the details: all groups accentuated that a properly operated landfill under current legislation can be considered safe, but older landfills are often perceived as less safe, posing potential risks. The landfill operators also made a distinction to “very old landfills” justified by changes in waste streams to be landfilled: “...when you go back in the past there are not that many risky waste streams...” This is coherent with the experiences of institutional participants stating that most landfills are in a better condition than estimated and the expected toxic “time-bombs seem not to be reality after all”, when talking about municipal solid waste (MSW). Additionally, the institutional side stressed that changing circumstances can affect the safety of a landfill, for example through higher flood risks due to changes in climatic conditions. Flooding a landfill could potentially expose groundwater reservoirs to a higher content of toxics than common precipitation and, as such, floods endanger the stability of landfills through soil movements.

Perceived advantages of landfills are the potential for resource recovery and the removal of waste from the local communities. While the landfill operators focused more on the resource potential, participants from institutions and the local community also emphasised waste removal. The institutional side also stated an advantage in being able to control the process of waste disposal. Perceived disadvantages, on the other hand, were approached differently. While all stakeholder groups mentioned a suboptimal use of land and environmental risks like ground water contamination through leachate, operators also mentioned the installation of additional security measures against wildlife as well as risks coming directly from on-going operations as a disadvantage. The local community further perceived a risk for human health coming from toxic materials in landfills, *e.g.* mercury or asbestos, whereas a researcher stated a disadvantage of industrial landfills often containing toxic material in combination with a lack of control mechanisms.

Concerning the REMO site, all stakeholder groups had positive associations, although opposing groups to the project from local communities and politics were also mentioned. The operators were described as “thinking in a modern way” or

“courageous” for taking new risks and trying to implement new technology. Most critique about the REMO site came from the operators themselves, where the need for optimisation of processes and technology was expressed. Negative associations from local community members and the institutional side were mainly towards landfills in general and coming from experiences pre-dating the EU Landfill Directive.

### **Concept and attitude towards ELFM**

The concept of ELFM and distinctions to traditional LFM were perceived quite differently between stakeholder groups. At the same time, all stakeholder groups stated a mostly positive attitude towards ELFM. For the operators, the primary objective of ELFM lies in the recuperation of land, energy and resources and should be carried out as a private business activity. The main difference to traditional LFM was presented by involving stakeholders in the process to produce higher-added values. The local community members and institutional participants put a focus on material recovery using high-level recycling and sorting technology, whereas the institutional side even expanded the concept of ELFM to *Enhanced Landfill Management and Mining* (ELFM<sup>2</sup>) including management of landfill sites and their interim-use until mining activities would start. Both institutions and operators shared the view that most landfills will be mined in the future, while it remains unclear when exactly this will happen. The scientific side emphasised the importance of ELFM having almost no discharge flow and described it as an (economically) “risky recycling activity”.

Operators stated they are for actively engaging in ELFM for the value of land, energy and materials as well as environmental reasons, given a “clear, positive, net balance”. However, the institutions, science and local community members were mainly motivated doing so for environmental reasons and the necessity of ELFM to avoid future risks mentioned before. Nevertheless, ELFM should be able “to be economically independent” from an institutional point of view. Yet, operators and institutions both stressed that not every landfill is suitable for ELFM.

### **Economic challenges, drivers and barriers of/for ELFM**

All stakeholder groups consider similar economic drivers and barriers for ELFM. Yet, the economic dimension has a different significance for different stakeholder groups within the sustainability framework. While participants from the scientific world and local communities emphasised the importance of environmental aspects of ELFM, Institutions and operators focused on economic factors with environmental and social “spill overs”.

