Tackling industrial waste
Cement kilns versus Incinerators

An environmental comparison

Introduction

The European Union has developed a highly comprehensive legislative system on waste management since 1975. The framework directive relating to waste (directive 2006/12/EC) sets out for Member States the general principles required to prevail in national policies for managing waste.

*This European framework is based on **a waste treatment hierarchy** according to which priority has to be given to **waste prevention** programmes and reducing the harmful or hazardous nature of waste.*

*Any unavoidable waste should be **recovered**. In other words, it should go through a process that consists of extracting secondary raw materials by reusing the waste, recycling the waste, or using the waste in any other process that extracts its content in terms of matter and/or energy.*

*If, for technical or economic reasons, the recovery of waste is not possible, we should then resort to what are known as **disposal** techniques, such as disposing of the waste at landfill sites or burning it in specially designed incinerators.*

Unlike recovery processes, disposal allows for very little in the way of saving natural resources. The main aim of elimination is to destroy the waste under conditions that are safe both for human health and the environment.

The aim of this waste hierarchy is to give priority to processes that present the least risk for the environment and for human health, and which also make it possible to save natural resources. While the Member States remain in control of the way in which this hierarchy is given a place in their national legislation (the principle of subsidiarity), they are still required to abide by its principles.

On 22nd December 2006, a decree issued by the Flemish Region resulted in a controversy between the Flemish Region and the Belgian cement industry regarding the way in which the hierarchy is to be implemented. In point of fact, the decree introduced an identical tax for incinerating waste (as a form of disposal) and the co-processing of waste in cement furnaces (as a form of recovery).

In issuing this decree, the Flemish Region showed it was of the opinion that the environmental impacts of the two methods of treatment were similar and that accordingly, there was no justification in giving priority of one method over the other.

This argument is disputed by the Belgian cement industry, which commissioned a scientific study designed to provide both sides of the argument with a common and objective basis to be able to compare the environmental impact of incinerating waste in Flanders and its co-incineration in cement kilns in Belgium.

The study was conducted by the Dutch research bureau TNO in conjunction with a panel of scientific experts, the cement industry and the Flemish Region, and presided over by the Walloon Region. The texts of this brochure are an accurate summary of the TNO study and have been produced by GreenFacts at the request and under the supervision of TNO. This summary aims at making the results of this study accessible to people who are not specialists in this area.

What waste treatment options are compared and why?

This study compares the environmental impact of two options for dealing with a tonne of certain types of industrial waste in Belgium:

- using waste as an alternative fuel and raw material for cement production (co-processing)
- burning waste in hazardous waste incinerators while recovering electricity and steam (incineration)

The two options are referred to as thermal treatment because they involve high temperatures in the processing of the waste.

As a reference point, the study considers current emissions to air, water, or soil and the use of natural resources for both treatment options in Belgium. It estimates how emissions and resource use would change if a tonne of waste were added to either treatment process, in effect replacing some of the energy sources (and raw materials) otherwise used. The changes in terms of emissions and resource use are then translated into a series of environmental impacts that can be compared.

The Netherlands Organisation for Applied Scientific Research (TNO) carried out the comparison at the request of the association of Belgian cement producers (Febelcem) in the context of a change in the Flemish taxation on the use of waste as alternative fuel. To improve its quality, the assessment was conducted in cooperation with an expert panel, consisting of representatives from OVAM (Public Waste Agency of Flanders), the Walloon region, VITO (Flemish Institute for Technology Research), Neosys, cement producers (Holcim, CCB, CBR), and Febelcem.

What types of industrial wastes are considered?

Five types of industrial waste are considered:

- solvents and waste oils
- paint and ink residues
- wastewater treatment sludges
- filter cakes from wastewater treatment
- fluff (mixture of shredded textiles, plastics and other materials)

These types of waste are currently used as alternative fuel in cement kilns in Belgium, but can also be disposed of in waste incinerators. They are affected by the change in taxation on the use of waste as alternative fuel. Such waste mainly comes from industrial facilities and wastewater treatment plants located in or near Belgium.

Certain waste types are excluded from the scope of this study, for instance because they are not affected by the change in taxation (animal meal) or because the waste streams are relatively small (seeds, tyres, rubber, etc).

Overall, more waste than fossil fuel was used in the six cement kilns considered in 2006 (in tonnes).

Each type of waste differs in the amount of energy released, moisture contained, and ashes left behind. Waste oils and solvents, for instance, contain little water, burn as well as fossil fuels, and leave hardly any ashes. On the contrary, waste water sludge and filter cake still contain a lot of water, release less energy per tonne, and leave behind a lot of ashes.

