INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

deep

Sustainable solid waste management (SWM) framework

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GIRUS (2005-2007)

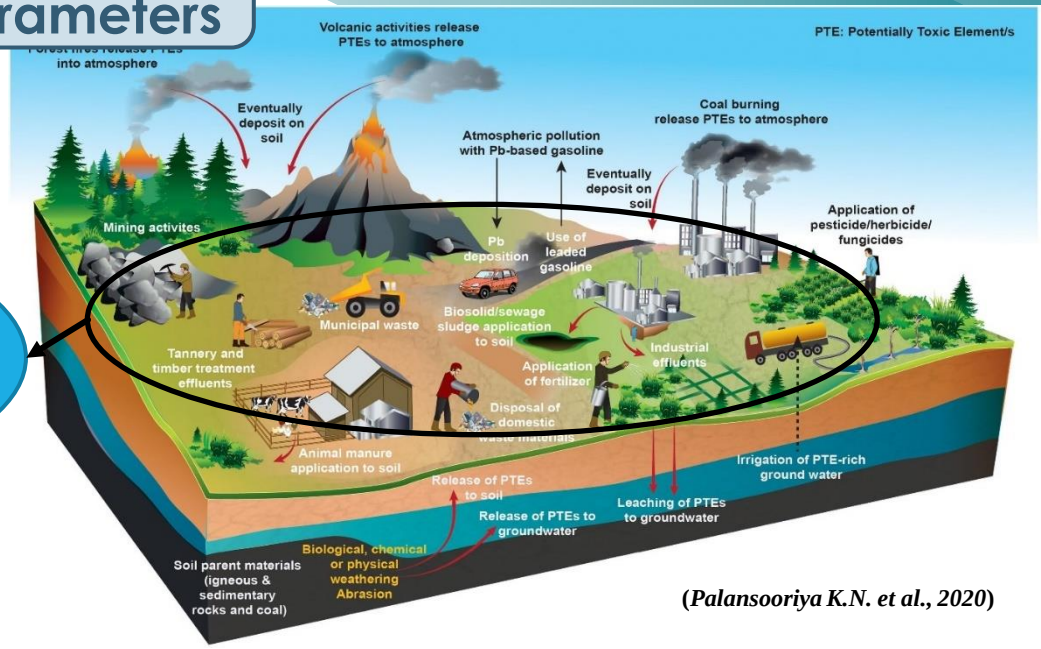
Laboratoire DEEP (Déchets, Eau, Environnement et Pollutions - Wastes Water Environment Pollutions)

Environmental engineering in the age of Anthropocene

≠ scenarios

≠ bio-physico-chemical parameters

Fate and management of complex polluted environments



(*Palansooriya K.N. et al., 2020*)

Limiting environmental impact

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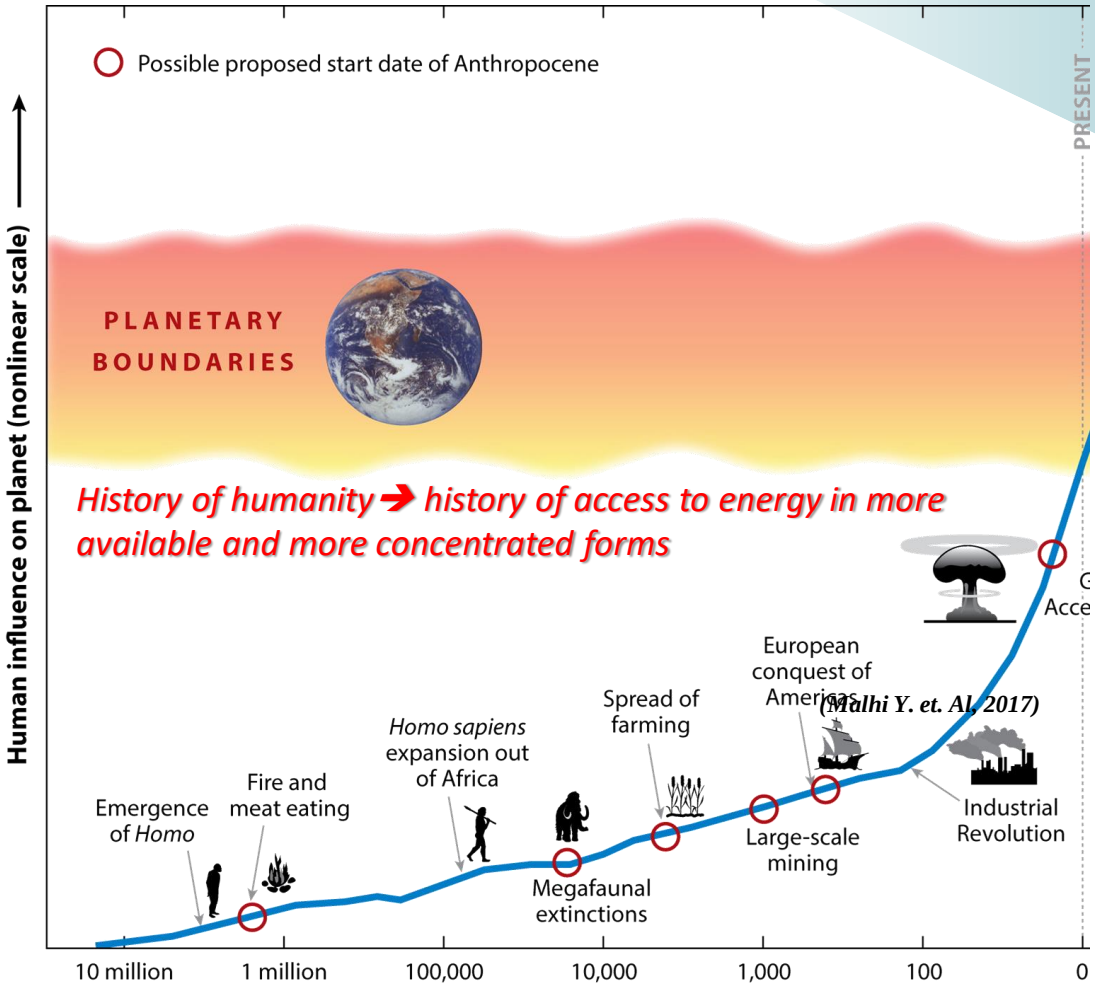
PREAMBULE

« ***Anthropocene [...] marks the collision of the planet's history with that of the humanity that occupies it.*** »

[Atlas de l'Anthropocène, p. 11, F. Gemenne, A. Rankovic, atelier de cartographie de Sciences Po, presses de Sciences Po, 2019]



This **increased use of energy** is leading to:

- **Disrupting the Earth's major biogeochemical cycles**;
- **Depleting the various "stocks" of living organisms;**
- **Generate a considerable amount of waste (3.8 Gt of waste/year for OECD countries alone, according to UNEP in 2015)**.

326 Mt de déchets produits en France, en 2017

PREAMBULE

DEBATS • LES DESSOUS DES DECHETS

Comment les déchets ont envahi tous les milieux : la folle histoire du « poubellocène »

Par Claire Legros

Publié le 02 février 2024 à 18h15, modifié le 03 février 2024 à 15h06

Lecture 12 min.

Article réservé aux abonnés

Ajouter à vos sélections

ENQUÊTE | **Alors qu'ils n'existaient pas jusqu'à la fin du XIXe siècle, les déchets ont colonisé le vivant. Au-delà des défis techniques qu'ils soulèvent, ils sont devenus un terrain d'enquête pour les sciences humaines, qui s'attachent à éclairer les systèmes et les mythes à la source de leur production.**

How waste has spread to every environment: the crazy story of "wastocene"

PREAMBLE

What do you know about waste ?

Waste fresk

Objective: the aim of group work is to enable students to understand their daily consumption of resources and its ecological impact through the prism of waste..

