LIFE12 ENV/GR/000427 LIFE reclaim "Landfill mining pilot application for recovery of invaluable metals, materials, land and energy

TECHNICAL REPORT - ACTION C2
FOR THE POLYGYROS LANDFILL, IN THE MUNICIPALITY OF POLYGYROS, CHALKIDIKI

SUBJECT:

Technical Report on the 2nd Annual Socioeconomic Impact evaluation of the Project

STUDY : **ENVECO S.A.**

ENVECO S.A. ENVIRONMENTAL PROTECTION MANAGEMENT & ECONOMICS

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1. Introduction

1.1. Report context and Objectives

The present report is the third Deliverable of Action C2 of the Life reclaim Project "Landfill mining pilot application for recovery of invaluable metals, materials, land and energy", which is funded by the European Union through Life+ financial instrument, under the contract with code LIFE12 ENV/GR/000427.

The objective of this report is to assess and document the performance of the indicators established in the Baseline Evaluation of the LIFE reclaim project, on an annual basis. The present report constitutes the 2nd Annual Socioeconomic Impact evaluation of the Project.

The table with the indicators set on the first deliverable of the action "Baseline socioeconomicl impact evaluation of the project" will be filled in with the values obtained during the implementation of the project but they will be adapted as if the Polygyros Landfill underwent a complete Landfill Mining project and was completely cleared from waste (39,000tn). The values used were obtained during the Socioeconomic Analysis (Action B9) of the project and specifically from the first scenario. Also, the results from the Local survey will be used.

The objective of the analysis is to assess to what extend the economic, socioeconomic and social conditions of change if the Landfill Mining operation was carried out until the landfill was completely emptied.

1.2. General information on Life+ reclaim

1.2.1. Project objectives

The Project aims at building a temporary pilot application on productive scale in order to mine parts of existing landfills, separate useful materials and produce marketable products, introducing innovative techniques from the mining industry, suggesting a new concept of waste valorization. It will also assess the viability of the proposed method as well as provide a scientific evaluation on the potential alternatives of the management of waste disposal sites. The basic objective is to introduce landfill mining (LFM) as a complementary approach of management of past landfill (controlled or uncontrolled) sites and create a useful tool for the recovery of:

- useful materials, especially ferrous and non-ferrous metals
- space, which equals to extra landfill capacity and lifetime in cases of expansion
- soil material, which has been disposed off along with the waste and which is a natural resource valuable to local ecosystems as well as to landfill industry itself
- recyclable materials, like plastic and paper products, which can be either post-processed in a suitable recycling plant or burned in modern incinerators

- land, in the case of old landfills, which will lead to a successful rehabilitation scheme with minimal environmental footprint which in turn, can be easily adapted to different waste compositions and site conditions.

At the same time the Project objectives include the familiarization of the public with the issue of post-disposal-processing of waste and with the potential of the procedure for metal recovery and site rehabilitation, resulting in a cleaner environment and rational waste management. The abovementioned objectives of material and/or energy recovery are widely known today in the waste processing industry and precede disposal, but have not been so far utilized in connection to (a) a wider program of waste post-disposal processing and (b) material beneficiation for valuable metals, by means of ore processing methods.

1.2.2. Actions and means

In order to establish LFM as a standard waste management procedure there are two basic tasks to be completed:

- LFM consolidation and application: Detailed elaboration on all technical aspects of LFM, from designing the waste mining operation to creating alternative final products (metal concentrates) that can be directly fed into metallurgical plants.

- Environmental and Social analysis: Detailed approach on the foreseeable socioeconomic impacts of adopting LFM practices.

More analytically, the Project includes the following Actions:

1. Preparation: International experience in LFM, Permitting of additional activities in Polygyros Landfill (PL), Baseline environmental and social conditions

2. Implementation: Landfill inventory, Exploitation plan, Design of production line, Sub-contracting procedures, Pilot-scale Demonstration Unit, MSW mining, operation and tests, Environment rehabilitation plan

3. Socioeconomics: EIA Study, Financial and socioeconomic analysis, Action Plan and Master Plan elaboration

4. Monitoring the environmental & socioeconomic impacts of project Actions

5. Dissemination Actions

6. Project management Actions

7. After-life communication plan

1.2.3. Expected results

According to existing literature, there is considerable experience in waste mining regarding energy and soil recovery, but not regarding non-ferrous metals, since the waste requires further processing which very few have attempted to undertake. It is expected that the Project will help consolidate knowledge, give practical experience in the field and contribute to the adaptation of an innovative production line under, various site conditions and waste compositions. Specifically, the Project is expected to bring the following results:

- Web GIS database for operational landfills and dump-sites in Greece combined with a Website during and after the duration of the Project, connected with the web-GIS database application
- Processing of of waste for the production of different separation samples
- Two field environmental economics surveys on the acceptance of LFM
- Action plan on national level for LFM and Strategic Environmental Assessment on national level
- Socioeconomic analysis of LFM
- Publication of one bilingual book/album on LFM
- Dissemination of the experience and information gained, through conferences (2 national and 1 international) as well as through proper dissemination material

All results will be supported by respective Technical Reports (one of which is the present one), with documentation on the background, methodologies, alternatives examined and relevant results. In addition, a special report regarding the carbon footprint of the Project will be submitted in order to support the footprint minimization policy of the project.