Operators and institutions both mentioned land-recuperation as the clear primary economic driver of ELFM. Operators also stressed the integration of stakeholders

through platforms like EURELCO and the necessity for “doing activities” in the form of large-scale pilot projects, helping the development of ELM towards an industrial activity. One participant stated that, “when we start mining the REMO site, from this one activity many spin-offs will develop”. With technological development, not only costs could be reduced, but also new opportunities for processing unusable waste fractions could open up. In agreement with the scientific participant, operators are also favouring the idea of combining public and private money for investment support to build up a new industrial sector. This could take the form of private-public partnerships (PPP) or public insurances. The reasoning for this belief lies in the societal and environmental benefits ELM generates, and would be at least needed in the beginning. No participant mentioned the internalisation of environmental and societal costs in monetary terms. Rising market prices for primary and secondary raw materials would strengthen the economic viability of ELM. The institutions also mentioned an economic driver in the avoidance of long-term monitoring costs as well as cost reductions through interim use of landfill sites, for example by generating electricity through solar panels. Additionally, a long-term industrial activity would stimulate the regional economy. Local communities, on the other hand, identified the generation of employment, especially of low-skilled labour, as well as energy generation and material recovery as main drivers for ELM.

While the operators mentioned technological development as a driver for ELM, it could also work as a barrier for investments, if new technology emerges before the planned return on investments. Local community members and the scientific participant share this view with the operators. More importantly, institutions and operators described finding investors in general as one of the most difficult challenges for ELM. This is explained partly by a lack of awareness about ELM in the relevant sectors and partly by known risks in the development of market prices, new technology and social acceptance: “You get investment support a bit there, a bit there. So, you have to combine all these bits and pieces of support for your large investment and this is, of course, time-consuming.” A lack of public money for large-scale pilot projects including technology providers was also mentioned. Operators emphasised that high monitoring and sampling activities would drive up costs and could hinder ELM projects from being implemented. Institutions and local community members mentioned that large and time-consuming projects tend to be very costly, yet permitting processes and changes in regulations need this time. Currently, low market prices for primary and secondary raw materials seem to hinder ELM activities, although, as mentioned before, change is expected by three of four stakeholder groups. As stated by institutional and scientific participants, for individual projects the location of the landfill and waste composition could also be a relevant barrier or driver for implementing an ELM project.

## **Environmental benefits and risks of ELFM**

Environmental benefits are generally perceived as coming from the reduction of risks through waste removal and the mitigation of primary resource use. Such benefits included the mitigation of ground water contamination, the elimination of potential pollutants to the soil or the mitigation of traditional mining activities. Although an overall agreement on the risks coming from ELFM activities could be discerned, they are still perceived with different importance to each stakeholder group. Thus, differences are mainly perceived with respect to the distinct focus on those risks.

In general, risks were described as being similar to those coming from having and operating landfills at current times. This included odour, noise and risks for human health coming from dust or ground water contamination, since the landfill would have to be re-opened. Institutional and the local community members also expressed their concerns about auto combustion of gases coming from the change of anaerobic to aerobic conditions in the landfill. The operators also mentioned that the energy consumption of ELFM activities today is mainly fossil fuel based and, as scientific and institutional participants also point out, were aware that not all waste could be processed. This again implies that waste streams from ELFM activities would partly be re-landfilled, which again implies the same risks as traditional landfilling for an uncertain timeframe. Local community members were also concerned that toxic materials could be brought back into the material circle and the scientific participant brought up the point that poor execution could lead to bigger environmental problems than before: “These are huge risks, also on the environmental level the risk of creating a bigger environmental problem than before is still there.”

## **Societal challenges, drivers and barriers of ELFM**

All stakeholders perceived the biggest societal challenge in involving the public in ELFM projects. Operators, for example, fear public opposition by non-involvement but also consider a need for more awareness of ELFM in general to make financing and permitting processes easier. The time-consuming permitting process played an important role for most interviewees. An institutional participant also included public authorities in this challenge, stating “[The] most important thing from my point of view is the transitioning of the mind-sets, that’s a policy aspect.”

The inclusion of stakeholders was also recognised as the main possible societal driver for the implementation of ELFM projects. By raising awareness about ELFM and anticipating opposing views a project would benefit. To maximise gains from stakeholder integration, it was considered important to include all relevant actors from an early stage on.



Local community members also expressed the wish for more information about processes, risks and benefits of ELFM activities and a broad distribution of this information: “I think it's very important that people should be more informed...” Furthermore, they urged, on a par with the institutional side, that politicians should also be included in this process and criticised the conflict of interest between short-term politics and long-term development. Other drivers mentioned were the reclamation of land for recreational purposes and the mitigation of risks through waste removal.

