



1.3.2. REPORT ON METHODOLOGIES FOR CALCULATION OF CO₂ EMISSIONS IN CONSTRUCTION PROCESSES IN SPAIN

OERCO2
ONLINE EDUCATIONAL RESOURCE FOR INNOVATIVE STUDY OF CONSTRUCTION
MATERIALS LIFE CYCLE

This project has been funded with support from the European Commission.

This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein

This report reviews the existing methodologies in Spain which is possible to estimate CO2 emissions associated with building sector. Some of these tools are translated versions of internationally known methods, whilst others have been developed in our country departing from research projects in recent years.

Firstly, are described the methods of certification of the building contemplated the CO2 emissions associated to the building materials. These affect the endpoint scores, although do not appear us such a numerical value of kilograms of CO2 emitted into the atmosphere.

Spain Green Building Council (SpainGBC), leads the use of the LEED certified in Spain with its version 4 [1], where the fields of application have been subdivided into five categories: buildings, interiors, operation and maintenance, urban development, y housings (Fig. 1). For each of these categories are evaluated various aspects, including CO2 emissions stem from the manufacture of construction materials and the energy consumed by the operation of the building. These are related to the use of clean energies, the adaptation to energy efficiency of building relative to demand, the using of sustainable materials, supported by Environmental Product Declarations (EPD), or the proper management of waste. The measures taken as CO2 emissions in the design, construction or operation of the building designed affect to the amount points for the final evaluation of the LEED certificate.

With this certificate, can be obtained basic, silver, gold or platinum level, depending on the score achieved.



Figure 1. Certified LEED categories in Spain

Similarly, Spanish version of the certificate BREEAM [2] is subdivided into five categories equivalent to LEED, replaced interiors category by a new type “Customized” (Fig. 2). The system is similar, with different aspects scores about the evaluated building. Whereas these methodologies require a quantification of

CO2 emissions by the professional certifying body to award the score in the respective sections, these is not numerically reflected in the final certificate, which is based just on the total score. It can be said that BREEAM, together with LEED, are world leaders in sustainable buildings certifications, although are emerging alternative tools in Spain, some of them from the academic sector.



Figure 2. Certification arrangements BREEAM ES

The Green Building Council also contains a set of tools VERDE [3], involved on the help to design (HADES), new building (VERDE NE), renovation (VERDE RH), and urban development (VERDE DU). These tools give the highest weighting to greenhouse gas emissions (GEI), about 25%, to emphasise its importance about environmental impacts that they wish to avoid.

On the other hand, exist energy rating tools, which is possible to estimate CO2 emissions that will take place as a consequence of the energy demand in the use of buildings. Do not take account the CO2 corresponding to building materials used, only analyse the use phase of the buildings.

These tools fall into two categories: on the one hand, which is used for simplified calculation procedure, only apply to existing buildings; and in the other hand which use the general procedure, more complex, and is compulsory for newly constructed and tertiary buildings, although they too use to existing buildings. Among the first are CE3, CE3X, o CERMA [4], developed by partnerships and Spanish universities. Like documents acknowledged for existing buildings we have the Unified Tool LIDER-CALENER [5], developed by Sevilla University, and CYPETHERM [6], by CYPE Ingenieros. All of them give estimated results of kgCO2 per m2 constructed.

Lastly, there are several more specialised platforms which permit detailed calculation of CO2 emissions based on buildings projects measurements.

The first to appear was the price bank BEDEC [7], developed by the Institute of Building Technology in Cataluña. This bank allow to measurements in each code are included incorporated energy data and CO2 emissions of the building materials, as well as the generation of construction and demolition waste (RCD) derived from the use of them.

For the elaboration of the bank BEDEC, the information was extracted from the database Ecoinvent de Análisis de Ciclo de Vida (ACV)[8], it's known to be one of more comprehensive bases at the European level, and by its integration with ACV Simapro software.

In the analysis of the bank BEDEC, the information on the CO₂ emissions of the materials takes into account the extraction of raw materials, the transport from origin to the factory, and its processing in the factory.

The processing in the final construction product and the transportation to the building site are not included, so we can assume that this bank implements an ACV model from start to finish, except some transformations to obtain a construction product. This tool does not show visible linking of information resources or analysis applied to each material, as is the case with other ACV database like Ecoinvent, consequently its lack of documentation and traceability constitute the main drawback. Despite these problems, currently it is the most deployed database in Spain for environmental analysis of the building process [9], since it includes a wide range of constructive elements, which facilitates the analysis of entire buildings.

The arCO₂ tool is a calculator that permit us to estimate the Carbon Footprint from start to finish obtained from the measurements and budget of a project [10]. In addition to greenhouse gas emissions (GEI), it is possible to obtain the weight of the materials or the proportions between materials and others. This application forces to use the base of prices CENTRO of Guadalajara, respecting their structure formed by Chapters and Work Units.

For the carbon emissions of the materials, arCO₂ uses a database called OpenDAP, in which emissions factors have been obtained in turn from various sources: UE sectoral reports, ITeC databases (BEDEC), DAPs of product, Inventory Carbon and Energy (ICE), PE 2 Inventory, Highway Agency carbon calculation, among others [11]. Finally, arCO₂ reports the total project emissions according to three different functional units: kgCO₂/m², kgCO₂/user, y kgCO₂/€.

