

INTRODUCTION TO ELFM

The lesson plan introduces students to the concept of Enhanced Landfill Mining (ELFM) and encourages them to think of valorisation opportunities for waste.

LESSON OBJECTIVES

Students will be able to:

- Define key waste vocabulary
 - List common waste streams found in landfills
 - Discuss key waste valorisation options
 - Explain the benefits of ELFM
-

SUMMARY OF TASKS

PART 1 – INTRODUCTION TO LANDFILLS

- Start with asking students to research the closest landfill to them
- Introduce the students to landfills and ELFM from the 'Introduction to ELFM' fact sheet
- Complete 'Waste Vocabulary' activity sheet – *this activity could be done using a Kahoot style quiz*
- Watch 'The Missing Link of the Circular Economy 2.0' video¹ (2 mins)

PART 2 – WHAT RESOURCES ARE IN LANDFILLS?

- Split into groups and ask students to discuss: (1) What materials are in landfills? (2) How they get there? Answers are in the fact sheet
- Ask students to write their answers on post-it notes and feedback to the group

PART 3- VALORISATION OPTIONS

- Discuss the terms 'Waste to Energy' and 'Waste to Materials' using the fact sheet
 - Complete 'Waste Valorisation Routes' activity sheet and discuss possible end products
 - Follow-up discussion about benefits of ELFM and key valorisation opportunities
-

RESOURCES/ EQUIPMENT

- 'Introduction to ELFM' fact sheet
- 'Waste Vocabulary' activity sheet
- 'Waste Valorisation Routes' activity sheet
- Access to a computer/phone

HOMEWORK/ EXTRA ACTIVITIES

- Research different case studies and examples of ELFM using resources on the accompanying fact sheet
-

¹ <https://h2020-crocodile.eu/2020/04/15/new-video-the-missing-link-of-the-circular-economy-2-0/>

FACT SHEET: INTRODUCTION TO ELFM

FACT SHEETS HAVE BEEN DESIGNED FOR TEACHER USE TO AID CREATING OF TEACHING RESOURCES, OR THEY ARE FREE TO BE REPURPOSED FOR STUDENT USE.

PART 1 – INTRODUCTION TO LANDFILLS

The UK has around 22,000 landfills, and in Europe there are estimated to be up to 500,000 landfill sites.² Each year up to 95% of worldwide municipal solid waste produced is sent to landfill and this has some devastating effects on the environment.³