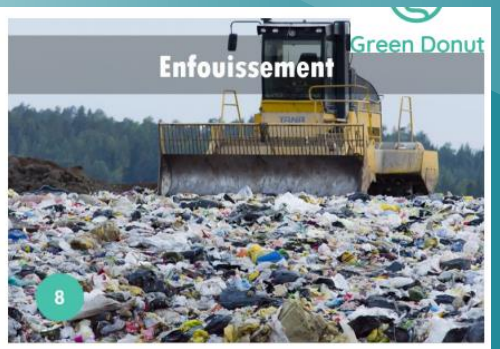
How it works: following the model of the climate fresk, participants are handed a series of cards to link together in a logic of causality and the transfer of material and waste flows.

PREAMBLE

Lot 1 : (**10 min**)

- Environmental consequences of everyday products and the main ways in which we process our waste, highlighting the benefits of composting.

- Example of negative consequences: for 1 ton of incinerated waste, 180 kg of bottom ash, 30 kg of REFIOM and 11 kg of metals are produced.



PREAMBLE

Lot 2 (15 minutes)

Our products BECOME waste through our decisions (card 4)

- Extended Producer Responsibility (EPR): Principle that assigns producers the responsibility of managing the waste generated by their products at the end of their useful life. (Cf. lecture)

- Methanization is a natural process that can be industrialized to transform OM into gas and fertilizer.

- 40% of our waste consists of packaging

PREAMBLE

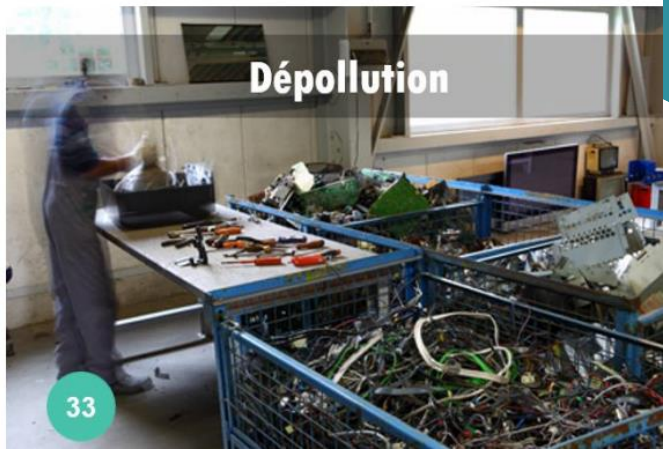
Waste fresk

Lot 3 (15 minutes)

- Breakdown of our household waste: 35% paper and packaging, 27% organic waste, 5% dedicated waste, 14% sanitary textiles, 19% other waste.

- 68% of household waste is incinerated

- Recycling prevents the emission of 23 million tons of CO_2 in comparison with the use of raw materials (*source: Citeo*).



PREAMBLE

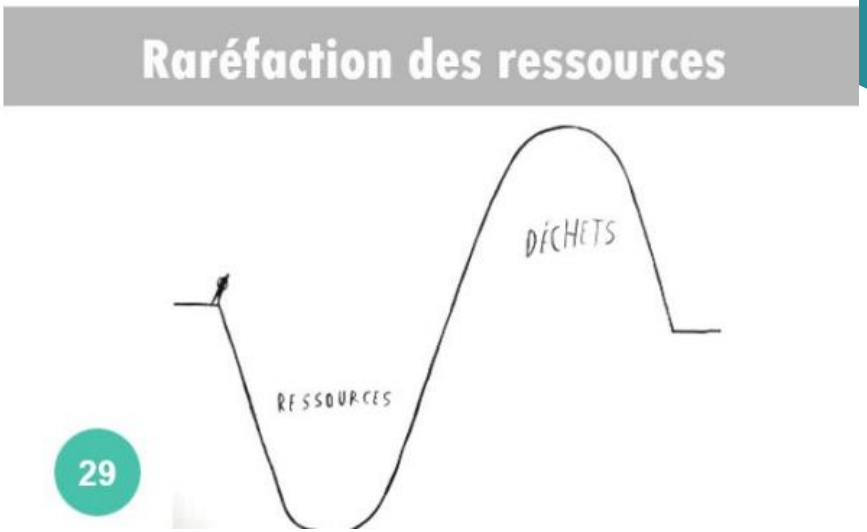
Waste fresk

Lot 4 (10 minutes)

- **Smartphone-induced pollution:** Pollution + resource depletion

- Europe produces 30 million tons of plastic waste a year, of which only 17% is reused or recycled.

- Resource depletion: by 2025, 1.8 billion people will be living in countries or regions with absolute water poverty. Water is used in mineral extraction processes.



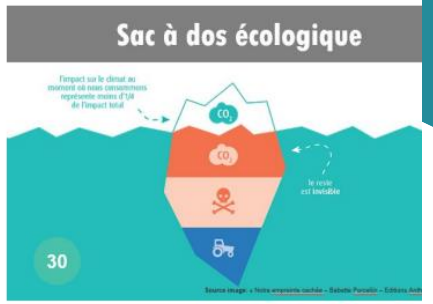
PREAMBLE

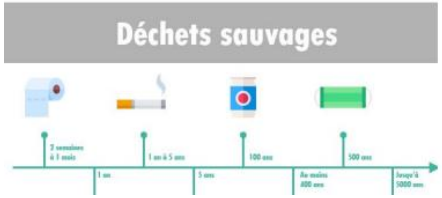
Waste fresk

Lot 5 (10 minutes)

- **Littering in France:** every year, the equivalent in weight of 6 Eiffel Towers (63,000 tons) is dumped in the countryside, representing 5% of all our annual waste.

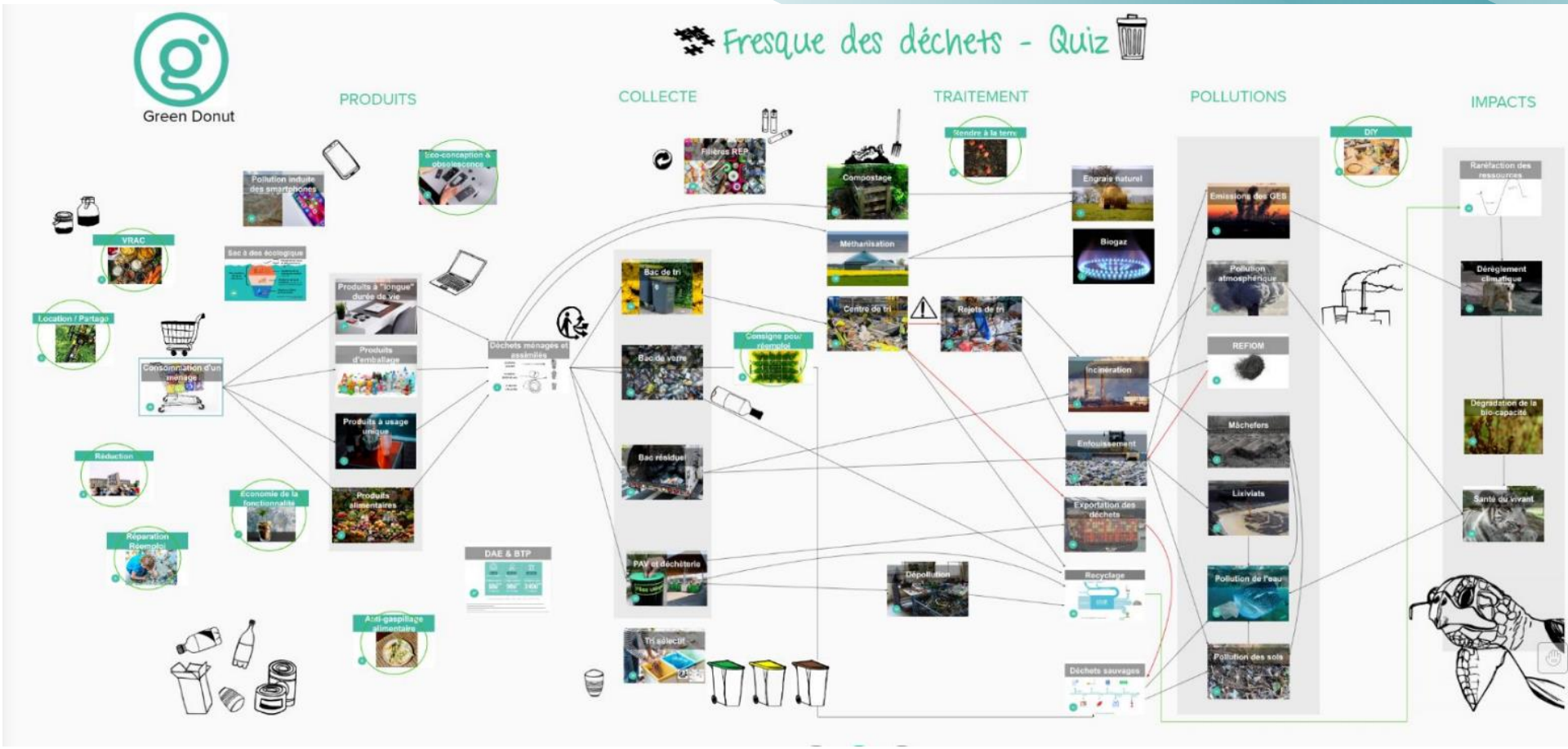
- **Difference between the Ecological Backpack and LCA:** The Ecological Backpack is a simple calculation of the weight of materials used in the production of the final product. LCA is a comprehensive analysis that measures the environmental impact on several aspects (depletion of abiotic resources, soil and water acidification...).





