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AVAILABILITY ASSESSMENT OF ANTHROPOGENIC RESOURCES: FROM PROSPECTION TO PRODUCTION

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Introduction

The mining industry has a long tradition in assessing the availability and the recovery feasibility of resources from geogenic deposits. This allows for predictions of recoverable quantities under defined conditions. These quantities, however, are not fixed and depend on changes in science, technology, legislation and economic conditions (cf. McKelvey and Kleepe, 1976). Qualified persons or interdisciplinary teams do this challenging assessment task in order to help the industry to attract investments in exploration and mining projects. Various classifications have evolved over time, with the United Nations Framework Classification for Resources (UNFC) being the most comprehensive system (UNECE, 2010). This framework harmonizes the terminology and evaluation principles for different stakeholders and resource types, such as mineral and energy resources. Resource classifications serve for communication means only, i.e. they do not prescribe specific methods to characterize and evaluate mining projects. Winterstetter et al. (2015b) presented first UNFC applications to anthropogenic resources and in 2018 the scope of the UNFC was extended to anthropogenic resources extended (Kral et al., 2018a). The new Specifications (UNECE, 2018) allow to communicate the maturity level of recovery projects in a circular economy context, from the early stage of prospection to the final stage of production.

This article describes the availability assessment of anthropogenic resources and presents the application of UNFC to communicate the availability of materials to be mined from a historic landfill site in Belgium.

Methodology and case study

In the past, various authors developed general frameworks for availability assessment and applied them to case studies (cf. Fellner et al., 2015, Lederer et al., 2016, Winterstetter, 2016, Mueller et al., 2017, Kral et al., 2018b, Winterstetter et al., 2015a, Zuser and Rechberger, 2011). We divided the availability assessment into four phases, i.e.from prospection to potential production (Table 1).

To demonstrate the availability assessment in practice, we selected a historic landfill as potential material source and defined a landfill-mining project to produce secondary raw materials (cf. Table 1). Resource recovery under present conditions is contrasted to a future scenario with assumptions on decreasing sorting costs and increasing land prices, moving the project closer to the maturity level of production. The detailed case studies have been published by Winterstetter et al. (2018).

Table 1: Anthropogenic resource assessment applied to the Bornem landfill (cf. Winterstetter et al., 2018)

<table>
<tr><th>N°</th><th>Phase</th><th colspan="2">Approach</th></tr>
<tr><td>1</td><td>Prospection</td><td colspan="2">The Public Waste Agency of Flanders (OVAM) developed the FLAMINCO tool (Behets et al., 2013) to map, screen and investigate old landfills for contamination risks and resource potential. Based on these criteria and the access to real-life data, we selected a former landfill site, located in Bornem covering about 5 ha and containing about 390'000 tons of municipal solid waste.</td></tr>
<tr><td>2</td><td>Exploration</td><td>We estimated the landfill's rough resource potential by gathering information on the type, location, size, depth, volume and rough composition. We examined the share of extractable materials and recoverable land as well as its contamination level as a function of different technology alternatives and project set-up options with their specific recovery efficiencies.</td><td rowspan="4">We classified the quantities under present and future conditions under UNFC (UNECE, 2018) as follows:
• G-Axis: Depending on whether the level of confidence about the potentially extractable and usable share of materials and / or land is high, medium, low or whether knowledge on the recoverable quantities is practically not existing the deposit is graded with G1 to G4.
• F-Axis: The technical and project feasibility is indicated by an existing and well-enforced legal framework and societal, institutional and organizational structures, by fully mature technologies applied and ongoing project activities (F1). One or several of those criteria, being unfulfilled, result in the lower categories F2 – F4.
• E-Axis: A positive NPV implies that a project is economically viable (E1). If the NPV turns out to be negative, one has to judge, whether there are reasonable prospects for economic extraction in the foreseeable future (E2) or not (E3) by anticipating realistic changes of key economic parameters.

