Questions and Answers

related to co-processing

CEMBUREAU and its members proactively communicate on benefits of co-processing to communities and policy-makers at all levels from local to national to European.

This Q&A document aims at providing an easy to grasp overview of the industry's understanding of co-processing.

CO-PROCESSING

1. What is co-processing? Is this positive?

Background

Co-processing refers to the combination of simultaneous materials recycling and energy recovery from waste in a thermal process. This results in replacing natural mineral resources and fossil fuels such as coal and petroleum products. In 2017, the European cement industry has already used 46% fuels derived from waste and biomass in supplying the thermal energy to the clinker making process.

Specific to the cement industry

Co-processing of waste in cement kilns contributes to:

- The circular economy

  Co-processing allows material recycling to reduce the use of virgin materials in cement manufacturing.

- Improved waste management

  Co-processing can reduce the volume of waste that is being landfilled or incinerated, and uses its energy and material content in a very efficient manner. In that sense, it fits directly into the waste management hierarchy, set out in the EU Waste Framework Directive.

- Climate change mitigation

  The use of waste to replace virgin raw materials and fossil fuels, especially biomass from waste, forms one of the main levers for reduction of CO_2 intensity in cement manufacturing. In Europe, with substitution rates of 46% (achieved in 2017), the combined use of waste biomass and waste fossil fuels helped to avoid the emission of 20.1 Mt of CO_2. If the industry achieves a target substitution rate of 60%, the CO_2 emissions avoided will be 26 Mt.

2. What is the difference between waste incineration and co-incineration and between co-incineration and co-processing in a cement plant?

The main difference lies in the fact that the main purpose of cement plants is to produce cement whilst incinerators are dedicated facilities for the disposal of waste. As the processes are different, in its Article 3 (definitions), the Industrial Emissions Directive (IED) makes a distinction between:

- incineration plants which are dedicated to the thermal treatment of waste and may or may not recover heat generated by combustion; and
- co-incineration plants (such as cement or lime kilns, steel plants or power plants) whose main purpose is the production of material products or energy generation and in which waste is used as a fuel or is thermally treated for the purpose of disposal.

Co-processing is a type of co-incineration, unique to cement manufacturing, where waste is simultaneously used as both a source of energy and a source of mineral content in a single process. Additionally, it is a zero-waste solution.

The cement manufacturing process is highly energy efficient. For example, an extensive share of waste heat is recovered by drying the raw materials and fuels in the integrated grinding mills. According to the technical report "Evaluation of the energy performance of cement kilns in the context of co-processing" issued in November 2016, by the European Cement Research Academy (ECRA) the energy efficiency in the cement kilns varies between 70% to 80% depending on the raw materials moisture content.

In order to ensure a complete fuel burnout, the residence time of combustion gases has to be at least two seconds with a minimum temperature of 850°C. The typical residence time of combustion gases in the cement kiln main firing zone is more than five seconds at a temperature up to 2,000°C. In the second firing zone (calciner) residence time is also higher than two seconds with temperatures round about 1,000°C. Residence time for solid materials in cement kilns varies from 20 minutes to an hour depending on the cement process[1]. The clinker burning process – in contrast to other combustion processes (e.g. incineration plants) – consequently offers the best conditions for complete valorization of alternative fuels.

3. What are the investments needed by modern cement plants which co-process alternative fuels and raw materials?

- Closed systems for storing, transporting and dosing the alternative fuels
- Pre-treatment such as sorting, shredding, drying and homogenization of waste
- Automated sampling devices
- Purposely designed firing systems for the different fuels
- Modern dust filtering devices
- Chlorine by-pass systems
- Further emissions abatement techniques like selective non-catalytic reduction (SNCR), selective catalytic reduction (SCR) for abatement of NO_x emissions, wet scrubbers or lime injection systems in case of high SO_2 emissions
- On-line emissions analysers
- Investments for specific plant modernization
- Laboratory equipment
- Specific training for the employees

4. Can the cement industry use all types of wastes? Which waste materials are most suitable for co-processing?

- Waste used as an alternative fuel

  The cement manufacturing process offers the necessary conditions to enable the use of many different types of waste materials that can replace a portion of conventional fossil

[1] Cement Sustainable Initiative (CSI) "Guidelines for co-processing fuels and raw materials in cement manufacturing", July 2014

fuels. Waste materials can be solid, liquid or pasty and are defined by their origin, e.g. industrial, agricultural and municipal sources and by their specific features, e.g. hazardous and non-hazardous. The market availability is largely responsible for the different types of waste fuels used in different European cement plants.

