

The role of LCA to assess environmental performances of mineral construction materials production in Portugal and in Italy

Il ruolo dell’LCA nella valutazione ambientale della produzione di materiali per l’industria delle costruzioni in Portogallo e in Italia.

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Abstract

The growing interest towards the protection of the environment and the correct management of natural resources is being pursued through the implementation of new strategic policies which are aimed at improving, at the same time, the efficiency of processes as well as the eco-compatibility of products. The above mentioned strategic policies are based on two milestones which are discussed in the paper. First, the perception that the environmental performance of a product should be evaluated throughout its whole life cycle (production, use, recycling and disposal). Second, the policy-makers, with particular regard to the EU, have based their environmental strategies on the active involvement of all those subjects that have a role in the matter: namely everybody, from the producer to the final user. Within this framework, the production of cement in Italy and Portugal is analysed through LCA methodology and the results are presented and discussed in the paper with particular regard to both the role and the environmental impact of mineral commodities in the economy of an industrialised country.

Riassunto italiano

Il crescente interesse per la protezione ambientale e la corretta gestione delle risorse naturali è accompagnato dall'adozione di nuove strategie politiche intese a migliorare, al tempo stesso, l'efficienza dei processi produttivi e l'eco-compatibilità dei prodotti. Queste strategie si basano su due premesse fondamentali, che sono discusse nell'articolo. La prima è la convinzione, ormai universalmente condivisa, che le performance ambientali di un prodotto devono essere valutate lungo tutto il suo ciclo di vita, dalla produzione all'impiego al riciclaggio allo smaltimento. La seconda è la presa d'atto che i responsabili delle politiche ambientali, e in particolare le Commissioni EU, hanno basato le loro strategie sul coinvolgimento attivo di tutti i soggetti che intervengono in qualche modo nel ciclo di vita del prodotto, dal produttore al consumatore finale.

In questo quadro, l'articolo prende in considerazione la produzione di cemento in Portogallo e in Italia e ne analizza i dati nell'ottica della metodologia LCA. I risultati sono presentati e discussi con riferimento specifico al ruolo socio-economico e all'impatto ambientale che le relative materie prime minerarie hanno nell'economia di un paese industrializzato.

1 Introduction: construction industry and sustainable development

The spread of philosophies arisen from the Sustainable Development concept has deeply changed many human activities. The rising interest towards the environment and the proper management of natural resources, that several times conflicted against economic growth requirements, made it possible to find out new strategies and policies that claim for a renewal of many economic sectors.

Industry, for instance, that is an activity based on transformation of natural raw materials and therefore thought to be responsible of most environmental concerns, is probably the field in which the change is more remarkable. "Industrial Ecology" is an expression of this process towards a sustainable production.

It is well known how manufacturing industry requires huge inflows of raw materials and energy and, at the same time, how not only production of goods but also their uses are source of pollutants and wastes. In such a context industrial ecology represents the proper way to run industrial activities taking into account their environmental impact in terms of both pollution and depletion of resource stocks. Industrial Ecology is then the keyword that is changing a lot in the field of construction industry.

Building and construction activities deserve attention due to their remarkable economic significance, but, at the same time, are source of concern due to their environmental impact.

With reference to the produced wealth, one must consider that 4.8% of the Italian GDP, in 2001, can be ascribed to the construction sector (ISTAT 2003), the nominal overall growth of the sector in the same year being 7.2%. If we consider the downstream linked activities, the contribution to GDP rises up to 14%, in case building leases are included. These are figures that unambiguously show how construction industry represents a core contribution to the national economy and, in particular, to its growth.

Such economic benefits are emphasized by the employment statistics, according to which the contribution of construction and downstream linked activities reaches 7.9% of the national occupation.

On the other hand, one must consider the negative environmental aspects that can be ascribed to the growing use of land resources, energy and consequent air emissions. Obviously, the heavy economic weight of the sector emphasizes these negative aspects.