PREAMBLE

Waste fresk



LECTURES OVERVIEW

- **Introduction - Waste system**
- Classification and current legislation
- Sustainable waste management

INTRODUCTION

Watch this video to learn SWM is a universal issue that requires immediate attention

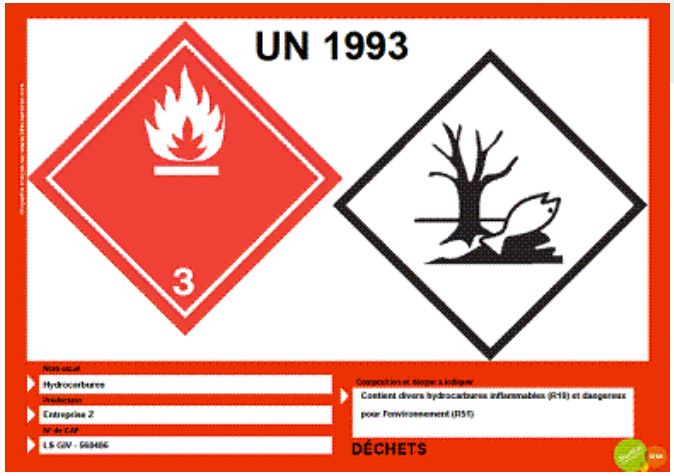
(OLC) Open Learning Campus

Waste is growing and it makes sense to manage it properly. In an era of rapid urbanization and population growth, waste management is a critical component of sustainable, healthy and inclusive cities and communities.

INTRODUCTION

- **No satisfactory waste definition**.
- **Depending on the actors involved and the context to which we refer, the notion of waste may cover objects of different natures and functions.**
- **Each definition aims to establish, for a given stakeholder group, the set of targets that must be met with particular behavior or attention, but it is ultimately the legal definition that must serve as a reference.**

INTRODUCTION



Regulatory approach

Code de l'environnement : Art L 541-1 (15 juillet 1975)

« For the purposes of the present law, "waste" means any residue of a production, transformation or use process, any substance, material, product or, more generally, any movable resource discarded or intended for discarding by its holder ».

European Directive of March 18, 1991

INTRODUCTION

Business approach

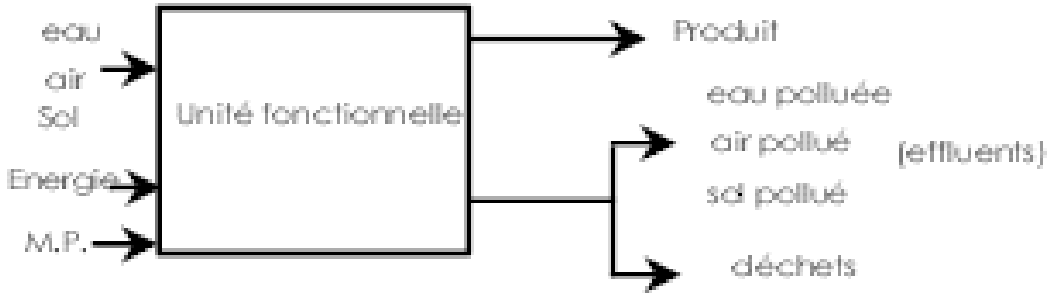
« In business terms, waste is a material or object whose economic value is zero or negative for its holder at a given time and place ».

« This definition **excludes a large proportion of recyclable waste**, which has even a small economic value. Some manufacturers may therefore be led to believe that certain types of waste are by-products, in order to avoid the law ».

INTRODUCTION

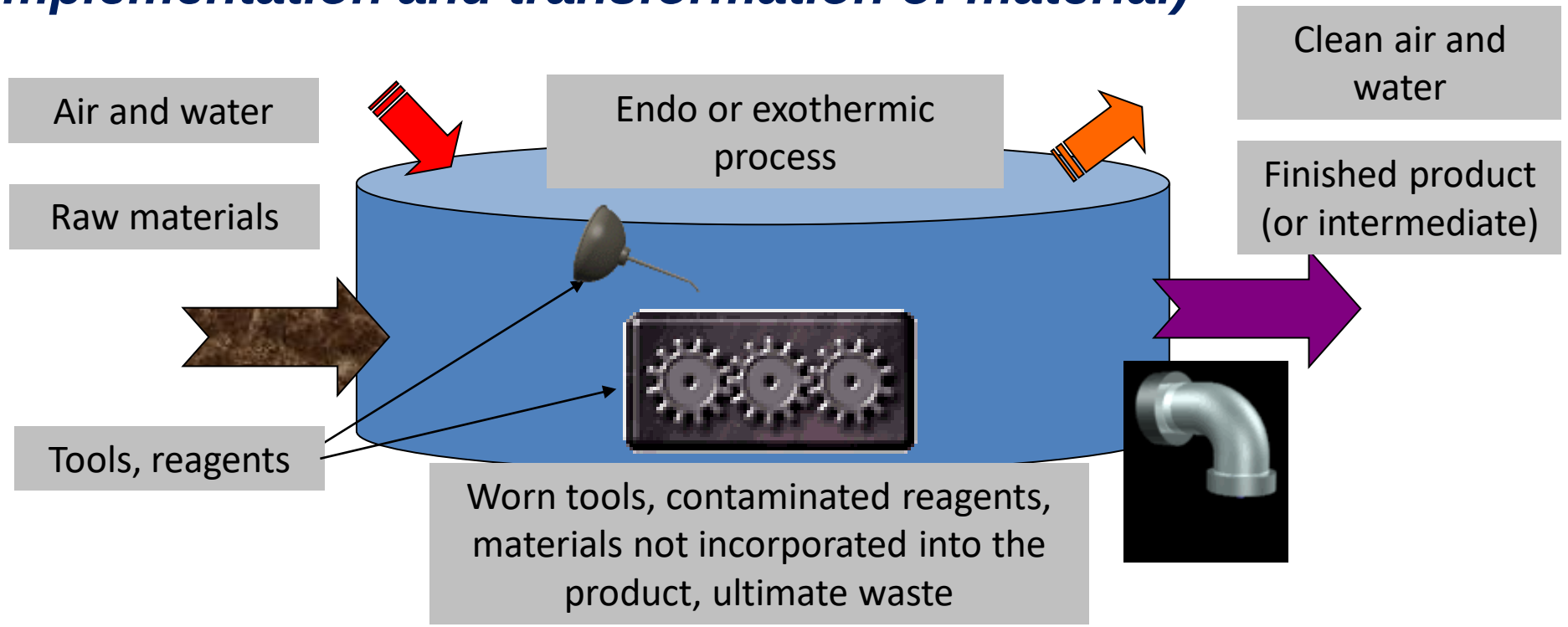
Functional approach

« Waste is then considered as a flow of material from a functional unit, representing an activity or set of activities »