In some occasions, waste requires preliminary treatment before it can be used in cement kilns, whereas it can be fed into incinerators as is. For instance, water needs to be removed from wastewater sludge, while paint and ink residues need to be mixed with sawdust. This pre-treatment also has consequences for the environment.

How is waste used in cement production?

Cement is a basic ingredient of concrete and mortar. It is made of quarried limestone and other minerals.

First, raw materials are crushed, combined in adequate proportions, mixed, and optionally preheated. Then they are subjected to high temperatures in a cement kiln in order to chemically convert them into cement clinker, which requires a lot of energy. Finally, the small lumps of solid material that come out of the kiln (clinker) are cooled, ground and blended with other materials to produce a fine cement powder.

Cement kilns are currently heated by burning fossil fuel and waste. Adding an extra tonne of waste to the process would not change the overall amount of cement produced, it would merely replace some of the fossil fuel and raw materials needed.

The addition of a tonne of waste would slightly change overall emissions to air and the composition of the clinker, depending on the constituents of the waste and of the fossil fuel they replace. For example, if the waste contains less sulphur than the fossil fuel it replaces, sulphur emissions into air will decrease leading to less acid rain. There are no direct emissions to water and soil in the case of cement production.

How is industrial waste incinerated?

Waste incinerators comprise a combustion chamber in which the waste is incinerated at high temperatures, a steam boiler that recovers part of the energy contained in the waste as steam, and a steam turbine that partly converts the steam into electricity. Moreover, dust and harmful chemical substances are removed from the exhaust gases before they are released to the atmosphere. This flue gas cleaning process in some cases leads to a wastewater discharge to surface water. Ashes or other solid residues remaining after incineration are generally disposed of in landfills.

Depending on the type of waste, a different type of incinerator is more appropriate.

- a rotary kiln incinerator is suitable for most waste types considered (solvents and waste oils, filter cake, and paint and ink residues). Nearly a quarter of the energy contained in the waste is recovered by this system, mainly as steam. Its wet gas cleaning system leads to a wastewater discharge to surface water.
- a fluidised bed incinerator is more suitable for fluff and wastewater sludge. More than a third of the energy contained in the waste is recovered by this system, as steam and electricity. Its semi-dry flue gas cleaning system prevents any wastewater discharge to surface water.

In both cases the addition of a tonne of waste would increase emissions to the environment depending on the constituents of the waste. The energy recovered would reduce the overall need to produce electricity and steam from other energy sources, which in turn avoids some emissions to the environment.

GLOSSARY

Life Cycle Assessment (LCA)

Process of comparing the environmental performance of products or services, to enable an informed choice.

The term 'life cycle' refers to the notion that a fair assessment must consider all steps from cradle to grave: raw material production, processing, use and disposal, and transportation.

Co-processing

Recovery of energy and materials from waste as a substitute for fossil energy and virgin raw materials

Industrial wastes

Waste produced or arising mainly from manufacturing or industrial activities or processes. Depending on the amount of harmful substances present in the waste it is considered hazardous or not.

The five types of industrial wastes considered in the present assessment are:

Solvents and waste oils, sludge from municipal and industrial wastewater treatment processes, filter cake from wastewater treatment, paint and ink residues and fluff (mixture of plastics, textiles and other materials)

Cement kiln

Kiln used for the manufacture of Portland and other types of cement.

Cement kilns are rotary kilns consisting of a long cylinder that is nearly horizontal and rotates slowly around its axis. The raw materials are fed into the slightly higher end and gradually move down towards the lower end while being heated at high temperatures (up to 1450°C) and stirred.

Considerable quantities of fuel are needed to keep the kiln hot for the desired chemical reactions to take place.

Rotary kiln incinerator

A type of waste incinerator mainly used for the thermal treatment of hazardous waste.

A rotary kiln is made up of a slightly inclined cylinder that rotates to facilitate the constant advancement of the waste being fed in. The waste is fed into the upper extreme of the kiln, and the combustion residue is deposited from the opposite (lower) end. The plant has extensive flue gas washing equipment and an energy recovery system.

Fluidised bed incinerator

A type of waste incinerator made up of a vertical cylinder that contains a bed of sand held in suspension (fluidified) by high-velocity air injected through a grid at the base of the cylinder. The waste products are fed into and burned on the sand bed, which enhances the heat exchange process and supplies sufficient thermal inertia to the system to regulate the combustion process (at a temperature of at least 850°C).

How are environmental impacts compared?