1.3. The Study Team

This Report has been elaborated by the following Life reclaim collaborators:

From the team of ENVECO S.A.

- Spyros Papagrigoriou, Civil Engineer, Environmental Engineer, Dipl., MSc., MLitt
- Chrysa Papara, Environmental Scientist (University of the Aegean)
- Nikolaos Mihas, Civil Engineer (AUTH), MSc in Environmental Engineering
- Kyriaki Manitara, Chemical Engineer NTUA, MSc Techno-economic Systems (NTUA)
- Alexandros Karanasios, Civil Engineer NTUA

From the team of the Municipality of Polygyros

- Georgios Papasarafianos, Electrical Engineer
- Georgios Diamantoulakis, Administrative officer

2. Socioeconomic indicators for the RECLAIM project

2.1. Proposed socioeconomic indicators

The socioeconomic indicators are summarized in the following Table 1. Each indicator is discussed in more detail below.

Table 1: Socioeconomic indicators used in RECLAIM project

Impact category	Socioeconomic Indicator	Unit
Economic	Revenues from recycled materials	Euros per ton of waste treated
Economic	Revenues (avoided costs) from energy savings	Euros per ton of waste treated
Economic	Value of green space saved	Euros per ton of waste treated
Economic	Value of CO_2 savings	Euros per ton of waste treated
Economic	Investment cost	Euros per ton of waste treated
Economic	Operational cost	Euros per ton of waste treated
Economic	Financial Net Present Value	Euros
Economic	Financial Internal Rate of Return	Per cent
Socioeconomic	Economic Net Present Value	Euros
Socioeconomic	Economic Internal Rate of Return	Per cent
Social	Acceptance of landfill facilities	% of people
Social	Perception of the environmental impacts of landfills	% of people
Social	Perception of the state of the environment	% of people
Social	Willingness to support landfill mining	% of people
Socioeconomic	Direct employment generaton	n. of workers
Socioeconomic	Indirect employment generation	n. of workers

- SE.I.1. Revenues from recycled materials: This economic indicator aims to monitor the potential revenues derived from the waste that will be excavated and treated during the RECLAIM project. It will be measured in Euros per ton of waste excavated and treated. And will be calculated by multiplying the quantities of the materials recovered (i.e. glass, paper, ferrous metals, etc.) with the unit price of each type of material in the recycled market. This indicator will be connected with Environmental Indicators no. 3, 4, 5, 6, 7 and 8.

- SE.I.2. Revenues (avoided costs) from energy savings: This economic indicator is related to potential avoided costs from reduction in energy consumption of recycled materials in comparison to the use of new materials. It aims to monitor and assess potential energy savings in monetary terms from the materials that will be recycled during the RECLAIM

project. It will be measured in Euros per ton of waste excavated and treated and will be calculated by multiplying the estimated energy savings with the cost of energy (e.g. Euros per kWh). The energy savings will be estimated by means of literature data. This indicator is based on Environmental Indicator no. 10.

- SE.I.3. Value of green space saved: The aim of this economic indicator is to monitor and monetize the benefits from the potential green space saved owing to the landfill mining process throughout the duration of RECLAIM project. The value of green space will be assessed by means of suitable environmental valuation approaches. The indicator will be measured in Euros per ton of waste excavated and treated. It will be estimated by multiplying potential land savings (e.g. in ha) per ton of waste excavated and treated by the value of green space (e.g. Euros per ha). The latter will be estimated by literature data using the Benefit Transfer method. This indicator is connected with the Environmental Indicators no. 17 and 18.

- SE.I.4. Value of CO_2 savings: The aim of this economic indicator is to monitor and assess in monetary terms the reduction in greenhouse gas of recycled materials compared to use of new materials that will be achieved during the RECLAIM project. The indicator will be measured in Euros per ton of waste excavated and treated. It will be calculated by multiplying the kg of CO_2 eq. provided by the Environmental Indicator no. 9 with the value of CO_2 provided by literature data.