WASTE SYSTEM

Nature of waste : Concept of reactor (unitary operation of implementation and transformation of material)



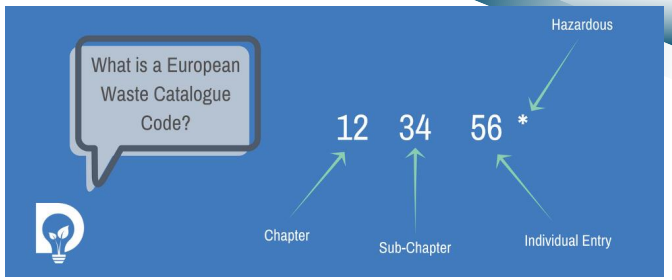
- **Waste vs Effluents**
  - Effluents : continuous production via a liquid or gaseous outfall (sewer, chimney, etc.)
  - Waste : batch production (solids or liquids, rarely gaseous)
  - Common characteristic: composition and characteristics not voluntarily controlled by the process (difference with co-product)

WASTE SYSTEM

Nature of waste : Concept of reactor (unitary operation of implementation and transformation of material)

Most industrial systems evolve towards this scheme ideal which favors the choice of materials, savings of energy and material, develops recycling, minimizes use dangerous substances ... any strategy that we found in what is now commonly called ecology industrial.

CLASSIFICATION OF WASTE



A large variety of definitions and classification approaches are used.
Defining waste can at times also be a case-by-case decision.
The national waste regulation is the main reference point in this regard.

Waste can be characterized (and classified) by its nature, but also by its producer, its method of collection, the organization that supports it, or a mix of these concepts.

Classification according to the waste producer

- **"household waste", the initial producer of which is a household**;
- **"waste from economic activities" (DAE), the initial producer of which is not a household.**

CLASSIFICATION OF WASTE

Classification of waste by origin

Source: National Audit Office of Estonia

CLASSIFICATION OF WASTE

Classification according to waste nature

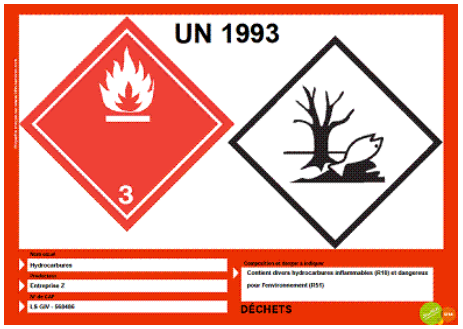
Here are two main categories of waste according to the risk they pose to humans or the environment.

- **hazardous waste** ;

- **non-hazardous waste** (paper, plastics, metals, organic waste…)**.**

In this last category, we also distinguish **inert waste**, which is neither chemically nor biologically reactive and will not decompose or only very slowly.

CLASSIFICATION OF WASTE



Hazardous waste - Generalities

Hazardous waste induces risks to both people and the environment. They must therefore be the subject of special precautions. As with other waste, the **priority is to reduce their quantity and their harmfulness**.

Regulation and classification of hazardous waste

Content in variable quantities, toxic or hazardous elements presenting **risks to human health and the environment** (article R. 541-8 of the environment code: *).

Whatever their origin or the quantity produced, **classified as dangerous** if it has **1 or more of the 15 hazardous properties listed in Appendix I** (Art. R. 541-8 EC).
They can be **organic** (solvents, hydrocarbons...), **mineral** (acids, metal hydroxide sludges...) or **gas**.

With around **11 million tons**, hazardous waste represents **3% of the waste produced in France**. The **mixing of hazardous waste is prohibited**, except by exemption (Art. R. 41-7-2 EC).

CLASSIFICATION OF WASTE

Hazardous waste – List of hazardous properties

H1	"Explosive": substances and preparations which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene.
H2	"Oxidising": substances and preparations which exhibit highly exothermic reactions when in contact with other substances, particularly flammable substances.
H3A	"Highly Flammable" - liquid substances and preparations having a flashpoint of below 21°C (including extremely flammable liquids), or - substances and preparations which may become hot and finally catch fire in contact with air at ambient temperature without any application of energy, or - solid substances and preparations which may readily catch fire after brief contact with a source of ignition and which continue to burn or to be consumed after removal of the source of ignition, or - gaseous substances and preparations which are flammable in air at normal pressure, or - substances and preparations which, in contact with water or damp air, evolve highly flammable gases in dangerous quantities.
H3B	"Flammable": liquid substances and preparations having a flashpoint equal to or greater than 21°C and less than or equal to 55°C.
H4	"Irritant": non-corrosive substances and preparations which, through immediate, prolonged or repeated contact with the skin or mucous membrane, can cause inflammation.

H5	"Harmful": substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may involve limited health risks.
H6	"Toxic": substances and preparations (including very toxic substances and preparations) which, if they are inhaled or ingested or if they penetrate the skin, may involve serious, acute or chronic health risks and even death.
H7	"Carcinogenic": substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce cancer or increase its incidence.
H8	"Corrosive": substances and preparations which may destroy living tissue on contact.
H9	"Infectious": substances containing viable micro-organisms or their toxins which are known or reliably believed to cause disease in man or other living organisms.
H10[2]	"Toxic for reproduction": substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may produce or increase the incidence of non-heritable adverse effects in the progeny and/or of male or female reproductive functions or capacity.
H11	"Mutagenic": substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce hereditary genetic defects or increase their incidence.
H12	Substances and preparations which release toxic or very toxic gases in contact with water, air or an acid.
H13	Substances and preparations capable by any means, after disposal, of yielding another substance, e.g. a leachate, which possesses any of the characteristics listed above.
H14	"Ecotoxic": substances and preparations which present or may present immediate or delayed risks for one or more sectors of the environment.
HP 15	'Yielding another substance': waste capable of exhibiting a hazardous property listed above not directly displayed by the original waste.

CLASSIFICATION OF WASTE

Hazardous waste - Particularities

Most hazardous waste originates from industrial production.

• **E-waste** : from electric and electronic equipment such as end-of-life computers, phones and home appliances. (PCB, metals…).

• **Medical waste** : from the human and animal healthcare systems (medicines, chemicals, pharmaceuticals…). It could be infectious, toxic or radioactive or contain bacteria and harmful microorganisms.

• **Radioactive waste**, with a special management and regulation.

CLASSIFICATION OF WASTE

Altogether, the European Union produces up to 3 billion tons of waste every year.

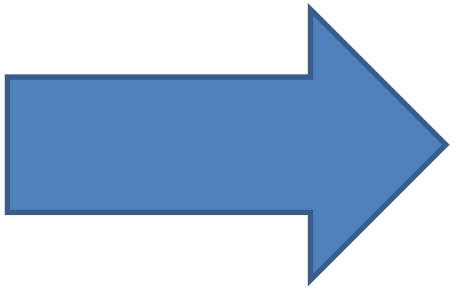
GENERAL STRATEGY OF WASTE MANAGEMENT

Paradigm shift from Waste Management to Resource Management

20th CENTURY

WASTE MANAGEMENT

"How do we get rid of our waste efficiently with minimum damage to public health and the environment?"



