CEMBUREAU Environmental Product Declaration for Cement

User's Guide

Contents

CEMBUREAU, The European Cement Association, is the representative organisation of the cement industry in Europe.

1. What is an Environmental Product Declaration (EPD)?

ISO/TR 14025:200 defines an EPD as a so-called Type III environmental declaration. But what exactly is a type III environmental declaration?

- It gives *verified (peer reviewed), quantitative information* on a number of *standardised* environmental effects of a product that has got a well-defined function.
- It should - in principle - include the environmental effects of the product *through all the stages* of its manufacture, use and disposal.
- It is mainly a carrier for *business-to-business* communication.

An EPD consists of a format and of data content. The format complies with ISO-standards. EPDs are appropriate for final products fulfilling a specific function, like a beam or a paving slab, in which the EPD can include all the stages of its life cycle (from the mining of raw materials to the disposal of the product).
With intermediate products (like cement) that can be used in products fulfilling very different functions, an EPD is also an option. Then it will only include the stages from the mining of raw materials to the manufacture of the intermediate product. It excludes the final use, repair and disposal which are a variable depending on the specific application.

In all cases EPD must be based on the Life Cycle Assessment (LCA) methodology, which is briefly explained in the following section.

2. What is a Life Cycle Assessment (LCA)?

Life Cycle Assessment (LCA) is a methodology that allows the evaluation of the environmental effects of a product, considering all the relevant stages in its life cycle. A LCA should be, in principle, from the mining of raw materials to the waste dumping (‘cradle to grave’), and going through the manufacturing, use and eventual re-use or recycling processes, since significant impacts may occur in any of these phases.
As mentioned in the previous section, this is not feasible with specific processes within the life cycle or with intermediate products, such as cement, which subsequently have many applications. In these cases, the analysis ends in the considered process or else in the manufacturing of the product. Such assessments are often called ‘gate-to-gate’ or ‘cradle-to-gate’. In the case of cement the first gate refers to the entrance of the factory and the second gate to its exit. ‘Gate-to-gate’ and ‘cradle-to-gate’ assessments are useful to analyse specific parts of a complete life cycle or as parts of a complete ‘cradle to grave’ analysis.

The considered specific process or product must be defined precisely through its type, its amount and, if possible, especially through the function it should fulfil. This base for the further assessment is called *“functional unit”* (in the case of a ‘cradle to grave’ assessment) or *“analysis/declared unit”* (in the case of a ‘cradle to gate’ assessment). It is complemented by the definition of its system boundaries.

The system boundaries must be established precisely in order to know exactly the phases taken into account and those excluded in the LCA. Careful consideration should be given on whether all relevant phases have been considered. Furthermore it must be well described how allocation rules have been applied. Allocation rules provide clarification on the question how to divide environmental loads between processes or products.

Figure 1 shows the generic life cycle of a concrete product including all the relevant phases that the product goes through.