We classified the recovery project under current conditions as "Non-commercial project" and under future conditions as "Potentially commercial project". Detail are given in the results and discussion section.</td></tr>
<tr><td>3</td><td>Development of the recovery project</td><td>Using the Net Present Values (NPV), we evaluated the socioeconomic viability of the recovery project under present and future conditions, considering prices for secondary products and recovered land, investment and operating costs, costs for external treatment and disposal, avoided costs as well as possibly monetized social and environmental externalities and indirect financial effects.</td></tr>
<tr><td>4</td><td>Production</td><td>Potential production under future conditions.</td></tr>
</table>

Results and discussion

The availability of materials in the landfill "Bornem" is expressed by the maturity level in the life cycle of the recovery project (cf. Figure 1). The UNFC project life cycle starts after prospection with the exploration phase and the development of the recovery project towards the production of secondary raw materials. The "Bornem" project's maturity level and the associated quantities are evaluated and classified for present and potential future conditions:

Present conditions: We classified the landfill-mining project as "Non-commercial project" (E3F3G2). First, on the G-axis the "Bornem" landfill-mining project is scored with G2. The quantities in the landfill are estimated with a medium level of confidence based on data from the test excavations, trial sorting and waste characterizations and the landfill's logbook data. The applied technologies' recovery efficiencies are estimated with sufficient detail for assessing the landfill's material recovery potential. The land recovery potential is known since residues are re-landfilled off-site. Second, the field project status and technical feasibility (F-Axis) is classified with F3. Even though well-known technologies are applied and the institutional structure is already established with OVAM as committed partner, there are no activities on going other than test-excavations and trial sorting. The neighbors' attitude towards the project is positive. However, the LFM project is still in the pre-feasibility stage with mainly planning activities and operations on a very small scale. As there is no legal framework for LFM, individual licenses from local authorities are needed to advance the project. Third, the socio-economic viability (E-Axis) is scored with E3, due to a negative Net Present Value of -17 Million € (-44 € / t excavated waste materials). Under the present conditions, about 336,600 t materials and 50,000 m² of land can be recovered and sold, while 34,600 t of materials need to be re-landfilled off-site (Winterstetter et al., 2018).

Future scenario: Changes in the key economic parameters "land prices" and "sorting costs" result in a positive economic evaluation result. Therefore, the landfill mining-project is classified as "Potentially commercial project" (E2F3G2). A combination of increasing local land prices from currently 150 €/m² up to 350 €/m² and parallel decreasing sorting costs could potentially be reached (Winterstetter et al., 2018).

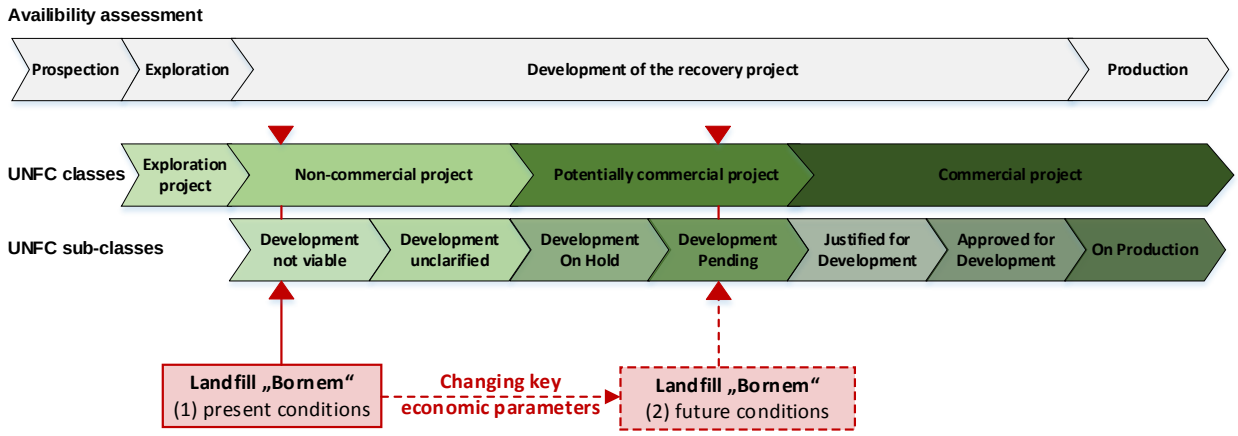

Figure 13 **Maturity level of the landfill-mining project "Bornem" under present (1) and future (2) conditions according to the UNFC (green colored boxes) and according to the phases of availability assessment (grey colored boxes).**

Conclusions

The United Nations Framework Classification for Resources (UNFC) can help to assess the availability of anthropogenic resources by classifying potential resource recovery projects with different levels of maturity, from prospection to potential production, under technical, socio-economic and project-planning aspects.

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