21st CENTURY

RESOURCE MANAGEMENT

"How do we handle our discarded resources in ways which do not deprive future generations of some, if not all, of their value?"

LECTURES OVERVIEW

- Introduction - Waste system
- **Classification and current legislation**
- Sustainable waste management

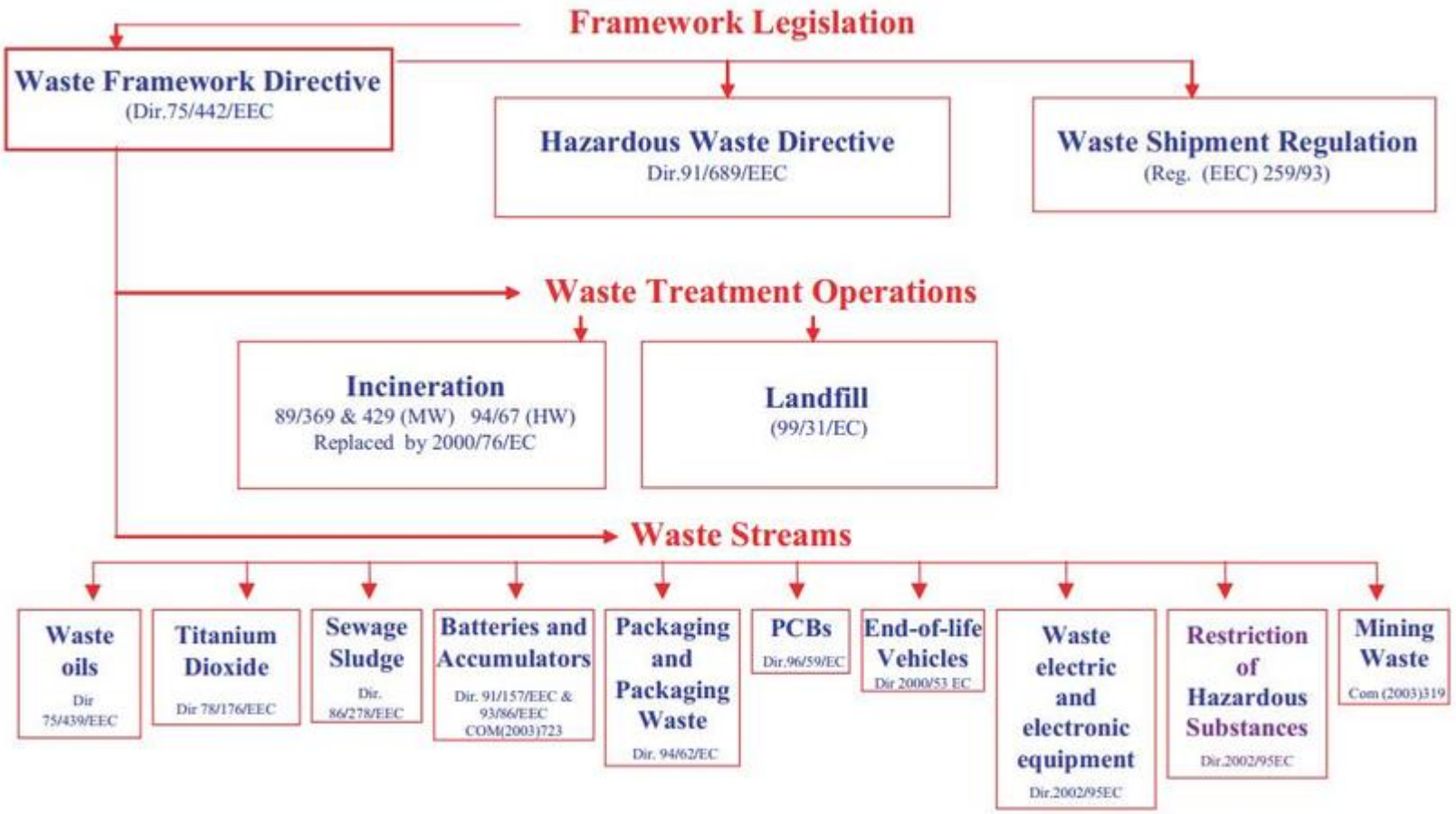
PREAMBLE

How to deal with Europe's waste?

https://youtu.be/ufL3yDs1ZQ8

Europe needs to reduce landfills and food waste, handle and recycle packaging waste better : these are the main goals of the "Waste Package" to be adopted by the European Parliament in Strasbourg.

EC WASTE LEGISLATION



– **horizontal** legislation;

– legislation on **waste treatment operations**;

– legislation on **specific waste streams**.

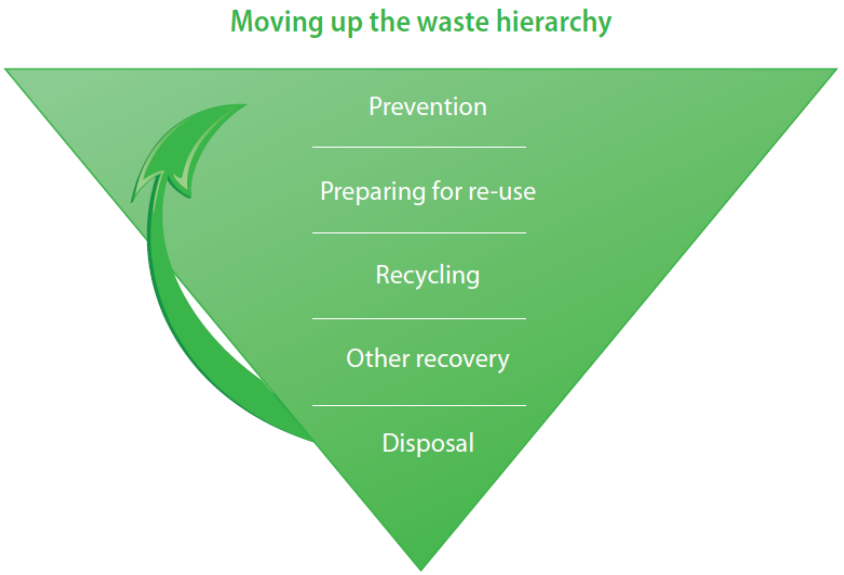
HORIZONTAL LEGISLATION

Horizontal legislation establishes the overall framework for the management of waste.

Council **directive 75/442/EEC of 15 July 1975 on waste** (the "**waste framework directive**" or **WFD**) includes the main definitions and principles concerning waste management. It was comprehensively revised in 1991, 1996 and again in 2008 and finally in 2018 (**Directive (EU) 2018/851**).

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.150.01.0109.01.ENG

WASTE FRAMEWORK DIRECTIVE



In essence, the WFD requires Member States to give priority to

- **Waste prevention** and to
- **encourage re-use and recovery of waste**.

- Member States must also ensure that waste is recovered and disposed of **without endangering human health** and
- **without using processes or methods which could harm the environment.**

- The directive also requires Member States to draw-up **waste management plans** and to establish a system for the authorization of waste management installations.

WASTE FRAMEWORK DIRECTIVE

The WFD defines waste as "**any substance or object in the categories set out in Annex I which the holder discards or intends or is required to discard**." Annex I of the WFD lists 16 categories of waste.