Preparation of different types of combustible wastes or wastes with separate calorific fractions for use as fuel or raw material can be performed at special waste management facilities or at the cement plant.

The delivered waste derived fuels need to be stored at the cement plant and then proportioned for feeding to the cement kiln. As these calorific waste materials can replace primary fuel in cement kilns, a consistent waste derived fuel quality is essential (e.g. adequate calorific value, low metal, low halogen (e.g. chlorine) and ash content).

Typical wastes used as alternative fuels in the clinker burning process e. g. are refuse derived fuels (RDF), plastics, used tires, animal meal or sewage sludge.

- Wastes used as raw materials

  The chemical suitability of wastes used as raw materials is important as they provide the constituents required for the production of cement clinker. Desirable chemical elements are calcium, silicon, aluminium and iron as well as sulphur, alkalies and others.

  Typical wastes used as alternative raw materials in the clinker burning process e. g. are fly ash, used foundry sand and residues from the iron and steel manufacturing industry.

There are several requirements to consider in the selection and use of a waste as alternative fuel and raw material. The use of all alternative fuels and raw materials undergo an official licensing procedure. Special provisions (e. g. feeding point to the kiln, caloric value, limiting values for trace element contents, sampling procedures etc.) are laid down in the permit.

- According to the Global Cement and Concrete Association's (GCCA) Sustainability "Guidelines for co-processing fuels and raw materials in cement manufacturing" issued in November 2018 the following materials are not accepted by cement manufacturing as fuel or raw materials:
  - Radioactive waste from the nuclear industry
  - Electrical and electronic waste (e-waste)
  - Whole batteries
  - Corrosive waste, including minerals acids
  - Explosives and ammunition
  - Waste containing asbestos
  - Biological medical waste
  - Chemical or biological weapons destined for destruction
  - Waste of unknown or unpredictable composition, including unprocessed municipal waste
  - Waste raw materials with little or no mineral value for the clinker (i.e. heavy metal processing residues).

- There must be regular monitoring of inputs, e.g. sampling and analysis of the waste materials.
- The fuels must have low volatile heavy metal concentration, i.e. mercury, thallium, and cadmium.

Individual facilities may also exclude other materials depending on the local raw material and fuel chemistry, the infrastructure and the cement production process, the availability of equipment for controlling, handling and feeding the waste materials, and site-specific health, safety and environmental issues.

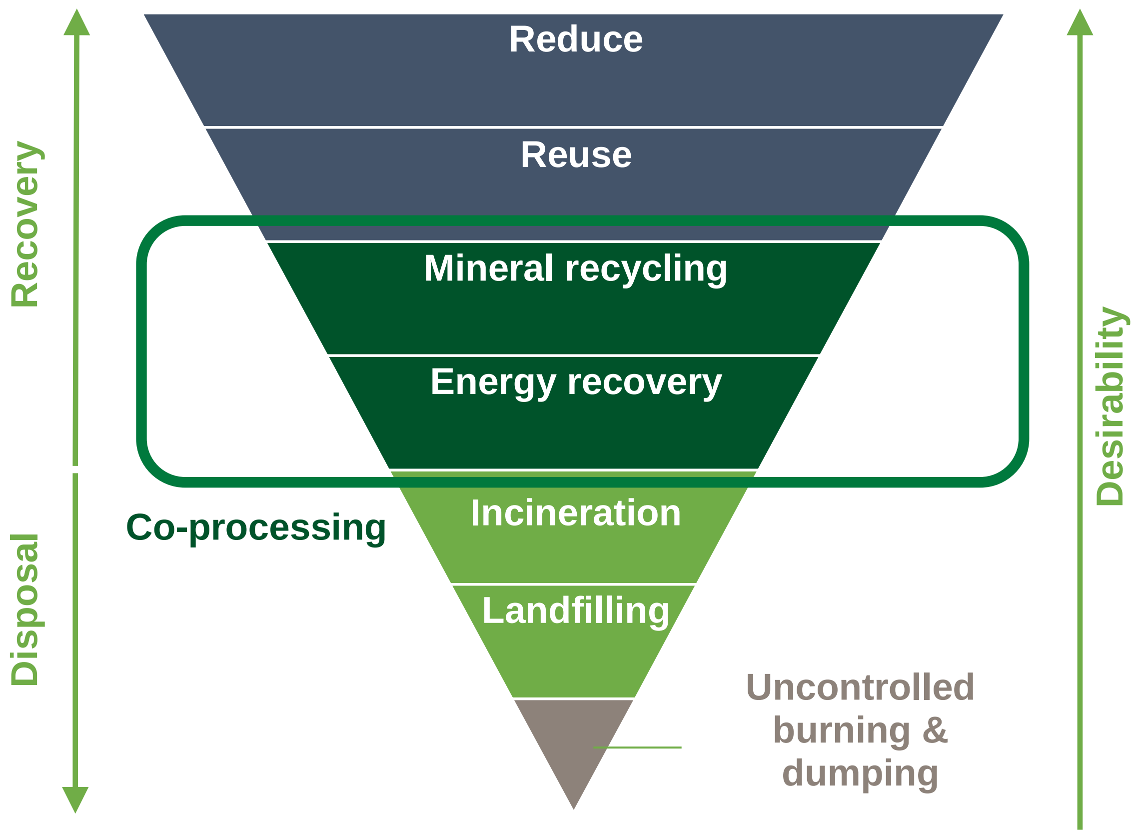
Contrarily to other waste treatment solutions, co-processing is a zero-waste solution – as all the 'ash' produced by the combustion of waste fuels becomes an input material of the cement product.