The modern construction industry makes an enormous use of raw materials and resources with or without energy content. The consumption of natural aggregates, for instance, officially reached 300 million tons in Italy and 80 million tons in Portugal, with reference to the year 2000, that means 6 and 8 tons per capita respectively. Even larger figures describe the situation in the US: 8.7 tons per capita in 1997 (USGS 1999). Another basic material for the sector is cement, huge quantities of which are used in many building activities. In this case, as well, figures are impressive: 40 million tons used in Italy in 2001, around 700 kg per capita; 10 million tons used in Portugal in the same year, over 1000 kg per capita. Similar statements can be made for other most common building materials such as bricks, iron bars, mortars, plasters and more.

Now, if we leave the technical and economic aspects and start dealing with the environmental impacts, we can draw other useful remarks.

Considering the case of cement, it is interesting to remark how its production is demanding in terms of both energy and non-renewable resources. In order to quantify these impacts, it is worth to remark that, with reference to year 2001, almost 3% of world total consumption of primary energy and 6% of greenhouse gas emissions can be ascribed to the production of cement (IEA 2003, UN-FCCC 2004, USGS 1999). The same analysis, referred to the Italian cement industry, shows a 3.7% contribution to primary energy consumption and 7% to greenhouse emissions in the country (AITEC 2002, ENEA 2003).

In order to extend this consideration to the whole construction industry, it is necessary to include other construction materials and, moreover, it is fundamental to consider the use phase of buildings.

According to the official statistics for the year 2001, the contribution of the overall Italian construction industry was 6% in terms of energy consumption and 10% in terms of greenhouse emissions. The use of energy in the residential and service sectors, that is strictly related to the use phase of buildings, was 30% of total (ENEA 2003).

All this considered, the application of sustainable development concept to the construction industry is not an easy target. In particular, the effectiveness of de-materialization policies promoted by EU must carefully be evaluated. Of course, due to the huge flows of materials and their environmental loads, the margin of improvement is promising. Nevertheless, it is worth noticing that construction industry is basic for both economy and employment and then adequate flows of materials and energy must be made available.

Construction industry is changing and, in order to allow that process, construction materials must be characterized by sustainable features. The most a given material is sustainable the smallest is its environmental impact during all life phases. Then, sustainable materials must allow a reduced consumption of energy and generate less waste and emissions during the extraction phase and subsequent production activities up to the final disposal phase.

2 Construction industry and life cycle assessment methodology

Criteria for assessing the sustainability of construction materials are not universally recognized and accepted. The definition itself of ecological material is still a controversial point.

To be sustainable, materials should be healthy, natural, renewable, recyclable, pollutant free and so on. But all this is not enough. For instance, a natural material whose production shows low environmental loads can, during the use phase, show lower performances and then cause higher impacts due, for example, to a larger consumption of energy.

In other words, the choice of materials that support the change of construction sector towards sustainability is a very demanding task. At least this material selection must prove and quantify eco-compatibility.

The methodology that better than any other allows this quantification, and is more and more spread, is LCA (Life Cycle Assessment). Such a methodology, that is likely the world best accepted, allows an objective measurement of environmental performances of products.

LCA is a technique for assessing the potential environmental impacts associated with a process or activity from “cradle to grave”, that means, in the case of construction sector, from raw material mining, to materials production, building construction, their use until demolition, recycling and disposal (Badino et al. 1998).

As is known, the “life cycle” approach to process analysis, originated in the 1970s from energy analysis studies and resources and environmental profile analysis, in 1990 had a systematic definition by SETAC (Society for Environmental Toxicology and Chemistry). In 1997, LCA methodology received an international recognition, becoming object of the ISO 14040 standards.

According to these standards, LCA methodology comprises four stages (fig.1). The Inventory phase (LCI) is the core stage, that must be supported by dedicated software in order to build a research

model and outline the environmental inputs and outputs relevant to the object under study. The results of the analysis, a task of LCIA phase, consist in gross energy requirement and pollutant emissions values, that should be interpreted and used for process improvement purposes and also for the selection of environmental best practices and technologies (Badino et al. 1998).

It is important to underline that, in accordance with its structure (fig. 1), LCA methodology can be applied to different systems defined by fixed boundaries, depending on different objectives. This means that, instead of a complete LCA “from cradle to grave”, the analysis of a production activity can be limited “from cradle” to the end of the production process.