This annex is now replaced by the **EWC** (**European Waste Catalog**)
Finally, the Waste Framework Directive (EU) 2008/98/EC (updated in 2018 - Directive (EU) 2018/851) sets criteria for By-products and End of Waste process

- ✓ *By-product is a substance or object, resulting from a production process, the primary aim of which is not the production of that item. By-products can come from a wide range of business sectors, and can have very different environmental impacts. An incorrect classification could be the cause of environmental damage or unnecessary costs for business.*

  Examples: lacto-serum in a cheese factory, beet pulp from the production of sugar, HCl in aqueous solution from the manufacture of lubricant additive, etc.

WASTE FRAMEWORK DIRECTIVE

What are the end-of-waste criteria, and why are they needed?

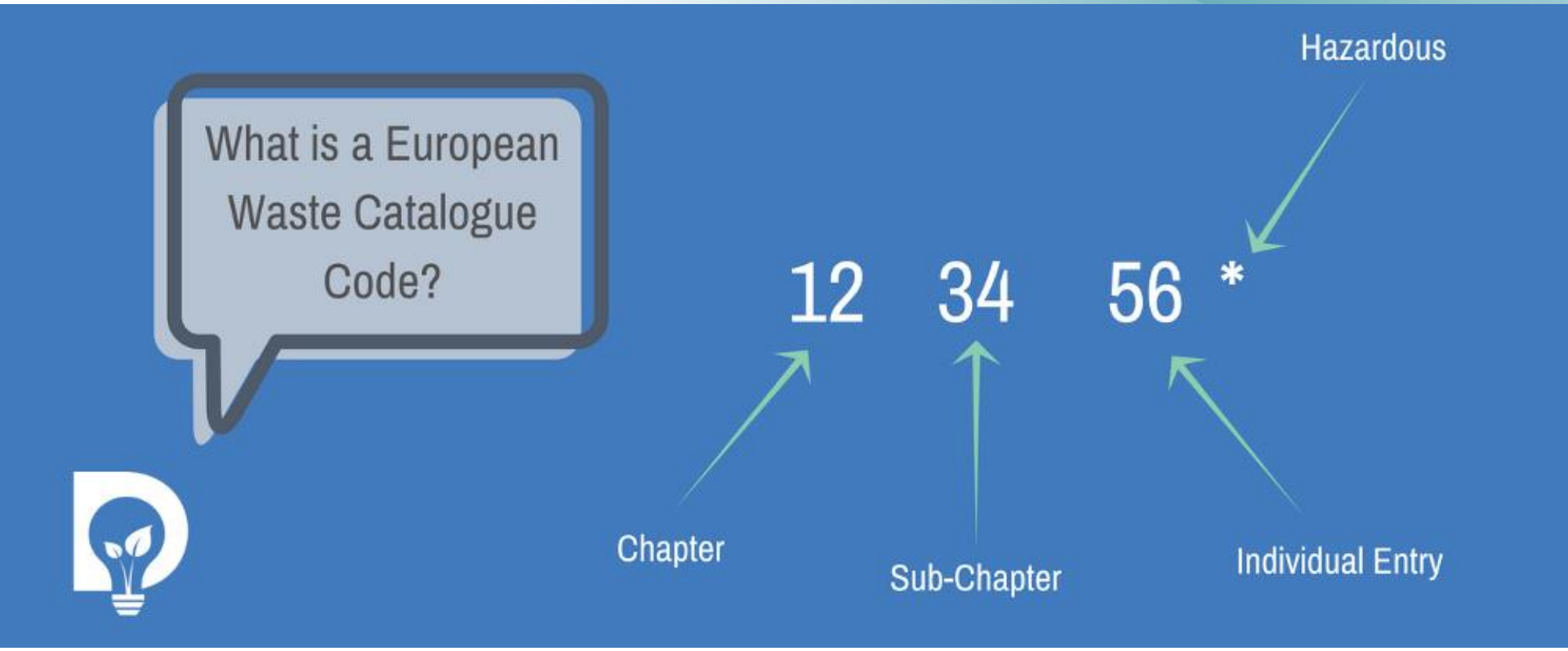
End-of-waste criteria specify when certain waste ceases to be waste and obtains a status of a product (or a secondary raw material).

According to Article 6 of the WFD 2008/98/EC, certain specified waste shall cease to be waste when it has undergone a recovery (including recycling) operation and complies with specific criteria to be developed in line with certain legal conditions, in particular:

- *the substance or object is commonly used for specific purposes;*
- *there is an existing market or demand for the substance or object;*
- *the use is lawful (substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products);*
- *the use will not lead to overall adverse environmental or human health impacts.*

Examples: a plywood panel made with a certain percentage of packaging wood chips, a fleece jacket made from waste plastic bottles ...

WASTE FRAMEWORK DIRECTIVE



An EWC Code is a 6-digit code used to identify waste as listed in the EWC. It is formatted as 3 pairs of numbers, for example 12 34 56.
It identifies and classifies waste into categories according to how these wastes have been produced. It adequately describes the waste being transported, handled or treated.

WASTE FRAMEWORK DIRECTIVE

What is the structure of the EWC Code?

Chapters

The EWC is divided into 20 chapters, numbered 01 to 20.

Some chapters are based on the type of industrial process or business activity that produced the waste. For example:

- ✓ ***Chapter 04: Wastes from the Leather, Fur and Textile Industries***

Other chapters are based on the type of waste. For example:

- ✓ ***Chapter 13: Oil Wastes and Wastes of Liquid Fuels (except edible oils, and those in chapters 05, 12 and 19)***

The titles of these chapters are important. The waste must fall within the scope of the title to be considered within it. Some titles, like that for chapter 13, also exclude certain wastes from that entire chapter.

WASTE FRAMEWORK DIRECTIVE

What is the structure of the EWC Code?

Sub-chapters

Most chapters contain several sub-chapters. These divide the chapter into sub-groups based on either industrial process and business activity, or type of waste..

Each sub-chapter is given another two-digit number (creating a four-digit number with the chapter number). For example:

- ✓ ***Sub-chapter 04 02: wastes from the textile industry***
- ✓ ***Sub-chapter 13 01: waste hydraulic oils***

The sub-chapter title, like the chapter title, is also important.

WASTE FRAMEWORK DIRECTIVE

What is the structure of the EWC Code?

Individual entries

Within each sub-chapter are the classification codes for individual wastes.

These are given an additional two-digit number, to create a six-digit number with the chapter and sub-chapter numbers. For example

- ✓ ***04 02 16* dyestuffs and pigments containing hazardous substances***
- ✓ ***13 01 10* mineral based non-chlorinated hydraulic oils***

The description accompanying the code explains the scope of the code. It may do this in a variety of ways including references to the type of waste, the activity or process that produced it, its composition, or properties.

WASTE FRAMEWORK DIRECTIVE

What is the structure of the EWC Code?

The asterisk (*)

The asterisk (*) indicates that the waste is hazardous, however there are 2 types of hazardous waste entries in the catalogue:

- ✓ **"Absolute entries":**
  Those entries with an asterisk (*) and without a specific or general reference to "dangerous substances". Wastes covered under these entries are hazardous waste regardless of the concentration of any "dangerous substance" within the waste. "Absolute entries" are highlighted in red and marked with an "A".