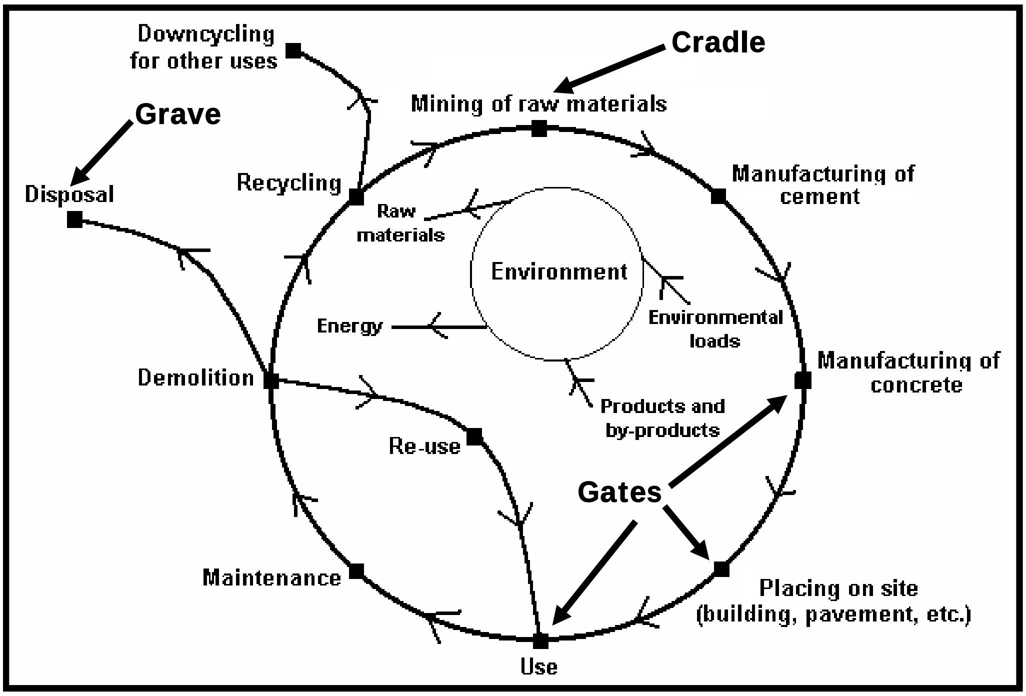

Figure 1: Generic life cycle of a concrete product

Generally speaking, during every phase of the life cycle different raw materials, products and by-products and some amount of energy will be consumed and some environmental loads (emissions to air, water and ground, waste) will be produced (see: figure 2).

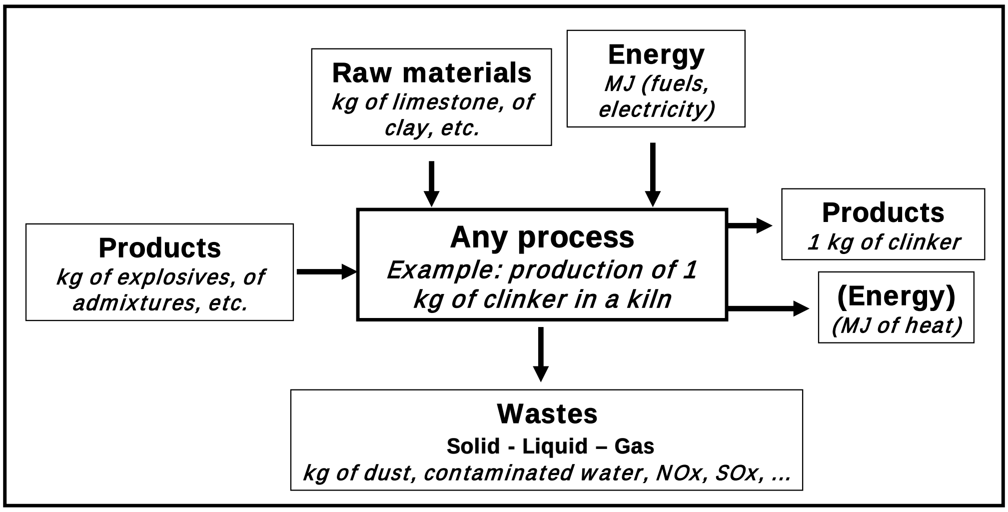

Figure 2: Inputs and outputs of a generic phase of a life cycle (example for clinker manufacture).

The addition of all these individual environmental interventions of all the life cycle phases will provide the total impact produced on the environment.

LCA's are expressed in terms of impact, not as loads (e.g. emissions). The result of a LCA is made up by a series of values corresponding to each one of the environmental impacts considered. Nevertheless such values may be reduced to just one (see below).

A LCA can basically provide three different types of results.
The first one is the Life Cycle Inventory (LCI).
This is the basic information of an LCA. It is composed of the (usually long) list of individual environmental interventions (see: figure 3). The emissions of carbon dioxide, methane and nitrous oxide are, e.g., such interventions.

LCI	
Use of natural resources and materials	
Limestone	Slags
Clay	Explosives
Gypsum	Water
Iron oxides	Etc.
Natural gas	Diesel
Heavy fuel oil	Crude Oil
Coal	Biomass
Petcoke	Etc.
Emissions	
Particules	Hg
CO_2	Cd
CO	Tl
NO_x	Sb
SO_2	As
N_2O	Pb
HC	Cr
NH_3	Co
HCl	Cu
HF	Mn
CH_3	Ni
VOC	V
COD	Sn
Wastes	Etc.
Other	
Energy	Noise
Area	Etc.