This is the case of the present research work, the aim of which was to evaluate and compare the environmental efficiency of the production of cement in Italy and Portugal. At this aim DIGET of *Politecnico di Torino* and CEGEO of *Instituto Superior Tecnico de Lisboa* are co-operating with Italian and Portuguese most representative cement producers: respectively BUZZI-UNICEM and CIMPOR.

LCA indicators of Italian cement (BUZZI-UNICEM 2001, 2004) are compared with preliminary indicators carried out on Portuguese cement produced by Cimpor at Alhandra plant.

The following software applications were used: Boustead Model 5.0, SimaPro 5.1 and an Italian LCA data base I-LCA 2.0.

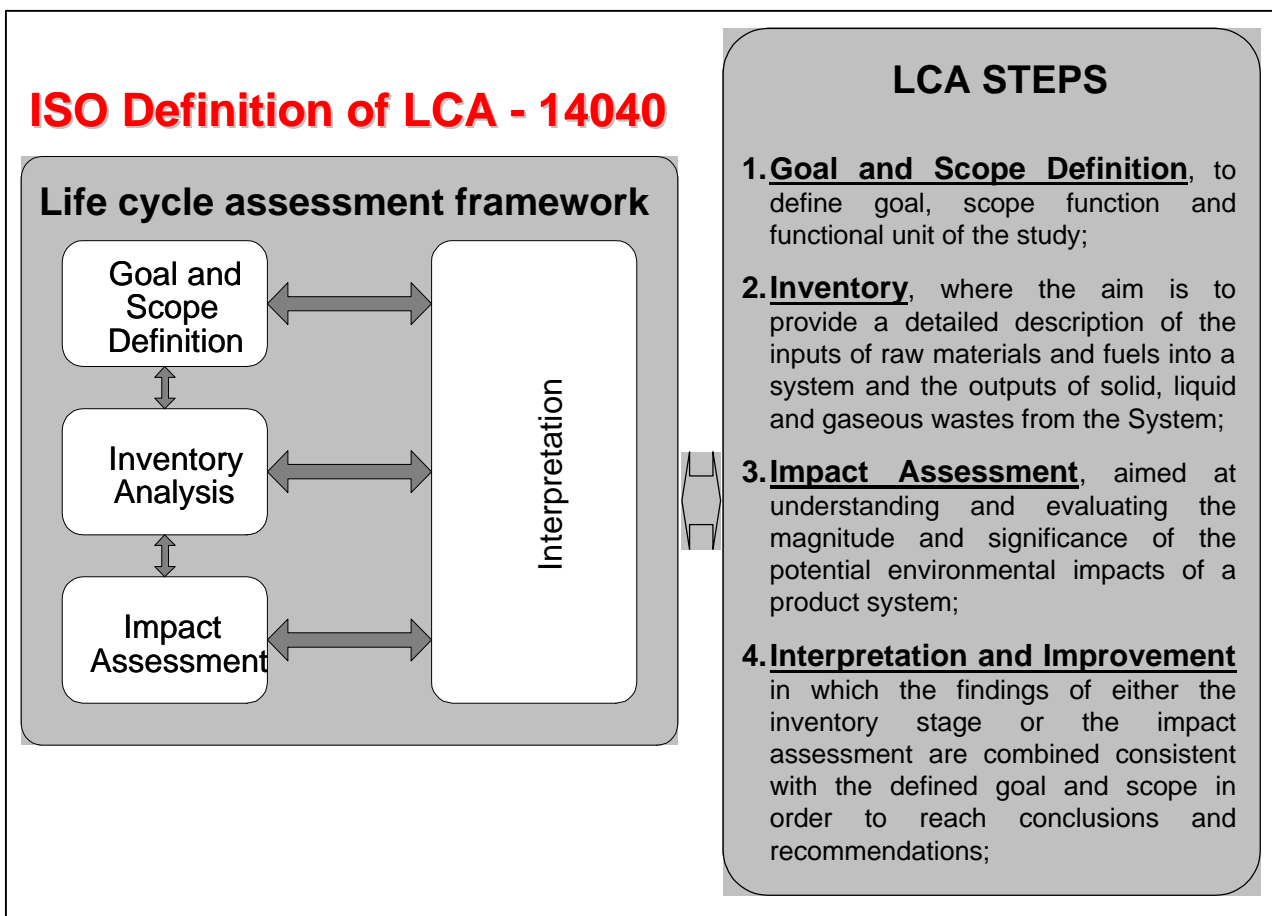


Figure 1: Life Cycle Assessment phases according to ISO 14040

Figura 1: Fasi della Life Cycle Assessment secondo la normativa ISO 14040

3 Cement production in Italy and Portugal

LCA studies were carried out on two cement factories: Vernasca (Italy) plant run by BUZZI-UNICEM and Alhandra (Portugal) plant run by CIMPOR.

Figure 2 shows the production sequence for cement production in which main operations are outlined. Basic raw materials such as limestone and shale are quarried by drilling and blasting method and then transported to the cement factories that are located at distances up to 40 km. Following the storage and preliminary homogenisation phases, raw materials are crushed and then conveyed