- SE.I.5. Investment cost: The aim of this economic indicator is to assess the investment costs of landfill mining process (e.g. excavation and processing equipment). The indicator will be expressed in Euros per ton of waste excavated and treated and will be based on existing information and data gathered during the RECLAIM project from Tasks B6 and B9.

- SE.I.6. Operational cost: This aim of this economic indicator is to assess the operational costs of landfill mining process (e.g. energy costs, personnel costs, etc.). The indicator will be expressed in Euros per ton of waste excavated and treated and will be based on existing information and data gathered during the RECLAIM project from Tasks B6 and B9.

- SE.I.7. Financial Net Present Value: This economic indicator aims to assess landfill mining project's financial viability by measuring its financial net benefits. The indicator will be expressed in Euros. It will be estimated using the Discounted Cashflow method from the financial analysis of the landfill mining process through Task B9.

- SE.I.8. Financial Internal Rate of Return: This economic indicator aims to assess landfill mining project's financial attractiveness by measuring the returns internally generated by the project. The indicator will be expressed in per cent. It will be estimated using the Discounted Cashflow method from the financial analysis of the landfill mining process through Task B9.

- SE.I.9. Economic Net Present Value: This socioeconomic indicator aims to assess landfill mining project's financial viability by measuring its socioeconomic net benefits. The indicator will be expressed in Euros. It will be estimated using the Discounted Cashflow method from the environmental and social cost-benefit analysis of the landfill mining process through Task B9.

- SE.I.10. Economic Internal Rate of Return: This socioeconomic indicator aims to assess landfill mining project's socioeconomic attractiveness by measuring the returns internally generated by the project. The indicator will be expressed in per cent. It will be estimated using the Discounted Cashflow method from the environmental and social cost-benefit analysis of the landfill mining process through Task B9.

- SE.I.11. Acceptance of landfill facilities: This social indicator aims at monitoring the acceptance of landfill sites in their current form. It will be examined by means of the local social survey that will be conducted in Task B9 and will be measured as the percentage of people that are willing to support landfill mining projects.

- SE.I.12. Perception of the environmental impacts of landfills: This social indicator aims at exploring the perception of people about the environmental impacts of landfill sites. It will be examined by means of the local social survey that will be conducted in Task B9 and will be measured in percentage terms (e.g. percentage of people considering that the environmental impacts are 'significant', 'minor', etc.).

- SE.I.13. Perception of the state of the environment: This social indicator aims at exploring the perception of people about the state of the environment. It will be examined by means of of the local social survey that will be conducted in Task B9 and will be measured in percentage terms (e.g. percentage of people stating the state of the environment is 'good', 'poor', etc.).

- SE.I.14. Willingness to support landfill mining: This social indicator aims at assessing the acceptance of landfill mining process. It will be examined by means of local and national social surveys that will be conducted in Task B9 and will be measured as the percentage of people that willing to support landfill mining projects.

- SE.I.15. Direct employment generation: This socioeconomic indicator aims at estimating the direct employment that will be generated by the landfill mining process. To this end, scientists and workers involved in Tasks B5 and B6 will be taken into consideration. If possible, this indicator will be expressed in person-months per m^3 of waste excavated and treated during the RECLAIM project.

- SE.I.16. Indirect employment generation: This socioeconomic indicator aims at estimating the indirect employment that may be generated by the landfill mining process as a result of the direct employment. Data from SE.I. 15 will be used together with data from the processes that will take place in Tasks B5 and B6 to determine employment generated in the businesses that supply goods and services. If possible, this indicator will be expressed in person-months per m^3 of waste excavated and treated during the RECLAIM project.

3. Second Annual Socioeconomic Impact Evaluation of the RECLAIM project

Based on the collected data, the second annual report for the socioeconomic impact evaluation was carried out to estimate the aforementioned Indicators. The results of the evaluation are summarized in Table 2 of the next page.

Impact category	Socioeconomic Indicator	Unit value	Total value	Comments
Economic	Revenues from recycled materials	€9.87 per ton of waste treated	**€384,930**	According to the Socioeconomic analysis of Action B9 (Scenario 1), the per ton revenues from recycled materials are 9.87 Euros *Total waste treated*: 39,000tn
Economic	Revenues (avoided costs) from energy savings	€65.8 per ton of waste treated	**€2,566,200**	*Energy saved from reclaimed materials* (from the C1 1st Annual Report – E.I.10): 94% for aluminum, 60-74% for ferrous materials, 85% for hard plastic, 50% for glass. *Reclaimed materials* (from the C1 1st Annual Report – E.I. 3, 4, 5 and 6): 19470kg of hard plastics, 1680kg of glass, 1612kg of aluminum and 6220kg of ferrous materials *Energy needs for production of new materials*: 23.3Kwh/kg for PET[1], 15Kwh/kg for aluminum[2], 2.26Kwh/kg for ferrous materials[3], 2.03Kwh/kg for glass[4] *Energy cost:* €0.09/Kwh *Total waste treated*: 39,000tn
Economic	Value of green space saved	€0.11 per ton of waste treated	**€4290**	*Potential land reclamation and rehabilitation* (the total surface of the landfill): 2,69ha