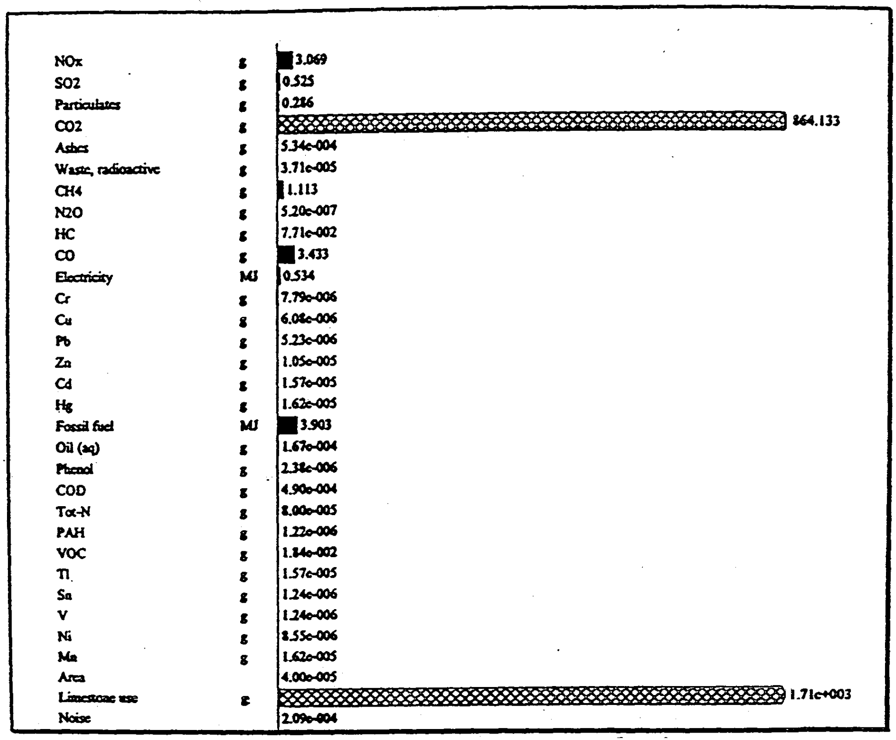

Figure 3: Example of environmental interventions for cement (left) and of a LCI for 1 t of cement (right)

The second one is the Life Cycle Impact Assessment (LCIA).
This long list from the LCI above can be reduced to a set of 6 - 12 figures.
This classification step into impact categories enables an analysis that is more meaningful. The emissions of carbon dioxide, methane and nitrous oxide contribute, e.g., to the global warming impact.
In the LCIA the environmental interventions of the LCI are first classified *and* then characterised. Characterisation is the translation from load into impact. The emission of methane is, e.g., 21 times more effective as carbon dioxide per kg of emitted substance in terms of global warming, nitrous oxide is 310 times more effective as

carbon dioxide. The overall result is the sum of the different impacts from a specific impact category (see: figure 4).

Greenhouse effect
Ozone layer
Ecotoxicity
Human toxicity
Eutrophication
Acidification
Summer smog
Energy resources
Solid waste

Figure 4: Example of impact categories

The number of impact categories is not really fixed. In theory 17 impact categories can be defined. Practically speaking scientific consensus is only reached for less than half of this number. Another problem is that LCI-data for a functional unit are not always available for all impact categories. If less than five impact categories are elaborated upon, one should not declare a full LCA.

In order to assess the environmental impact a conversion factor is needed. The comparison of the impact with the conversion factor is called normalisation. Normalisation is usually the last step in a LCA. Characterisation and normalisation factors are listed in the pan-European conversion model.
In order to perform an LCA a lot of data mining and calculation has to be done. There are well-tried and proven software programs on the market to facilitate this task.

Finally, in some cases, a single final value or score is to be obtained. This single value is obtained from the LCI or from the LCIA adding up the different environmental interventions or different impact categories, mostly through the use of coefficients based on social or political preferences. This means that a single value is not based on scientific considerations.
Figure 5 summarizes these three types of results.