into the clincker kiln. Firing of clincker at 1400 –1500 °C is achieved by use of coal and petcoke fuels. Fuel oil is used for the start up of the kiln. Clinker is then fine ground and mixed with gypsum, fly-ash and additives in order to obtain the cement. Finally, cement is bagged and distributed to the final users.

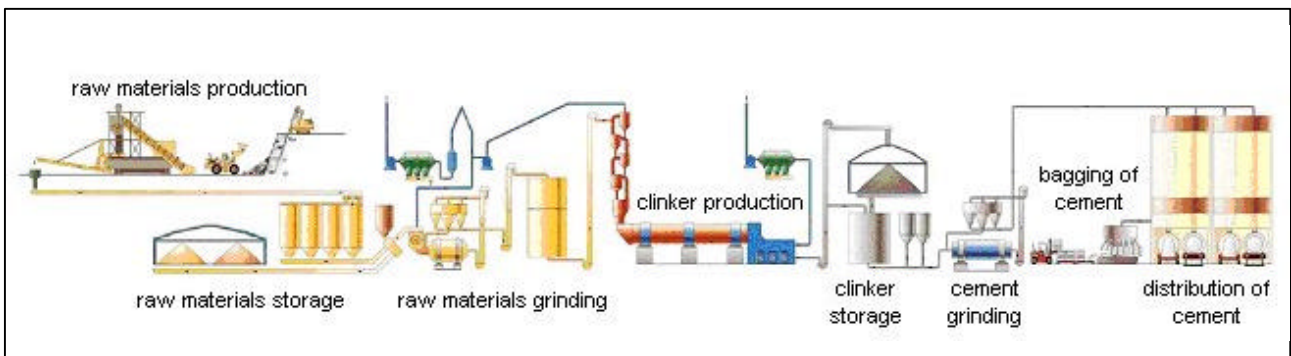


Figure 2: Cement production flowchart (Buzzi-Unicem 2001)

Figura 2: Schema tecnologico della produzione del cemento (Buzzi-Unicem 2001)

Buzzi – Unicem group is the second Italian cement producer with 3850 employees and 1450 million euros turnover. The group runs 11 cement factories in Italy that covers 19% of Italian market share. Production capacity at Vernasca plant is 1 million tons of cement.

Cimpor is the largest cement producer in Portugal with 1350 million euros turnover. The company runs 3 cement plants in Portugal supplying nearly 58% of the Portuguese market share. Production capacity at Alhandra plant is 2.6 million tons of cement per year. This company is engaged in a proactive action to comply with national and international regulations on environmental quality and sustainable development guidelines.

4 LCA results

LCA of average cement (most represented is CEM II/A-LL 32,5 type) has been carried out according to ISO 14040 standards. All figures presented in this paper refer to 1 ton of cement equivalent as adopted functional unit.