[1] Wong, Chee. "A study of plastic recycling supply chain." *The Chartered Institute of Logistics and Transport, University of Hull Business School and Logistics Institute. Available from: http://www.ciltuk.org.uk/* (2010).
[2] "Electricity consumption in the production of aluminium", Mr.Reid.org *http://wordpress.mrreid.org/2011/07/15/electricity-consumption-in-the-production-of-aluminium/*
[3] Fruehan, R. J., et al. "Theoretical minimum energies to produce steel." *Report to the US Department of Energy, Office of Industrial Technologies. Washington, DC* (2000).
[4] Recio, José María Baldasano, René Parra Narváez, and Pedro Jiménez Guerrero. "Estimate of energy consumption and CO2 emission associated with the production, use and final disposal of PVC, aluminium, and wooden windows." *Département de Projectes d'Engineyeria, Universitat Politecnica de Catalunya, Environmental Modelling Lab., Barcelona, Spain* (2005).

				Total waste treated: 39,000tn *Value of green space (Woodland):* 150 Euros/ha/yr[5] Social discount rate: 5%
Economic	Value of CO2 savings	€0.8 per ton of waste treated	**€31,200**	*Reduction in greenhouse gas of recycled materials compared to use of new materials* (from the C1 1st Annual Report – E.I.9): 56346.40 kg CO2 eq *Equivalent for global warming*: €8,3/1000kg CO2[6] *Total waste treated*: 39,000tn
Economic	Investment cost	€0.39 per ton of waste treated	**€15,000**	The Indicator is provided by the findings of the Socioeconomic analysis of Action B9 *Total waste treated*: 39,000tn
Economic	Operational cost	€42.2 per ton of waste treated	**€1,645,800**	The Indicator is provided by the findings of the Socioeconomic analysis of Action B9 (€823,397 for 19,500 tn of waste) *Total waste treated*: 39,000tn
Economic	Financial Net Present Value	Euros	**€-799,500**	According to the findings of the Socioeconomic analysis of Action B9, the LFM operations result in a net social loss of around €20.5 per tn of waste, in present value terms *Total waste treated*: 39,000tn
Economic	Financial Internal Rate of Return	Per cent	**--**	Cannot be estimated due to the negative Financial Net Present Value.
Socioeconomic	Economic Net Present Value	Euros	**€-210,600**	According to the findings of the Socioeconomic analysis of Action B9, the LFM operations result in a net social loss of around €5.4 per tn of

[5] Van der Ploeg, S. and R.S. de Groot (2010) The TEEB Valuation Database – a searchable database of 1310 estimates of monetary values of ecosystem services. Foundation for Sustainable Development, Wageningen, The Netherlands.
[6] Carr, Mathew "The Cost of Carbon, Putting a Price on Pollution" Bloomberg, *Available from:* http://www.bloomberg.com/quicktake/carbon-markets-2-0 (2015)

				waste, in present value terms *Total waste treated*: 39,000tn
Socioeconomic	Economic Internal Rate of Return	Per cent	--	Cannot be estimated due to the negative Social Net Present Value.
Social	Acceptance of landfill facilities	% of people	**83.2%**	Polygyros local survey: 83.2% believe that controlled landfills create less significant problems than the uncontrolled ones, while the rest say that the problems are of equal importance
Social	Perception of the environmental impacts of landfills	% of people	**96.5%**	Polygyros local survey: Respondents seem to be well-informed about the risks of uncontrolled landfilling provided that almost all (i.e. more than 96.5%) state that the specific waste disposal practice is associated with significant problems.
Social	Perception of the state of the environment	% of people	**74%**	Polygyros local survey: As regards the environment in their area, around 74% declare that they are somewhat or very dissatisfied.
Social	Willingness to support landfill mining	% of people	**24%**	The Indicator is provided by the WTP analysis from the findings of the local survey of Polygyros
Socioeconomic	Direct employment generaton	0,038 person-months per m^3 of waste	**1482 person-months**	Estimated by the total relevant scientists and workers involved in Tasks B5 and B6 during the landfill mining process in the Polygyros Landfill.
Socioeconomic	Indirect employment generation	0,06 person-months per m^3 of waste	**2340 person-months**	Estimated by direct employment and number of garbage trucks of the area, maintenance workers, etc. & suppliers of goods and services involved in Tasks B5 and B6 during the landfill mining process