A. The waste treatment options are compared following a Life Cycle Assessment (LCA) process that takes into account all steps of the process: from transportation and waste preparation, through treatment in cement kilns or incinerators, to the final treatment of emissions before their release to the environment. To guarantee the scientific integrity of the assessment, the methods used comply with the international standard ISO 14044 that specifies requirements and provides guidelines for Life Cycle Assessment.

First, the study considers emissions to air, water, or soil and the use of natural resources for both treatment options, based on the current situation in Belgium. Then, it estimates how emissions and resource use would change if a tonne of waste were added to either treatment process, in effect replacing some of the energy sources (and raw materials) otherwise used. Finally, the environmental consequences – positive or negative – of this change are quantified.

B. Emissions and resource use are translated into a series of environmental impacts, namely effects on the depletion of fossil fuel and raw materials; global warming; the ozone layer; human health; the health of freshwater, marine and terrestrial ecosystems; smog; acid rain; and eutrophication (excessive algae growth).

In this assessment, CO_2 emissions that do not derive from fossil fuels but are part of the carbon cycle – such as CO_2 released from the burning of organic matter contained in sludge or sawdust – are not considered a contribution to global warming.

Which treatment option leads to lower environmental impacts?

For the vast majority of environmental impacts it is concluded that using industrial wastes as alternative fuel in cement production is better for the environment than treating them in waste incinerators.

For both treatment options the use of a ton of waste generates energy which would otherwise have been provided by other sources, including fossil fuels that contribute to global warming.

Waste and fossil fuels contain a certain amount of energy (expressed in mega joules or MJ). In the case of cement kilns, burning 1 MJ of waste is as efficient as burning 1MJ of fossil fuel. Waste incinerators however are far less energy efficient than fossil fuel power plants when it comes to producing electricity and steam, because only a small part of the energy is recovered. As a result, more fossil fuels are spared when using the waste as an alternative fuel in cement production.

The burning of waste generally leaves behind ashes. In cement production these ashes are incorporated in the final product, in effect replacing some of the raw materials that would otherwise have been added to the product. In the case of incineration, the leftover ash is disposed of in landfills.

Is treatment in a cement kiln the better option for a specific waste and environmental impact?

10 environmental impact categories	5 types of waste				
	Solvents & waste oils	Sludge	Filter cake	Paint & ink residues	Fluff (plastics, textiles)
Depletion of resources	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Global warming	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Ozone layer	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Human health	No	**Yes**	**Yes**	**Yes**	**Yes**
Freshwater ecosystems	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Marine ecosystems	**Yes**	No	**Yes**	**Yes**	No
Terrestrial ecosystems	No	**Yes**	**Yes**	No	No
Smog	**Yes**	**Yes**	**Yes**	No	**Yes**
Acid rain	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Eutrophication*	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

*excessive algae growth

The use of filter cake from wastewater treatment in cement production to replace some fossil fuel and raw materials is the better option for all environmental impacts considered. For the other four types of industrial waste, treatment in a cement kiln is the better option for eight or nine out of ten environmental impacts.

The environmental impacts for which treatment in a waste incinerator is the better option for one or more types of waste are effects on human health, marine ecosystems, terrestrial ecosystems, and smog. For the remaining six environmental impacts (resource depletion, global warming, ozone layer, freshwater ecosystems, acid rain, and eutrophication), treatment in a cement kiln is the best option for all five types of waste.

Conclusion - How can the results be interpreted and how reliable are they?

For the vast majority of environmental impacts it is concluded that using industrial wastes as alternative fuel in cement production is better for the environment than treating them in waste incinerators.

What is more important: the preservation of our water resources or the preservation of the ozone layer? There is no objective answer. Currently, climate change is high on the political agenda and could potentially be given greater priority when comparing impacts. **For climate change and for many other environmental impacts, this assessment reaches the conclusion that the use of waste in cement production to replace some fossil fuel and raw materials is the better option.**

However, the subjective decision on what importance to give to different environmental concerns must rest with the decision makers. For experts and decision makers, weighed results (expressed in artificial monetary terms) and underlying assumptions are available in the full report (Level 3).

The overall results are still valid even if the characteristics or the waste or treatment process were slightly different or if a different assessment method is used. Extensive testing of how the results would change if the underlying assumptions were different (sensitivity testing) was an important part of this study and it demonstrated the reliability of the results.

A more complete presentation of the study of TNO can be consulted on the website www.coprocessing.info

FEBELCEM

This brochure was made by Febelcem.

The summary was made by Greenfacts,

GreenFacts
Facts on Health and the Environment

under the supervision of TNO.

Responsible editor: Jean-Pierre Jacobs, 8 rue Volta, 1050 Brussels - Printed on Cyclus Print 200g