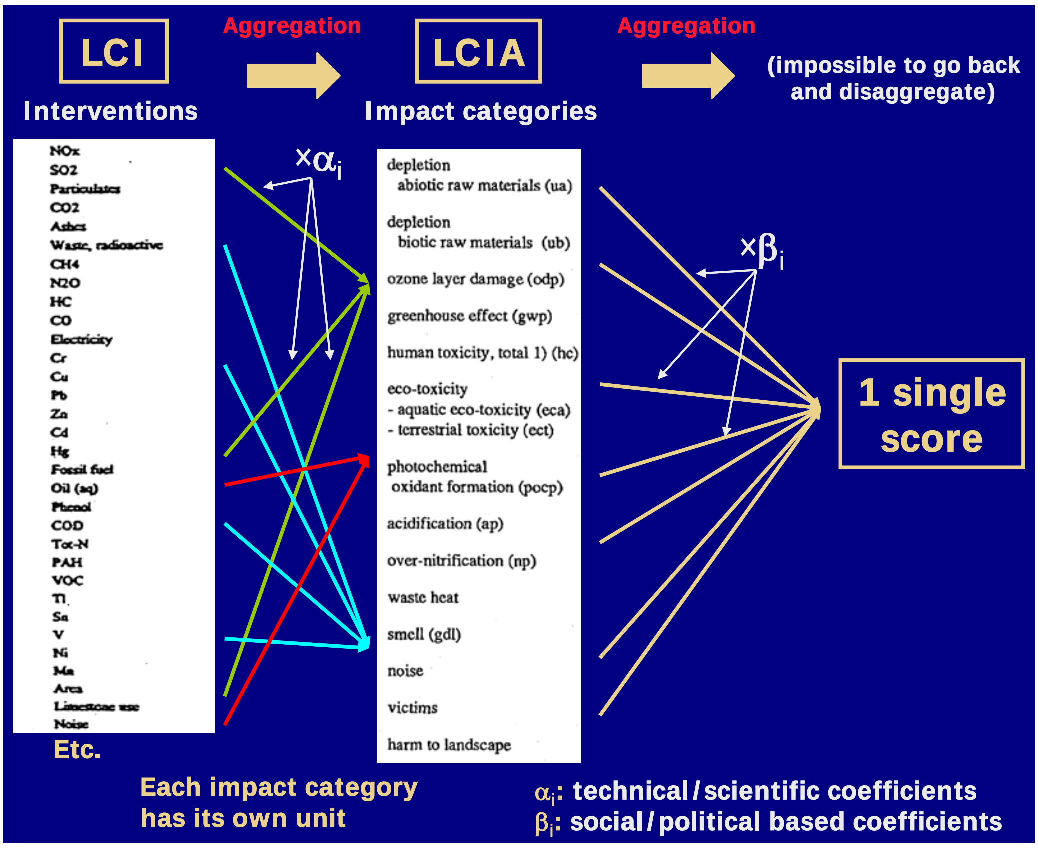

Figure 5: Summary of results of a LCA

All LCI's, LCIA's and LCA's are limited by specific temporal and spatial conditions. The change of the functional unit, the system boundaries, the time, etc. as well as the source or accuracy of data may affect very significantly the results. This means that all these points have to be very clearly defined and reported when producing a LCA or when giving the corresponding results.

LCA results may be used for a number of purposes. For instance:

1. The environmental improvement of specific processes or products
2. The environmental comparison of alternative functional units.
3. Communication of environmental information of products via Environmental Product Declarations (EPD's).

EPD's are allowed for both cradle-to-grave and cradle-to-gate. The latter provides an opportunity for manufacturers to give environmental information on intermediate construction products like cement that are applied in many applications.

For those who would like to do some further reading on LCA we recommend:
Handbook on Life Cycle Assessment – Operational Guide to the ISO-standards, Jeroen B. Guinée, Kluwer Academic Publishers, Dordrecht 2002, 692 pp
The Hitch Hiker's Guide to LCA. An orientation in life cycle assessment methodology and application. Henrikke Baumann, Anne-Marie Tillmann, Studentliteratur, Lund 2004, 543 pp

3. Life cycle context of cement.

Cement is an industrial fine powder which mixed with water sets and hardens being able to reach very high strengths. The main applications of cement are in mortars (mix of cement, water and sand) and concretes (mix of cement, water, sand and coarse aggregates. Basically cement is the binder of the fine and coarse aggregates in concrete. Cement properties comply with the European standard EN197.