5. Is co-processing in cement kilns compatible with recycling?

The Waste Framework Directive (2008/98/EC and its subsequent amendments) sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling, recovery. Waste legislation and policies of the EU Member States apply as a priority order the following waste management hierarchy (as defined by article 4 of the Waste Framework Directive):

This hierarchy is widely recognised and is applied in many other countries (e.g. Norway, USA). However, the use of waste in cement kilns is a combination of energy recovery and material recycling. Where waste materials cannot be managed technically or economically by prevention and reduction, reuse and recycling, the cement manufacturing process provides a more environmentally sustainable solution compared to landfill or incineration, thanks to the full energy and material recovery in the process.

Therefore, CEMBUREAU believes that co-processing should be recognised higher up in the waste hierarchy as per the following scheme:



Additionally, co-processing is also recognized as one of the most energy-efficient waste-to-energy techniques in the Communication from the EC in 26.01.2017.

6. Why the cement operators need strict quality control of the alternative fuels and raw materials?

The core business of the cement plant is not to co-process waste but to produce cement. The wastes need to have specifications that are suitable to produce the clinker which is used to manufacture cement products. Thus, strict quality control is required:

- To ensure the good functioning of the cement kiln system
- To ensure the quality of the clinker and cement.
- To ensure the health and safety of the employees
- To respect the limits of the European and national legislation for environmental protection.

7. What is the gate-fee for the use of alternative fuels and raw materials during co-processing?

As it was described in the Question 3, a cement plant will need to invest in various facilities which are necessary to feed the alternative fuels and raw materials into the cement kiln. The gate fee can contribute to the necessary payback period to make this capital investment viable.

The gate-fee for the use of alternative fuels during co-processing is variable and depends on different factors such as the nature of alternative fuels, their quality, calorific value and their availability. Moreover, it should be highlighted that one of the main characteristics of the waste market is the high price volatility. It has been observed that the gate-fee for a certain alternative fuel changes from positive to negative during a specific time period or vice-versa.

Another factor that affects the gate-fee of the alternative fuels are the specific country's and regional characteristics of the waste market. According to the study "*Status and prospects of coprocessing of waste in EU cement plants*" prepared by Ecofys in April 2017, the availability of high-quality wastes and the co-processing rate in a European country directly depends on the development of the waste management system in the country. For that reason, CEMBUREAU totally supports the European Commission's policy to improve separate collection and minimize the landfilling of waste.

8. What are the differences between the bottom ashes from the incineration plant and the mineral recycling during co-processing?

