Contribution of co-processing

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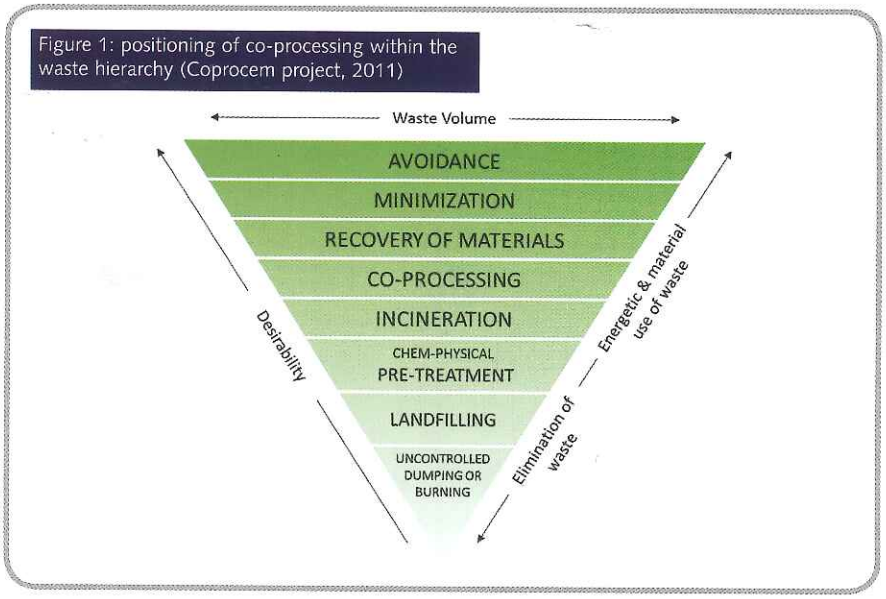
In 2014 a study on material recovery of alternative fuels (AFs) through co-processing in Portuguese cement kilns aimed to identify the real contribution of co-processing in the domestic cement industry. The multi-purpose study looked to quantify the amount of material recycled based on the ash content of the waste being processed, and considered procedures for the collection, preparation and analysis of AF samples. It also highlighted the environmental impact and benefits associated with the co-processing of AF and its potential contribution to meeting waste management targets on a European and national level.

The European Union states in the Waste Framework Directive (WFD) (2008/98/EC) that waste should be managed in accordance with the waste hierarchy, without posing any risk to human health and the environment. The waste hierarchy (see Figure 1) places waste avoidance at the top, followed by minimisation, recycling, energy recovery, elimination and final disposal.

Current European and national waste policies establish measurable targets for the waste recovery operations of several waste streams, particularly in terms of preparation for reuse and recycling operations. While most of these targets are already being met, others are currently being revised at the European and national level, with a tendency for more ambitious targets. For instance, the European Commission's "Towards a circular economy" programme (published in July 2014 and subsequently withdrawn and now undergoing a process of re-evaluation to include a much broader range of issues) suggested a target of 70 per cent in terms of preparation for the reuse and recycling of municipal solid waste (MSW) and 80 per cent for the recycling of packaging waste by 2030.

Figure 1: positioning of co-processing within the waste hierarchy (Coprocem project, 2011)



Co-processing recognition

In the case of cement kilns, several waste streams can replace traditional fossil fuels, such as coal and petcoke, as well as the raw materials used in clinker production. Energy is provided by the combustible fraction of the waste (ie, energy recovery) and the non-combustible fraction provides raw materials that are incorporated into the final product, clinker (ie, material recycling).

Recognition of this contribution is of utmost importance. The methods used to calculate target compliance must be reassessed to establish the real contribution of co-processing to waste policies, namely to meet national and European recovery and recycling targets.

In terms of the waste hierarchy, given its dual role, co-processing should effectively be framed between material recovery (recycling) and energy recovery. This positioning conveys the message that co-processing is focussed on the use of waste that can no longer be recycled by conventional means, but whose mineral and energy fractions can be recovered.