The construction of the model, or Inventory phase, has been performed according to the scheme described in figure 3. As stated above, the use phase and end of life phase have, at this stage, being excluded. The LCA analysis is then an ecoprofile of cement from cradle to gate. A further LCA study on concrete in co-operation between DIGET and Buzzi – Unicem is now in progress. Finally, analysis of environmental impacts of the LCI phase is consistent with ISO TR 14025 (SEMC 1999).

Impact indicators chosen for this study were: GER (Gross Energy Requirement) as parameter relevant to depletion of fossil fuel resources, and GWP (Global Warming Potential) as parameter relevant to greenhouse effect. GER is expressed in MJ and represents the total primary energy that must be extracted from nature. GWP is expressed as quantity of carbon dioxide equivalent (CO₂eq) released.

Figure 4 shows the results of LCIA of average cement produced by Buzzi – Unicem and Cimpor and emphasizes the differences between results achieved.

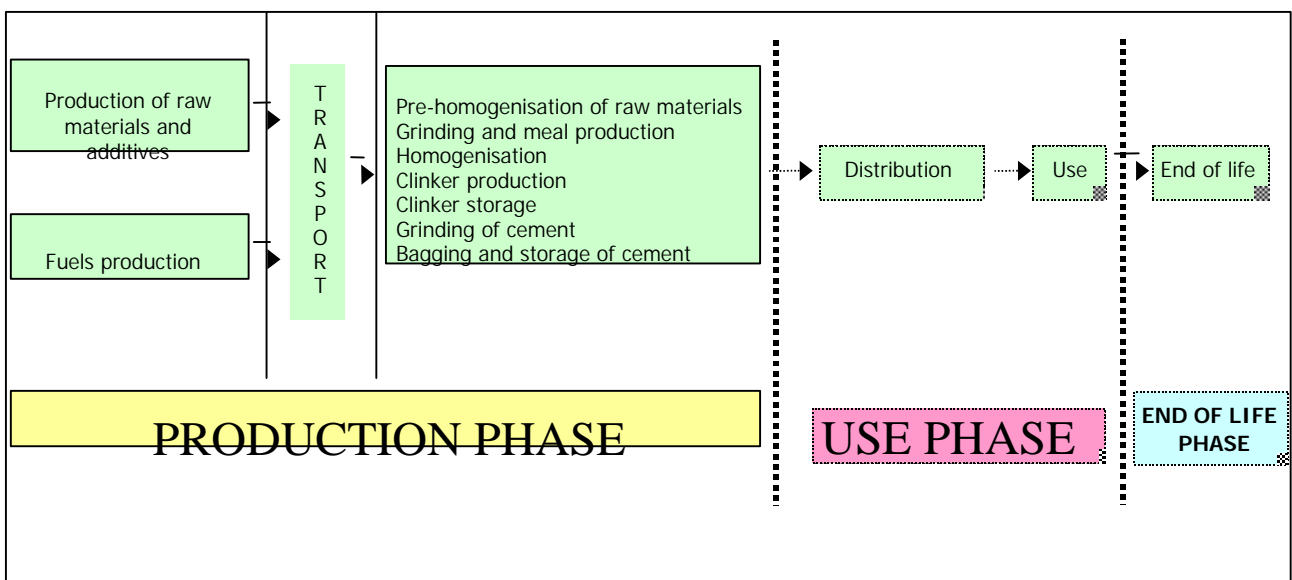


Figure 3: LCA of cement. Life phases included in the model (Buzzi-Unicem 2001)

Figura 3: LCA del cemento. Fasi del ciclo di vita considerate nel modello (Buzzi-Unicem 2001)

GER and GWP values have been calculated as an average of results achieved through Boustead Model 5.0 and SimaPro 5.1.

Total GER and GWP indicators of Cimpor cement are higher than Buzzi – Unicem cement, respectively 21% and 3% higher. However, impacts of raw materials production phase of Cimpor are lower than those relevant to Buzzi Unicem.

It is interesting to remark what is the contribution of the production phases to the overall indicators. Raw materials quarrying phase gives a contribution from 2 up to 11% of total impact. Transports give a contribution from 1 to 3% of total impact.