During the mineral recycling of co-processing the energy and the material part of the waste are fully recovered in the clinker production, which is the intermediate product of cement. This simultaneous process in the cement kiln sees the organic component of the waste products fuel the kiln and the mineral elements of the waste become part of the cement clinker. This means that co-processing results in no residue materials, like ash. Finally, cement is used for the production of concrete, which not only is one of the most valuable construction materials but it is also 100% recyclable at the end of its life.

This process is quite different from the recycling of the bottom ashes of the incineration plants. The heavily polluted and variable quality of the bottom ashes makes them a waste quite difficult to handle and it may occasionally be used as a filling material in the road construction works.

EMISSIONS

9. Are the emission levels from co-processing strictly controlled?

Background

Emissions to air arising from the manufacture of cement are regulated by the Industrial Emissions Directive (IED – Directive 2010/75EU). This Directive is the main European instrument regulating pollutant emissions from industrial installations. It aims to achieve a high level of protection of human health and the environment by reducing harmful industrial emissions, in particular through the application of Best Available Techniques (BAT) which are defined in BAT Reference Documents (BREFs).

All installations undertaking industrial activities are required to operate in accordance with a permit (granted by the authorities in the Member States). The permit conditions, including emission limit values, are set in accordance with the principles and provisions of the IED and must be based on the BATs.

Specific to the cement industry

The cement BREF and its BAT conclusions describe, in particular, applied techniques, present emissions and consumption levels, Best Available Techniques and associated emission levels. In addition, Annex VI, Part 4, Section 2 of the IED defines limit values for cement kilns co-incinerating waste.

The BAT conclusions cover:

- Total dust
- Hydrogen chloride (HCl)
- Hydrogen fluoride (HF)
- Oxides of nitrogen (NO_x) and other nitrogen compounds
- Mercury (Hg)
- Metals and their compounds
- Polychlorinated dibenzo-p-dioxins and dibenzofurans (generally referred to as dioxins and furans)
- Sulphur dioxide (SO_2) and other sulphur compounds
- Total organic carbon (TOC) including volatile organic carbon (VOC)
- Carbon monoxide (CO)

These air emissions are either measured continuously or discontinuously in order to ensure compliance with the limit values. Provisions for measurement of air emissions are also laid down in the IED. Operators have to provide the data to their competent authority and publish emission on a regular basis.

Cement plants can only operate if they abide by the conditions and emission limit values set in their permits. If this is not the case, the national authorities have the right to suspend the operation of the installation until the permit conditions and emission limit values are respected.

10. If the cement kilns were using only fossil fuels would the air emissions be lower?

The general answer is NO. Indeed, air emissions are mainly influenced by the natural raw material input, that is round about 85% of the whole material input compared to 15% input by the fuels.

More specifically:

- Dust: There is no difference between dust emissions when using alternative fuels or fossil fuels.
- Hydrogen chloride – HCl: Emissions vary irrespective of the fuel used.
- Hydrogen fluoride – HF: There is no difference in HF emissions when using alternative fuels.
- Nitrogen oxides – NO_x: Alternative fuels do not lead to higher NO_x emissions – in some cases, NO_x emissions can even be lower when using alternative fuels.
- Mercury: Mercury emissions are mainly raw-material related. Furthermore, the input of mercury into the kiln system via the fuels is strictly controlled. As mercury is a high volatile element with the potential to build up mercury-circles in the kiln system, emission levels are highly influenced by operational and kiln-specific parameters and not by the type of fuel used.
- Heavy metals: Emissions vary irrespective of the fuel used. However, nearly 100% of them remain in the cement clinker matrix. In any event, alternative fuels undergo a rigorous acceptance and inspection procedure before being used which additionally controls the emissions to air. The input of trace elements into the kiln system of most alternative fuels is regulated in the permit and has therefore to be strictly controlled in practice.
- Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF): No difference has been found in dioxin emissions when the diverse array of alternative fuels is used.
- Sulphur oxides – SO_2: Alternative fuels have no influence on total SO_2 emissions as these are mainly raw-material related.
- Total organic carbon – TOC: There is no correlation between the use of alternative fuels and TOC emissions levels as these are mainly raw-material related.
- Carbon monoxide (CO): Emissions are mainly raw-material related and cannot be influenced by the type of fuel used.
- Dioxins / Furans (D/F): Dioxins and Furans emissions are destroyed within cement kilns thanks to:
    - long retention time of the gases in the kiln system
    - high temperatures in the waste burning zone

- the excess of air in the kiln burning conditions
- low chlorine levels, which is an essential component to produce dioxins and furans. Chlorine is restricted in the specifications of alternative fuels and is also an undesirable element for cement kiln operation because it can create process difficulties.
- the lower temperatures of the exhaust gases due their utilisation for drying raw materials and cooling, prevents the formation of complex organic molecules like dioxins.