A Portuguese perspective

This was the driver that led to a study within the Portuguese cement industry entitled: "Co-processing – material recovery of alternative fuels in the cement industry." The project was developed by the consulting company 3Drivers – Engineering, Innovation and Environment Ltda and promoted by Portuguese cement manufacturers Cimpor and Secil, as well as by three local Producer Responsibility Organisations (PRO) – SPV, Valorcar and Valorpneu – who manage the national extended producer responsibility (ERP) systems for packaging waste, end-of-life vehicles and used tyres, respectively.

The project considered a broad range of wastes, ie refuse-derived fuel (RDF) from MSW and industrial waste (RDF-Ind), used tyres, shredder residues (SR), automotive shredder residues (ASR) and mixed hazardous waste (MHW).

The study's main objectives were to:

- Define and validate a methodology to calculate the fractions that are recycled as a material in the co-processing of alternative fuels (waste) in cement kilns, and therefore be considered as being subject to the process of material recycling.

- Establish a procedure for the collection, preparation and analysis of alternative fuel samples to determine the key characteristics within the context of material recycling and energy recovery.
- Assess the environmental impact and benefits associated with the co-processing of alternative fuels and potential contribution to meeting waste management targets defined under European and national waste legislation.

Project methodology

Literature review

Phase one of the project involved legal and technical analysis based on an extensive review of policy, operational and scientific literature.

This analysis confirmed that, from a technical point of view, the dual role of waste co-processing in cement kilns is duly justified. According to guidelines on the interpretation of key provisions of Directive 2008/98/EC on waste, 2012: "co-processing is an operation that combines two waste management recovery options at the same time. The energy content of the waste is recovered (...) as thermal energy, thus substituting fuels, while the mineral fraction of the waste can be integrated (hence recycled) in the matrix of the product or material produced, eg, cement clinker (...)".

Despite the fact that there is no formal recognition of this dual role from a legal standpoint, there is clear recognition within strategic and interpretative documents produced by official entities including the Basel Convention, European Commission, and the Joint Research Council (JRC). Taking Portuguese waste law into consideration, one can conclude that there is no impediment for effective accounting of the recycled fraction.

Following the literature review, it was also concluded that accounting of the recycled fraction should be undertaken by considering the ash content of a given waste type, on a mass-to-mass basis, as the inert materials are incorporated within the clinker matrix. In addition, the calculation of the ash content should be made directly by analysing the representative waste samples of a given batch.

Since the ash content of some wastes is influenced by several factors (such as seasonality, typology, origin, shape and size distribution), the waste types considered were grouped into three different categories: used tyres, RDF and similar wastes, and mixed hazardous wastes. For each group, the minimum batch characteristics were assessed and defined, considering the characteristics of the waste, origin and variability. This also led to the definition of three different procedures to collect and prepare representative samples to be analysed to determine the ash content associated with each batch.

AF sample collection, preparation and analysis procedures

The procedures used by the Portuguese cement manufacturers for the collection, preparation and analysis of samples were revised to allow for the identification of the ash content of the alternative fuels, based on international standards and best-practices.

More specifically, the revision focussed strongly on aspects related to occupational health and safety procedures, population size, number and size of samples, the confidence level required and the equipment used to collect, store and transport the samples.

Three different procedures were established for used tyres, RDF, SR, ASR and other similar wastes as well as for hazardous waste mixtures. These procedures form the backbone of the data collection that will be used to calculate the overall recycled fraction of the alternative fuels for a given period of time, type of waste and producer.

To guarantee a high degree of confidence in the results, a procedure for the interaction and cooperation of different stakeholders was also proposed, namely between the cement manufacturers, the national authorities and the PRO which are responsible for managing several specific waste flows according to ERP policy.

Potential contributions to targets

Finally, considering the analysis and results obtained in the previous project phases, the potential contribution of co-processing to the fulfilment of waste management targets was assessed for several waste streams. This assessment was based on historical data from cement companies as well as data from scientific literature using indirect methods that take into consideration the typical composition of Portuguese waste materials, their potential ash contents, as well as previously-observed waste ash generation data.

The average obtained values are shown in Table 1. It is important to note that, for some wastes types, the observed standard deviation was relatively high due to the variability of factors that affect the composition of the waste and, therefore, their ash content (such as seasonality and origin). This was taken into account in the aforementioned defined methodology and procedures.