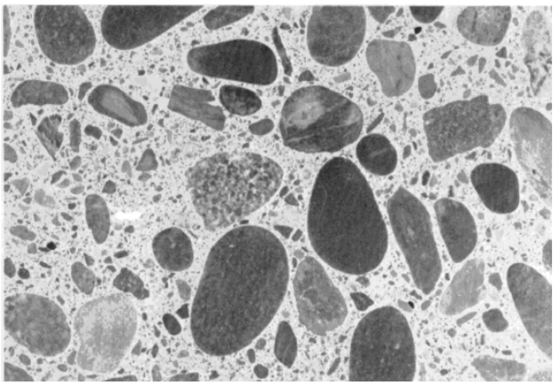

Figure 6: Cross section of a hardened concrete sample. Cement glues sand and coarse aggregate particles together

The main raw materials for cement, mortar and concrete production are basically natural stones and formations like limestone, clay and mineral aggregates which are the most common geological materials on earth. When they set and harden they actually become artificial stones, having similar chemical compositions as their raw materials but with the particular shape, texture, and physical and mechanical properties designed for them.

The use of concrete comprises a wide set of applications including all types of basic infrastructures (buildings, roads, bridges, dams, water treatment plants, etc.). It is also an essential material in a wide range of environmental applications like the treatment of brown land, the prevention of soil or water contamination, or the land protection through different types of structures (retaining walls, breakwaters, flood defence etc.).

This wide range of uses is possible due to the versatility of cement and its applications. Concretes can reach extremely high strengths, can be porous or very tight, can have from low to very high densities, can be coloured or textured in surface, can be used in small and thin or in massive elements.
And in all applications it is very durable and requires, as natural stone, very little maintenance.
Other relevant properties are their thermal inertia for thermal efficient buildings and their resistance to fire.
Concrete can also be combined with other materials to optimise some of its properties.

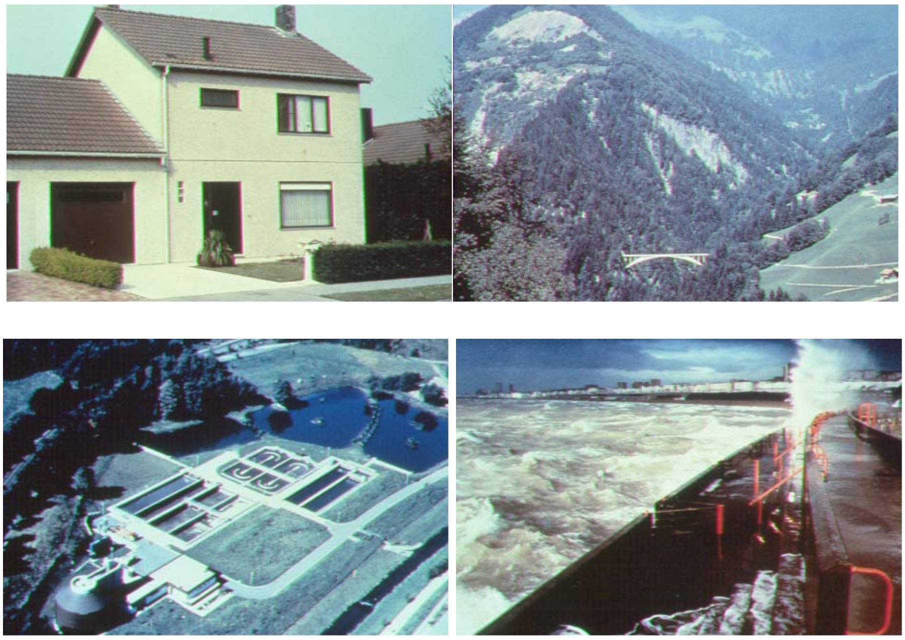

Figure 7: Examples of the applications of concrete

4. What is the use of an EPD for cement?

Since cement has many applications, an EPD of this material can only include the environmental effects that are produced until the manufacture (and storage) of cement. It does neither include the effects of its transport to the building site or concrete factory, nor the use and disposal ("analysis/declared unit"). But it does include the products that are purchased by the cement industry and – by definition - the several types of waste that are produced by the cement industry. This means that the information in the EPD for European cement doesn't cover the complete life cycle of the material, though…… it is no less than a prerequisite for defining the total environmental effects of the life cycle in which cement plays a role.
It is no use to compare intermediate products like 1.000 kg of steel, concrete and timber since these materials don't fulfil the same function.
The one and only basis for comparison are functional units. A functional unit is an end product that complies with a pre-defined set of functional requirements. For instance a concrete column with a length of 3,80 meter, a life time of 75 years and a load bearing capacity of 75 kN can be compared with one designed in steel.
A comparison can also take place between a reference solution and an alternative solution that are made with the same material. Always on the basis of a functional unit and the same set of requirements of course!