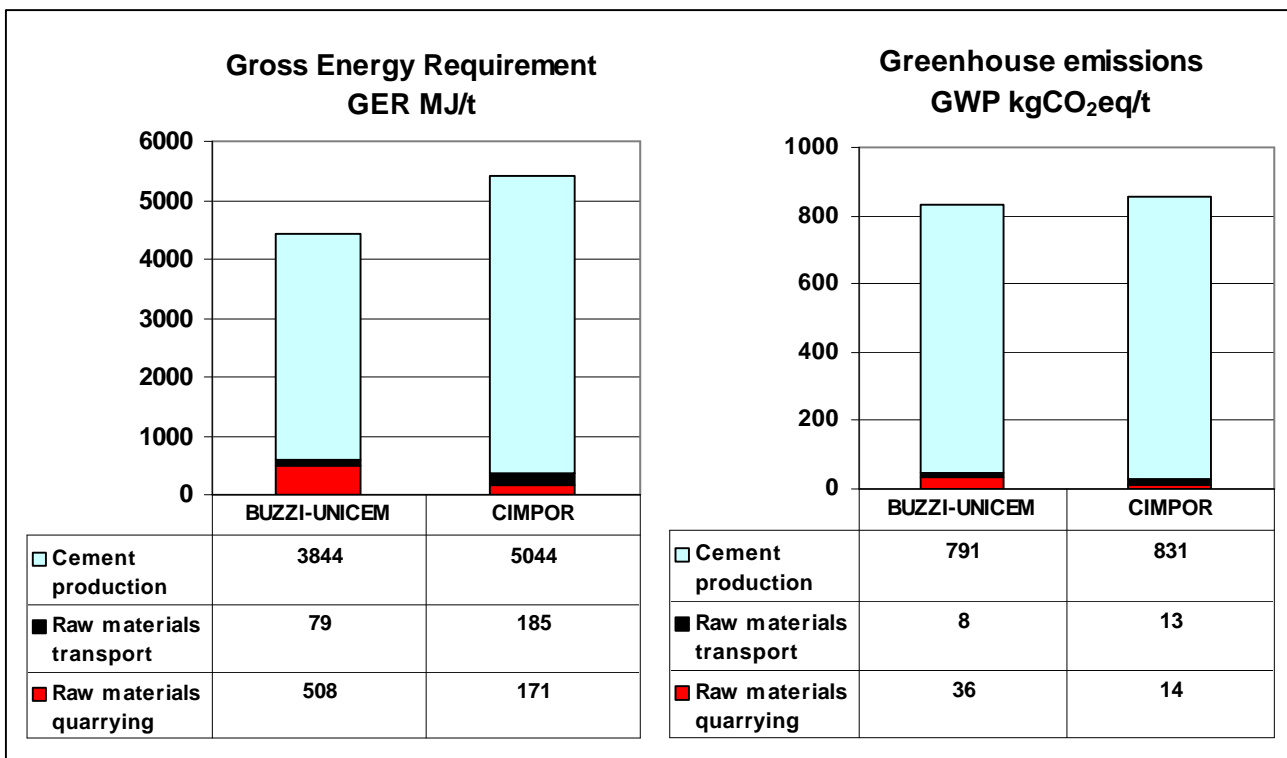


Figure 4: LCA impact indicators for 1 ton of cement produced.

Figura 4: Indicatori di impatto derivanti dall'analisi LCA calcolati per 1 tonnellata di cemento equivalente.

Conclusions

The goal of the present paper was not a fully detailed description and application of LCA methodology, but to show how results achieved through LCA could support changes towards sustainable development.

It is not easy to classify building products according to their environmental sustainability, due both to lack of information and lack of a generally accepted methodology of evaluation.

It is then of the utmost importance to find out and apply objective, credible and standardized criteria that allow comparisons based on significant figures.

Such an approach is represented by environmental management instruments based on life cycle analysis of products according to ISO 14040 standards.

While presenting the results of a research work on cement, the paper has emphasized the advantages that such a kind of analysis can offer in terms of decision support or product improvement, necessary to reach the sustainability goals of the construction industry.

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