11. What are the differences between the emissions from an incineration plant and a cement plant?

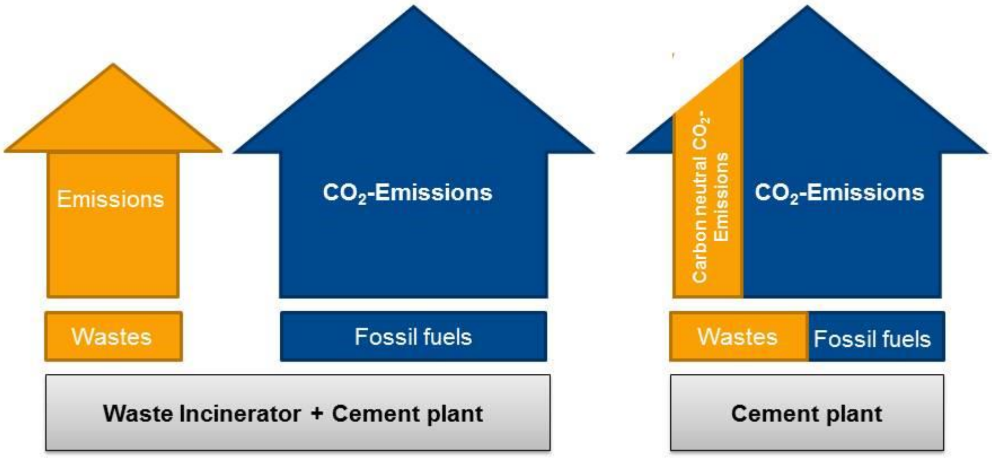
For a cement plant there are only emissions to air and no waste products. The emissions to air are regulated under the Industrial Emissions Directive (IED – Directive 2010/75EU).

For an incinerator there are typically in addition to emissions to air also solid and waste water releases to the environment. These solid and liquid wastes streams require further treatment before they can be released. With air emissions both an incinerator and a cement plant have equipment to pre-treat the final emissions, such as a modern filtering device to reduce dust levels and Selective Catalytic or Non-Catalytic Reduction techniques (SCR or SNCR) to reduce levels of NO_x. Air emissions of incinerators are determined by the fuel input whereas air emissions of cement plants are mainly determined by the raw materials in combination with the special clinker process burning technology (counter-current principle). That is why the IED foresees raw-material related exemptions for emission limit values for CO, SO_2, NH_3, and TOC.

With regards to the zero-carbon vision of the European Union for 2050, it is important to highlight that the carbon dioxide (CO_2) emissions from burning biomass are considered as carbon neutral. Therefore, burning wastes with high biomass content in a cement plant, instead of burning fossil fuels, not only saves natural resources but also reduces CO_2 emissions.
On the other hand, the carbon dioxide (CO_2) emissions of an incineration plant does not fall under the scope of the EU-ETS scheme.

Through continuous investment, innovation and modernisation, CO_2 emissions in the cement sector have been reduced by 14% since 1990. In line with its "2050 Low Carbon Roadmap" the cement sector is on track to achieve the goal of reducing its CO_2 emissions intensity by 32% by 2050 using conventional technologies, whereas the potential of breakthrough capture technologies could lead to an 80% reduction in emissions by 2050.

Moreover, when comparing the emission values from a cement plant and a waste incinerator it is important to consider the difference in the conversion factor which is used to calculate the emissions. While in a cement plant the Reference Oxygen is 10%, in an incineration plant the Reference Oxygen is 11%. This means that given the same limit value for a cement plant as well as for an incineration plant, that limit value is stricter for a cement plant due to the lower reference oxygen level.


Emissions
CO_2-Emissions
Carbon neutral CO_2-Emissions
CO_2-Emissions
Wastes
Fossil fuels
Wastes
Fossil fuels
Waste Incinerator + Cement plant
Cement plant

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