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Source: Bontempi, E. (2017). A new approach for evaluating the sustainability of raw materials substitution based on embodied energy and the CO_2 footprint. *Journal of Cleaner Production*, 162: 162-169. DOI: http://dx.doi.org/10.1016/j.jclepro.2017.06.028.

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1. Previous research has demonstrated, at the biological level, that COSMOS technology can abrogate the biotoxic effects of MSWI residues.

2. Smart INitiative of cities Fully cOmmitted to iNvest In Advanced large-scaled energy solutions (SINFONIA) was supported by the European Commission under the Seventh Framework Programme. See: http://www.sinfonia-smartcities.eu/.

European Commission

Science for Environment Policy

A new approach to evaluating the sustainability of substituting raw materials

If the EU is to combat resource scarcity, it is necessary to develop and refine strategies for substituting raw materials with sustainable alternatives, such as recovered by-products from waste. A recent study presents a new approach for evaluating the sustainability of raw materials' substitutions, based on the quantification of the embodied energy (energy required to produce the material from ores and feedstock) and carbon dioxide footprint (greenhouse gasses produced and released into the atmosphere during the production of the material) of both the raw material and its proposed substitute. The evaluation method has been applied to a real case, where it indicates that substituting a raw material (calcite) with stabilised fly ash for use as a filler in polypropylene composites in plastic manufacturing may be sustainable. The study also highlights the need for additional policy tools and legislation to encourage Europe's transition towards a circular economy.

The substitution of raw materials with recovered by-products, achieved through the use of appropriate processing technologies, can offer environmental and economic benefits. It also allows us to reconceptualise refuse as a resource for reuse, meeting the end-of-waste criteria set out in the EU Waste Framework Directive.

One material of note is municipal solid waste incineration (MSWI) fly ash, a hazardous waste generated during waste incineration. Typically, fly ash is partially chemically stabilised to reduce leaking of toxic heavy metals and other hazardous substances and then landfilled. However, application of a novel clean technology known as COSMOS (Colloidal Silica Medium to Obtain Safe inert) enables fly ash to be substituted for raw materials as a filler in polypropylene composites, which are widely used in plastics manufacturing[1]. To evaluate the sustainability of this raw material's substitution, one would conventionally conduct a Life Cycle Assessment (LCA), an analytical tool used to examine the environmental impact of a product by considering all stages, from raw materials to final disposal. However, LCAs can be complex, data-intensive, time-consuming and costly.

The study is based on research part-funded by the EU[2] and realised in the frame of the Mining the European Anthroposphere (MINEA) COST Actions, which aims to actuate the reporting of material resources/reserves in the anthroposphere (that part of the environment that is made or modified by humans). In the paper, the researcher outlines a new, simplified method for evaluating the environmental sustainability of a raw material's substitution. An index, called SUB-RAW, considers the environmental benefits of two parameters — embodied energy (total direct and indirect energy consumption per kg of material produced) and the carbon dioxide footprint (total mass of greenhouse gasses produced and released into the atmosphere per kg of material produced) — to quantify the sustainability of a proposed substitution.

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European Commission

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A new approach to evaluating the sustainability of substituting raw materials *(continued)*

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The new method was used to evaluate the sustainability of substituting various raw materials with COSMOS-treated fly ash as a filler in polypropylene composites in plastic manufacturing. The mean embodied energy and carbon dioxide footprint for each material were quantified and compared. They were found to be close to equivalent in the case of one raw material (calcite), resulting in a SUB-RAW index of almost zero, suggesting that the proposed substitution is sustainable. It should be noted that the method may not account for all relevant criteria, making further research advisable[3]. From a policy perspective, the paper highlights a potential large-scale waste-recovery opportunity — waste incineration in Europe produces over 1 400 Mtonnes of fly ash every year, and polypropylene is Europe's most used polymer.

More broadly, the study highlights the inadequacy of the existing legal framework to guarantee raw materials' preservation. According to the researcher, current waste legislation imposes strict controls that do not adequately account for raw materials' substitution, and legal uncertainty and lack of clear policy guidelines limit the development of the waste-recovery industry. The researcher, therefore, calls for the development of supportive measures within the end-of-waste criteria to encourage the use of recovered materials in substitutions for raw materials. She also emphasises the need for additional regulations to promote policy-driven eco-innovation in raw materials' substitution.

3. It is worth noting that, since the method was published, the European Commission has released a Communication on the implementation of the circular economy package: options to address the interface between chemical, product and waste legislation. The methodology, as described above, fails to account for the following considerations contained within the Communication:

- Introducing hazardous substances (e.g. heavy metals present in MSWI fly ash) in the material cycle might prevent the reuse of the produce materials. Potential heavy metal release must be prevented or minimised and tracked as part of a monitoring framework for the circular economy.
- Hazardous substances not providing a specific, useful function should not be introduced again in the economic cycle, but rather segregated and removed from the economy. It remains to be established whether the COSMOS-treated MSWI fly ash fulfils this criterion.