Landfills in Europe

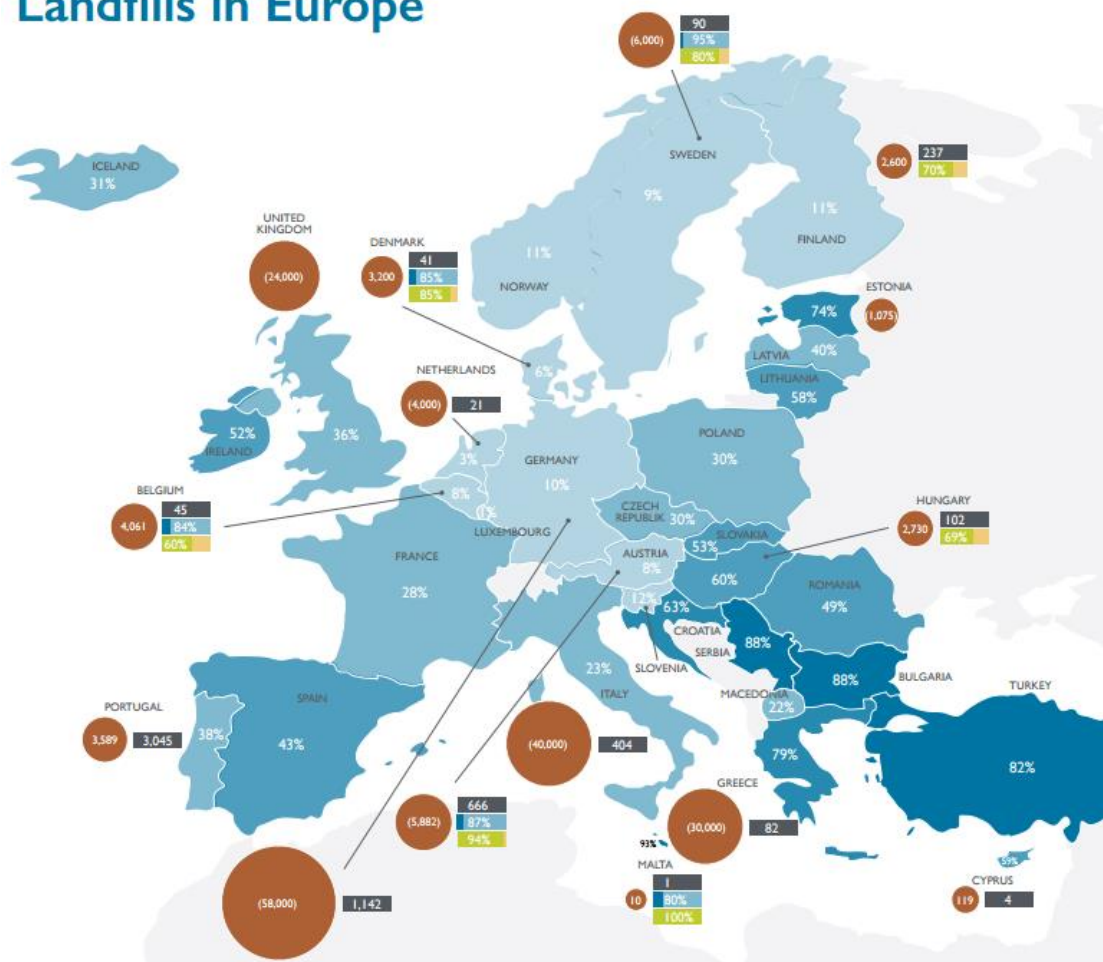


Figure 1: Landfill sites in Europe: Image from EURELCO⁴

² Detritus, 2018, 5, 105-110.

³ M. Rev. Environ. Sci. Biotechnol. 2015, 14, 93-122.

⁴ <https://eurelco.org/2018/09/30/data-launched-on-the-landfill-situation-in-the-eu-28/>

Enhanced Landfill Mining

Age range: 11-18 years

Landfills contribute to pollution in the form of greenhouse gases and toxic leachate (rainwater residue that's washed through the landfill) and take up a lot of physical space, which destroys habitats. They also affect public wellbeing as they can often be an eyesore and have a foul stench.

However, landfills are huge untapped resources and there is an opportunity to recycle and recover secondary raw materials from them which can reduce our dependence on finite resources. This is Enhanced Landfill Mining (ELFM).

ELFM has been defined by EURELCO (European Enhanced Landfill Mining Consortium) as “the safe exploration, conditioning, excavation and integrated valorisation of (historic, present and/or future) 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”.⁵

PART 2 – WHAT RESOURCES ARE IN LANDFILLS?

Landfill waste consists of:

- Organic waste (soil/food/gardening)
- Paper and cardboard
- Textiles
- Plastics
- Metals
- Wood
- Glass
- Inerts (bricks/stones)

Landfill sites contain both household rubbish (municipal solid waste, MSW) and commercial waste. MSW is mostly food, paper, cardboard or wood. The amount of plastic and tin packaging waste sent to landfill has decreased due to recycling schemes. Commercial waste is mostly soil, concrete and brick and is said to be inert because it does not react with other waste in the landfill.⁶

PART 3 – VALORISATION OPTIONS

Many finite resources are buried in landfills including secondary raw materials, critical raw materials and rare earth metals. By recovering these resources and selling them back into the market, the dependence on virgin materials is decreased and waste is reintroduced into material cycles which is in line with a Circular Economy. This is the definition of Waste to Materials (WtM).

Waste to Energy (WtE) is a form of energy recovery. Energy is generated from the incineration of less valuable, carbon-containing waste streams.⁷

⁵ Detritus, 2019, 8, 141-156.

⁶ <https://www.eastsussex.gov.uk/environment/rubbishandrecycling/landfill/whatarethey/>

⁷ P. Nuss, S. Bringezu and K. H. Gardner, ed. A. Karagiannidis, Springer London, London, 2012, pp. 1–26.