Project findings

The impact on Portuguese recycling targets was estimated using the results obtained. When looking at the waste flows for 2013 the results showed that the following potential could be realised:

- 8.1 per cent increase in the rate of used tyres to 78.8 per cent
- two per cent increase in the recycling rate of End-of-Life (ELV) to 87.1 per cent.

This impact is significant. For instance, 2016 European and national ELV targets are high (90 per cent) and will prove challenging to meet under current management systems and recycling technologies.

The potential for recycling rates of packaging and MSW is also significant. Portuguese cement producers estimate the following contributions:

- 2.6 per cent increase in national packaging recycling rates and preparation for reuse

Table 1: indicative average values for the recycled fraction, Portugal

Alternative fuels & raw materials	*Recycled fraction (%)*
Passenger tyres	19
Tyres (mix 2013)	23
SR/ASR	30
RDF – MSW	22
RDF – industrial waste	18
Hazardous waste mixtures	24

Based on bibliographical and historical data

- 2.8 per cent increase in the MSW recycling rate.

It's worth noting that in 2013, the Portuguese MSW recycling rate was 27 per cent. By 2020 each EU member state must reach 50 per cent, in accordance with the European Waste Framework Directive. Targets for 2025 and 2030 are currently under consideration and will be significantly higher.

Moreover, this increase would be the result of granting formal recognition to an activity which is already being undertaken in cement plants: the inert fraction of the waste consumed is being incorporated into the final product, and hence recycled. In addition, it is a type of waste which can no longer be recycled using conventional means, but whose mineral and energy fractions can still be recovered and recycled for clinker production.

Environmental considerations

As well as an impact assessment of co-processing, environmental analysis based on a streamlined Life Cycle Assessment (LCA) was performed, taking into account cement manufacturing technologies, the wastes that are currently consumed in Portugal and the direct and indirect impacts generated. The analysis showed that co-processing is a suitable process from a human health and environmental standpoint, as long as the established procedures and good practices are followed. Compared to the use of traditional fuels, such as petcoke, the co-processing of alternative fuels results in significant benefits, for instance in terms of reducing GHG emissions.

Moreover, the recovery of waste in cement kilns compared to other waste management options (such as dedicated incineration for electricity production or landfill), is more favourable from an environmental perspective. This is particularly the case in Portugal as the waste co-processed by cement kilns directly substitutes traditional fuels, whereas dedicated incinerators produce electricity that substitutes relatively 'clean' electricity production overall. National power production is largely based in renewable sources (namely hydroelectric and wind) and combined cycle gas turbine plants. Therefore, for several impact categories the impacts which are avoided thanks to co-processing are higher than those in dedicated incineration.

The 2014 study has contributed towards raising awareness about the dual role of co-processing as a procedure that combines energy recovery and material recycling, as well as plays a relevant role in the promotion of a circular economy and resource efficiency.

Attracting attention and raising awareness

The study has contributed towards raising awareness about the dual role of co-processing as a procedure that combines energy recovery and material recycling, as well as plays a relevant role in the promotion of a circular economy and resource efficiency.

Within this context, it establishes and provides support to a methodology for calculating the fractions that are recycled as a material in the co-processing of alternative fuels in cement kilns, as well as the procedures that should be applied for the collection, preparation and analysis of alternative fuel samples. The results provide the basis for calculating the material fractions obtained.

The project also assesses the environmental impacts and benefits associated with the co-processing of alternative fuels and its potential contribution to meeting waste management targets defined by European and national waste legislation.

The project was concluded at the end of 2014 and has already attracted attention from several parties as well as being referenced on several occasions. At the international level, it has raised significant interest in forums such as the European cement association, CEMBUREAU, and the European Tyre and Rubber Manufacturers' Association (ETRMA). On a national level, it has contributed to an explicit recognition of the material fractions that are recycled in clinker production, within the context of the new Portuguese Waste Management Tax Law (Law 82-D/2014, December 31).

Since 1 January 2015, the tax applied to waste which is destined for energy recovery – R1 operation (25 per cent of the landfill tax) should be reduced in proportion to amount of material recycled, when this operation occurs in the kilns of industrial installations, as in the case of cement kilns.

In terms of formal recognition for the dual role of co-processing for assessing recycling rates, the Portuguese authorities are currently analysing and validating the comprehensive methodology that resulted from this project.