In many cases the environmental impact of cement is only a part of the total impact. Cement is first of all incorporated in many products. And in many cases the use of a concrete road or bridge surpasses the environmental load that is caused by the production and construction of that specific device.
Protruding benefits of concrete may also be social and economic. Don't forget: sustainability is more than 'just' environment!

5. Other environmentally relevant effects of cement production

In short EPD's express the environmental impacts of products.
Basically it expresses the sum of environmental burdens and unburdens.

Cement production plays a significant role in saving the environment, in the efficient use of natural resources and of fossil fuels. Many industrial wastes are used as alternative fuels and/or raw materials in the cement industry. Such materials, that are not taken directly from the earth's crust and therefore may have a zero depletion factor, can be used:

- as a raw material for the production of Portland clinker, an important constituent of cement.
- as a raw material for the production of cement.
- as a fuel for the clinker burning process.
- as an (inert) filler in cement.

Some selected combustibles that are used as alternative fuel in the cement factory are dried sewage sludge, animal meal and used tyres. Alternative fuels replace fossil fuels. Some cement factories don't use alternative fuels at all, where others go up to 90% of their total fuel demand …

In EU-25 countries substitution of traditional fossil fuels in the cement industry by alternative fuels has increased from 3% in 1990 to 18% in 2004 on average. In the Netherlands it's even 75%, in Germany and Austria it's around 50%. Already an equivalent of 2,5 Mt of coal is saved by the use of alternative fuels by the European cement industry. 26 CEMBUREAU member countries produce a stable 250 Mt of cement per year. In 2000 China alone produced 576 Mt. In 2015 that will be 800 Mt.
The use of wastes in cement factory kilns where the temperatures can go above 1450 ºC, is not a "disposal" process but it is a "recovery" process since the burning is very efficient and even the non-combustible parts of the waste are consumed as raw materials for cement.

Industrial wastes and by-products such as blast furnace slag from iron industry, fly ash from coal fired power plants, other industrial slags, sludges and ashes, desulphurization products (FGD-gypsum) are used as a raw material for cement production. Depending on their specific composition they substitute raw material components and/or can be used as corrective materials for the raw mix or ground with clinker as admixture. Such brings several environmental benefits:

- Conserving natural resources by (partially) replacing raw materials (limestone, clay, natural gypsum) and intermediates (clinker).
- Reduction of the CO_2 emissions caused by decarbonation of limestone.
- Reduction of emissions caused by the clinker burning process.
- Saving the waste-producing industry from disposal measures, land filling etc. which could adversely affect the environment.

The cement industry is interested in using industrial by products such as fly ash and blast furnace slag also for technical reasons. The cement standard EN 197-1 includes several types of cement that can have fly ash additions up to 35% and slag additions up to 95%. Annually more than 40 Mt of fly ash and 25 Mt of blast furnace slag are produced in the EU.
Of a total cement production of 213 Mt/a in EU-25 today 7,4% is Portland fly-ash cement and 5 % is blast furnace slag cement. Thus the cement industry solves the environmental problems of several industries!

One should realize that an EPD (partially) takes into account the beneficial contribution of alternative raw materials and fuels to the environment.

The word partially is placed between brackets because in some cases LCA-allocation (or should we say accounting?) rules and system boundaries prevent the cement industry to take maximum benefit from alternative materials and fuels.
The second reason is that different authorities treat raw materials and fuels differently as well. Further international standardisation on what are primary or alternative fuels are and what biomass exactly is has to take place yet.

Throughout the EPD the cement industry has chosen the conservative approach: in case of doubt materials and fuels are called primary and bear the full environmental load. Secondly, the independent third parties that check LCA-data, the so-called peer reviewers, using a precautionary approach. As a result of this the environmental benefits of cement may be a little bit underestimated in the EPD for European cement and the impacts overestimated.