Enhanced Landfill Mining
Age range: 11-18 years

There are many options for waste valorisation, some of which are more practical than others. Generally, landfill mining separates waste into directly recyclable materials (glass, plastics and metals) and materials to produce energy. However, new plasma gasification technology has shown it is possible to also produce high-added-value products from organic waste.⁸

ADDITIONAL RESOURCES

- <http://new-mine.eu/>
- https://new-mine.eu/wp-content/uploads/2018/09/Poster_NEW-MINE.pdf
- <https://www.ft.com/content/0bf645dc-d8f1-11e7-9504-59efdb70e12f> - REMO site case study
- <https://h2020-crocodile.eu/2020/04/15/new-video-the-missing-link-of-the-circular-economy-2-0/> - Introductory video

⁸ <https://www.weforum.org/agenda/2017/06/landfill-mining-recycling-eurelco/>

ACTIVITY 1: WASTE VOCABULARY

Instructions

Please see the web page for more information about Enhanced Landfill mining.

This activity introduces key waste vocabulary that are related landfill mining.

This activity is intended to be used alongside the 'Introduction to ELM' lesson plan but could be adapted to use as a stand-alone activity.

Task

Ask students to match up the waste vocabulary word card with the definition card.

Can then discuss to ensure that students understand all of these words.

This activity can also be completed as a Kahoot style quiz.

If you are based in a classroom

Use this activity as a starter for the lesson to ensure the students understand the vocabulary that will be used throughout the lesson. Once the students have matched up the cards this can lead to a discussion about the words - e.g. give examples of some secondary raw materials

If you are doing this activity stand-alone

Use the 'Introduction to ELM' fact sheet to introduce the concepts of landfill mining and waste valorisation. Ask the students to match up the cards and then discuss the meaning of each word.

Waste vocabulary	Definition
Waste to energy (WtE) incineration	The burning of waste streams to produce energy
Landfill	The disposal of waste material by burying it
Enhanced landfill mining	The extraction of valuable materials from landfills which can be valorised
Waste valorisation	Any industrial processing of waste to produce useful products or sources of energy
Waste	A material or substance that is no longer wanted and is disposed of
Waste to material (WtM)	The waste is processed to produce materials of value
Secondary raw materials	Recycled materials that can be used in manufacturing processes alongside raw virgin materials
Leachate	Liquid that passes through a landfill and has suspended matter in it
Municipal solid waste (MSW)	Everyday household rubbish

ACTIVITY 2: WASTE VALORISATION ROUTES

Instructions

Please see the web page for more information about Enhanced Landfill Mining.

This activity is intended to prompt discussion around valorisation options for waste materials found in landfills.

This activity is intended to be used alongside the 'Introduction to ELFM' lesson plan but could be adapted to use as a stand-alone activity.

Task

Ask students to choose a valorisation route for each waste stream (WtE, WtM or both) and think of possible end products using the blank activity sheet.

Discuss students' thoughts and the examples given on the completed activity plan.

If you are based in a classroom

Once the students have thought of end products for each waste stream this can lead to a discussion about the practicalities of each suggestion.

Can discuss/research more into the current valorisation options that industries are looking at.

If you are doing this activity stand-alone

Discuss the terms WtE and WtM and ask the students to fill out the table for each waste stream, perhaps using the internet for research.

Follow-up discussion about end product ideas and could look into what current industries are doing as a research activity.

Enhanced Landfill Mining
 Age range: 11-18 years

Waste fraction	Valorisation route	End product
Glass	WtM	Materials for construction
Plastics	WtE and WtM	Thermal decomposition to energy and plastic monomers which can be reprocessed
Organics	WtE	Electricity
Textiles	WtE and WtM	Hydrolysis to recover sugar and polyester (PET) for material reuse; electricity
Paper	WtE	Electricity
Metals	WtM	Valuable secondary raw materials - construction of bridges/roads, manufacture of cars/wind turbines
Wood	WtE	Electricity
Soil	WtM (Reuse)	Fertiliser, compost, topsoil

Enhanced Landfill Mining
Age range: 11-18 years

Waste fraction	Valorisation route	End product
Glass		
Plastics		
Organics		
Textiles		
Paper		
Metals		
Wood		
Soil		