All stakeholder groups identified a lack of social acceptance as a project's biggest societal barrier at this time: “That's the barrier number one.” Operators, institutions and local community members explained this partly by knowledge and awareness gaps between the different parties involved, like local residents and politicians. Other reasons mentioned were the increase in traffic and the fear of smell and dust reoccurring with new ELFM activities. Local community members and operators also perceived a barrier in small groups being able to hinder a project through legal procedures overpowering a “silent”, but supportive, majority. A situation where “a small group talks for a large community that doesn't talk.”

### **Key actors of ELFM and the role of institutions**

All stakeholder groups – apart from the operators themselves, who perceived investors as highly important – named the operating company as the most important actor involved in ELFM activities. Besides, regulatory bodies should play a crucial role according to all stakeholder groups. The institutional and the scientific side also stressed that the involvement of local communities is important, yet difficult, because of a lack of knowledge and experience. For the institutional side the general public is perceived as even more important than local residents. Scientific bodies are mostly perceived as platforms for knowledge transfer between the involved parties, but would play a secondary role in the realisation of ELFM projects.

All stakeholder groups perceived the role of institutions, *i.e.* governmental bodies, as overall positive. Most participants named OVAM as one of the key actors involved and were overall satisfied with their role. The subsidiarity principal of the EU was positively acknowledged by institutional participants, who also perceived OVAM as a platform for experimentation and trials. It was criticised by a local community member as well as by scientific and institutional participants that advice from regulatory bodies is often not followed on a political level. Although no participants identified regulations “hampering” ELFM projects, institutional participants and operators would appreciate regulations that “help and stimulate landfill mining activities” and make them easier to monitor.

Operators and local community members described permitting procedures as too time-consuming, due to being in an early phase of a learning process coming with new industrial activities, also affecting authorities and regulatory bodies. The institutional side also emphasised the need for regulations concerning the interim use of landfills to be mined and expressed the wish for amendments on ELFM implemented at a European level. Finally, local community members and operators recognised a need for regulations also in production processes of non-ELFM products, for example a quota for recycled content in certain products. This would stimulate markets for secondary materials and drive ELFM projects.

## **Discussion and conclusion**

Interestingly, landfills are in general perceived as temporary storage facilities by all stakeholder groups, which most probably contradicts the view of the general public. This might be explained through the involvement of all participants in a specific ELFM project and a higher awareness for other perspectives through this involvement.

Overall, participants had a mostly positive attitude towards ELFM, although focusing on different aspects. Moreover, some drivers of ELFM projects could also work as barriers, depending on the context. While technological development would push ELFM through the ability to process unusable waste streams, it could also hinder investments by raising uncertainty and, hence, the risk for lower returns if technological development is faster than the payback period, for example. Similarly, the integration of stakeholders raises the awareness of ELFM and, therefore, serves as a driver. On the other hand, it could also attract opponents to such projects and therefore cause delay or even cancellation. Local community members and scientific participants put a focus on the mitigation of environmental risks, while institutions and operators also emphasised the need for an economic sound model for ELFM. This is reasonable since local residents are primarily concerned for the environment they live in, whereas the institutional side has to keep in mind the larger picture to ensure all parties involved are considered. Furthermore, the number of participants to this study, with eight interviewees, can be considered rather small and other points of views on ELFM remain unclear.

The results of this study show perceptions of different stakeholder groups. To determine if those perceptions can be generalised and transmitted to other cases of ELFM projects, more research is needed. To do so, it is not only important to raise the number of interviewees, but also to put the perceptions into context with semi-quantitative results from questionnaires and contrast them against state-of-the-art knowledge on environmental benefits and risks, economic drivers and barriers as well as societal challenges identified by other case-studies. Moreover, stakeholders along

the value chain of ELFM, as technology providers, investors and purchasers, should be included in future studies. From this and future research, knowledge gaps can be identified and help develop communication strategies for an enhanced stakeholder integration. The findings could also help defining policy guidelines for ELFM and mitigate societal risks.

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