Also in 2014 and like result of a development project from the Ministry of the Economy and Competitiveness, SOFIAS was born as a tool that currently can only be accessible in a test version via project platform [12]. This application analyses the complete lifecycle of buildings on the basis of input by the user of constructive solutions. For the CO₂ emissions, respective buildings materials use, as well as arCO₂, OpenDAP database. As a complete life cycle analysis, it includes hypotheses about transport of materials, impact of operational energy of the building, replacing materials once the work is finished, and the subsequent waste treatment [13].

E2CO₂Cero is IT tool for calculate the embedded energy and the carbon footprint of a building, according to the incorporated materials and building process used during the construction phase. It allows successive assessments at different stages of the project based on the level of existing knowledge [14]. The embedded energy is the TOTAL ENERGY consumed for the construction of a building. It includes the energy used in manufacturing processes of products or materials used for the construction, the energy consumed by the transport of these materials to work and the energy used by machinery in the execution of the different work units. In addition to embedded energy, the tool calculates CO₂ emissions associated



with extraction, manufacture, transport and application of the materials, as well as execution of the work. This application also forces to use the base of prices CENTRO of Guadalajara, respecting their structure formed by Chapters and Work Units. The IT tool has been subsidized by the Basque Government and the consortium of management companies is also from País Vasco. It is available in two software versions: full and simplified version. In the first one is necessary to incorporate in the project measurement and in the second does not.

It could also be argued that the tool implements an ACV model from start to finish.

ECOMETRO is an open source tool for measuring and transversal reading to the ecology in the design process, construction and use of the buildings, that quantifies the impact on the Earth, as well as ecosystems and human health. It uses an analysis life cycle language, and it is presented in a digital format by a programme (Open Source) through a website that measures the environmental impact of a building. It is similar to the environmental statement for a product but of a building, it is not a green label, it is not a medal, nor is it a prize, it is just an environmental statement and not social. It measures and communicates the findings as impacts to do the job and correct the results in the phase of an architecture project. These impacts set out five different categories, where we group similar indicators by families related to a main criterion, design, material, energy, water or environment.

Impact categories are valued by the tool for which there is international consensus; this is, climate change, depletion of the ozone layer, eutrophication, acidification, formation of photochemical oxidants and depletion of resources just like other impact categories: land use, ionizing radiation, toxicity or primary energy consumption. Included in the analysis stages are extraction of raw materials, production of buildings materials, transport to the work area, installation and maintenance. This evaluation must be carried on the basis of input from the tool's database or through registries established by the own user on the basis of information provided in environmental statements of product (eco-label type III).

References

- [1] SpainGBC. Certificado LEED. <http://www.spaingbc.org/web/leed-4.php>
- [2] BREEAM ES. <http://www.breeam.es/index.php/certifica/esquemas-de-certificacion>
- [3] VERDE. <http://www.gbce.es/es/pagina/herramientas-de-evaluacion-de-edificios>
- [4] MINETUR. Procedimientos simplificados para la certificación energética de edificios. <http://www.minetur.gob.es/ENERGIA/DESARROLLO/EFICIENCIAENERGETICA/CERTIFICACIONENERGETICA/DOCUMENTOSRECONOCIDOS/Paginas/procedimientos-certificacion-proyecto-terminados.aspx>
- [5] Código Técnico de la Edificación (CTE). Herramienta unificada LIDER-CALENER. <http://www.codigotecnico.org/index.php/menu-recursos/menu-aplicaciones/282-herramienta-unificada-lider-calener>



- [6] CYPE Ingenieros. CYPETHERM HE. <http://cypeterm-he.cype.es/>
- [7] Instituto de Tecnología de la Construcción de Cataluña (ITeC). Banco de Precios BEDEC. <http://metabase.itec.cat/vid/#/es/bedec>
- [8] ITeC. BEDEC. Contenido y criterios / Contents and criteria. <http://docs1.itec.cat/e/Guia.criterios.bedec.pdf>; 2015 [accessed 01.09.15].
- [9] Marrero M, Martínez-Escobar L, Mercader-Moyano MP, Leiva-Fernández C. Minimización del Impacto Ambiental en la Ejecución de Fachadas Mediante el Empleo de Materiales Reciclados / Environmental impact minimization of façade construction through recycled materials use. *Inf Constr* 2013; 65(529):89–97.
- [10] arCO2. <http://huella-carbono.es/>
- [11] arCO2c. Guía metodología. http://huella-carbono.es/wp-content/uploads/2014/12/guia.metodologica.arco2_.pdf
- [12] SOFIAS. <http://www.sofiasproject.org/>
- [13] Oregi Isasi X, Tenorio JA, Gazulla C, Zabalza I, Cambra D, Leao SO, Mabe L, Otero S, Raigosa J (2016). SOFIAS – Software for life-cycle assessment and environmental rating of buildings. *Inf Constr* 68(542):e151. doi: <http://dx.doi.org/10.3989/ic.15.055>.
- [14] E2CO2CERO. <http://tienda.e2co2cero.com/>
- [15] ECOMETRO. <http://ecometro.org/>