- ✓ **"Mirror entries": Those entries with an asterisk (*) and with a specific or general reference to "dangerous substances", which are generally identified by the word "containing" in the description and have a corresponding entry without an asterisk (*). "Mirror entries" are highlighted in blue and marked with an "M".**

✓ *01 03 04* acid-generating tailings from processing of sulphide ore A*

✓ *01 03 05* other tailings containing dangerous substances M*

WASTE FRAMEWORK DIRECTIVE

Hazardous Waste Directive & Waste Shipment regulation

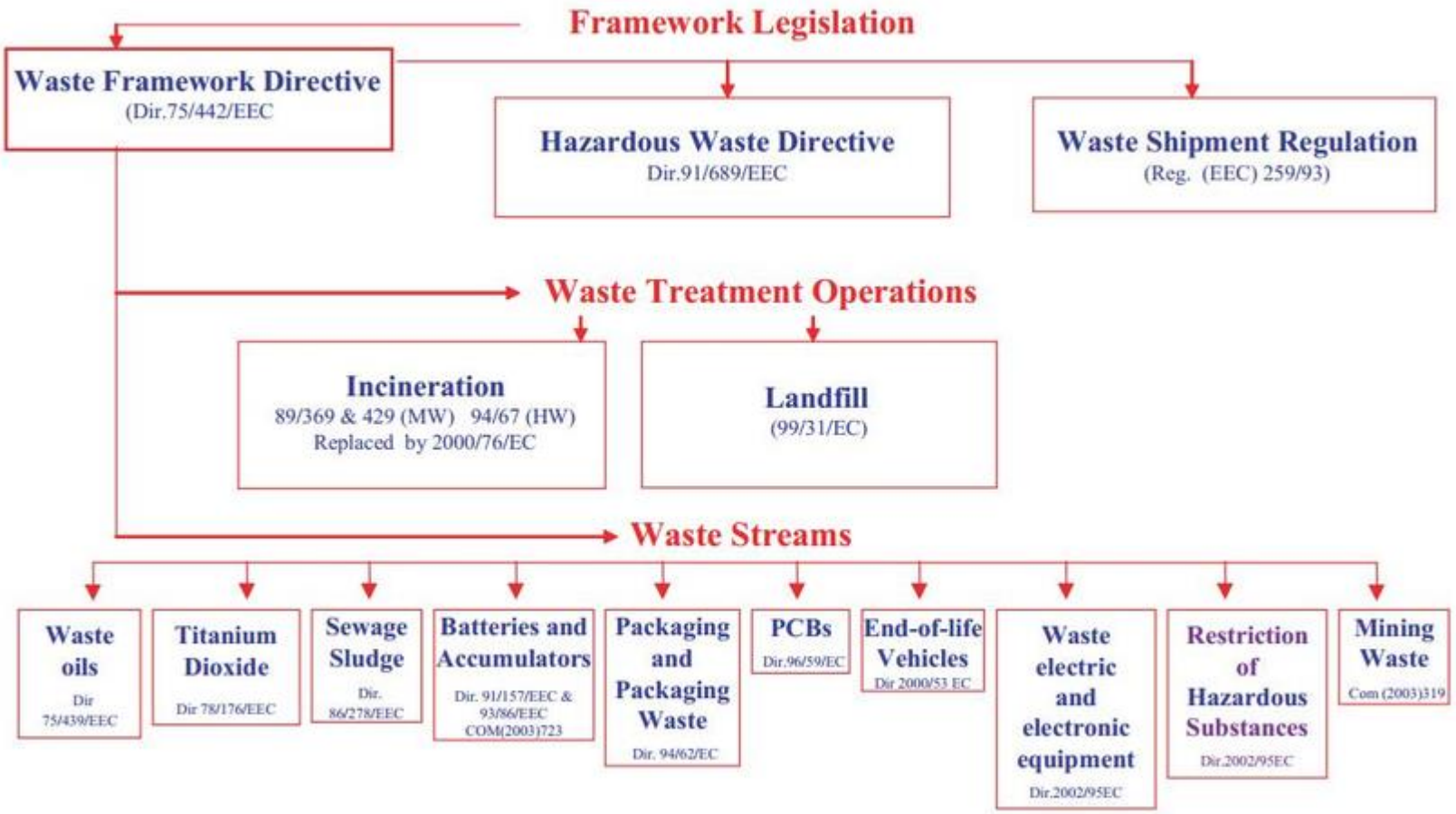
Council directive 91/689/EEC of 12 December 1991 on hazardous waste, as amended, complements the WFD for hazardous waste.
Annex III of the directive lists 15 properties of waste which render them hazardous within the meaning of the directive.

The directive also contains substantive requirements concerning, for example :

- ✓ the **permitting of installations handling hazardous waste**.
- ✓ **it contains additional requirements concerning**, for example,
  - **limitations of mixing** of hazardous waste,
  - **record keeping** and the **shipment of waste at national level**, which must be accompanied by a **tracking form**.

The Community has also adopted legislation concerning the **cross-border shipment of waste.** The main legal instrument in this field is **Council regulation (EEC) No 259/93 of 1 February 1993 on the supervision and control of shipments of waste** within, into and out of the European Community, as amended.

EC WASTE LEGISLATION



– horizontal legislation;

– legislation on waste treatment operations;

– legislation on specific waste streams.

LEGISLATION ON WASTE TREATMENT OPERATIONS

Landfill

Directive 1999/31/EC of 26 April 1999 on the landfill of waste ("the landfill directive") sets out a number of administrative requirements, including:

- **permit conditions**,
- **technical requirements** and **environmental standards** applying to landfills accepting various categories of waste (**inert, non-hazardous and hazardous waste**),
- **reduction of biodegradable waste** disposed of in landfills,
- **banning of the landfilling of certain types of waste**, such as liquid wastes, infectious waste and most tires.

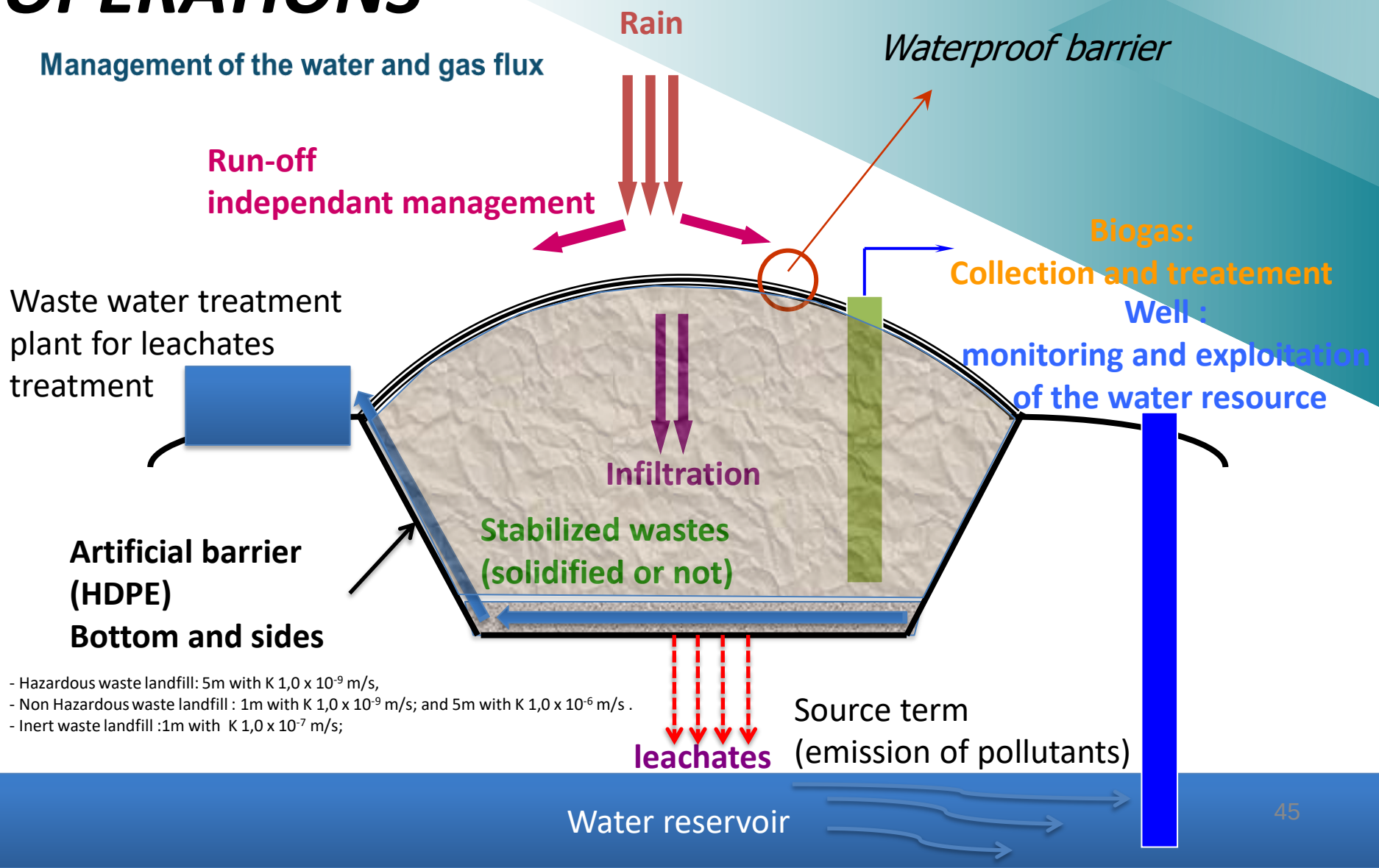
LEGISLATION ON WASTE TREATMENT OPERATIONS

Main principles to ensure environmental protection

The landfill directive also requires **all costs** relating to the **establishment, operation and closure of a landfill** are **internalized into the price charged by the operator**.

Description and illustration of **general criteria** for the Landfill Directive in order to protect the environment

LEGISLATION ON WASTE TREATMENT OPERATIONS



LEGISLATION ON WASTE TREATMENT OPERATIONS

Criteria for the limitation of the source term (via the leaching of waste prior to acceptance)

	L/S=10 l/kg dry matter in mg/kg			C_0 (essai de percolation) mg/l		
	inertes	non dangereux	dangereux	inertes	non dangereux	dangereux
As	0,5	2	25	0,06	0,3	3
Ba	20	100	300	4	20	60
Cd	0,04	1	5	0,02	0,3	1,7
Cr total	0,5	10	70	0,1	2,5	15
Cu	2	50	100	0,6	30	60
Hg	0,01	0,2	2	0,002	0,03	0,3
Mo	0,5	10	30	0,2	3,5	10
Ni	0,4	10	40	0,12	3	12
Pb	0,5	10	50	0,15	3	15
Sb	0,06	0,7	5	0,1	0,15	1
Se	0,1	0,5	7	0,04	0,2	3
Zn	4	50	200	1,2	15	60
Chlorures	800	15 000	25 000	460	8500	15 000
Fluorures	10	150	500	2,5	40	120
Sulfates	1 000,00	20 000	50 000	1500	7000	17 000
Indice phénols	1	-		0,3	-	
COT sur éluat **	500	800	1000	160	250	320
FS (fraction soluble)***	4 000	60 000	10 000	-	-	

10%

LEGISLATION ON WASTE TREATMENT OPERATIONS

The makeover of one of Europe's largest landfills

https://www.youtube.com/watch?v=c36kP3vp_kk

International Finance Corporation

LEGISLATION ON WASTE TREATMENT OPERATIONS

Incineration

Directive 2000/76/EC of the European Parliament and of the Council of December 2000 on the incineration of waste ("the incineration directive")

It replaces 3 older directives and thus consolidates the Community's legal requirements concerning :

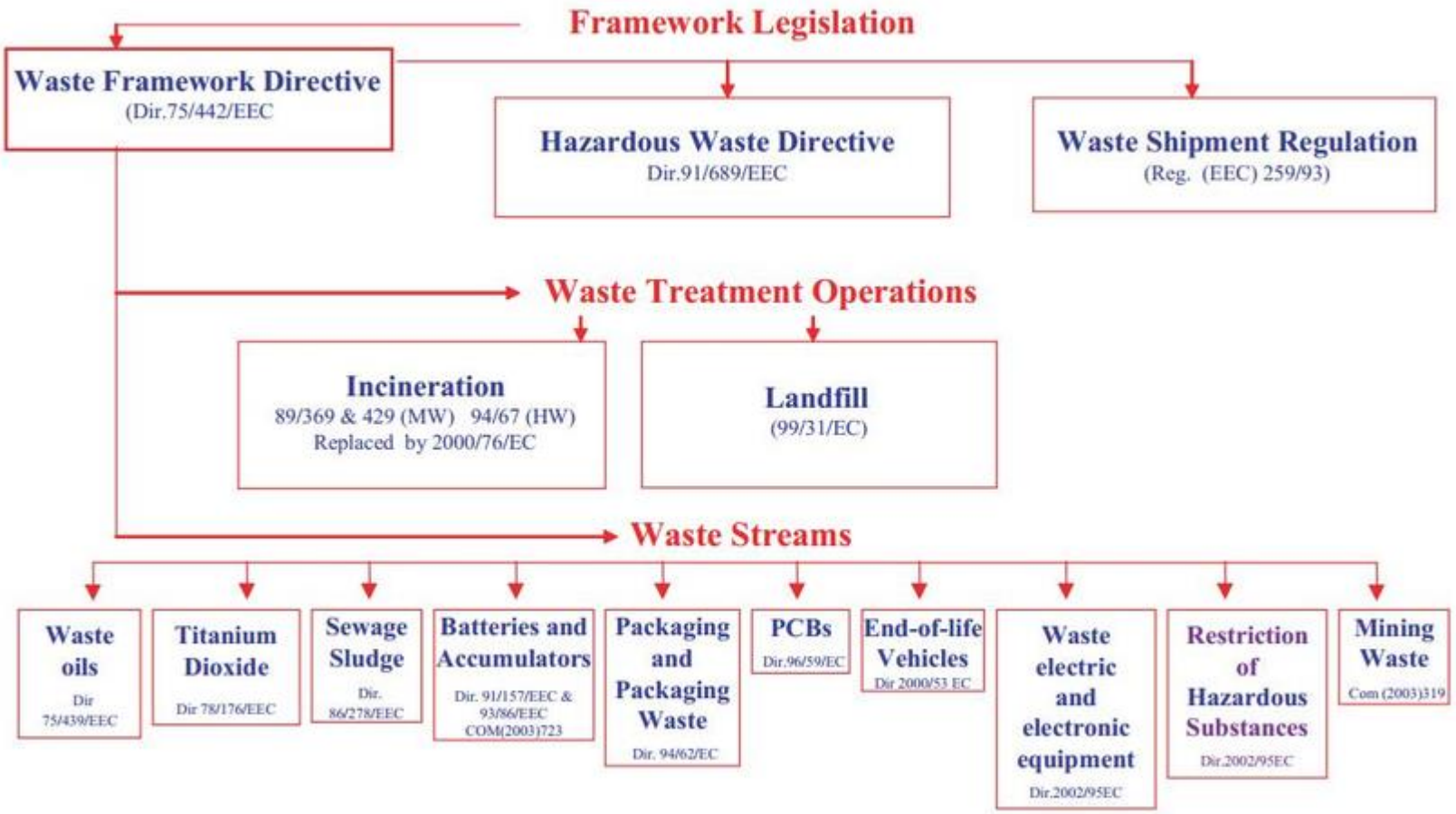
- **the incineration and co-incineration** of waste
- of **non-hazardous and hazardous waste**.

The directive establishes the **permitting conditions** for incineration plants, including under abnormal operating conditions, as well as limit values in relation to, for example, emissions to air and discharges to water.

The directive includes requirements concerning the **delivery and reception of waste** and concerning the management of **incineration residues**, including the requirement that when appropriate the residues be recycled.

Finally, it also includes requirements on **control, monitoring and measurement**.

EC WASTE LEGISLATION



- horizontal legislation;
- legislation on waste treatment operations;
- legislation on specific waste streams.

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THANK YOU FOR YOUR ATTENTION