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1.3.2. REPORT ON METHODOLOGIES FOR CALCULATION OF CO_2 EMISSIONS IN CONSTRUCTION PROCESSES IN ITALY

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

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1. Introduction

One of the most important factor to evaluate product's environmental impact is the calculation of carbon footprint and, in particular, CO_2 emissions. Currently, in Italy there are many different existing methodologies and thanks to these ones is possible to estimate CO_2 associated to construction sector at different level, from material, to component to building scale.

This paper will describe in brief the Italian scenario related to these methodologies. First, building certification systems will be described, which take into account the CO_2 emissions associated with construction materials and calculated by means of LCA methodology. In fact, the estimation of CO_2 emissions is included in the assessment of environmental impact level of building, related to the whole construction process. Some of these certification systems are translated version of international weel-known methods (such as LEED and BREAM protocols), while others have been developed in Italy (Itaca Protocol, GBC Home, CasaClima).

However, carbon footprint calculation, focused on building elements and products is necessary to evaluate the real environmental impact. For this aim, will be described some existing rating tools used in Italy to estimate the carbon footprint and specially the CO_2 emissions of construction materials, from the raw materials extraction, to transport and production process. In particular, will be taken into account both Italian tools and international known ones that are commonly used in our country.

2. Most common building certification systems used in Italy

For what concerns building certification system, one of the most important certificate at international level is the LEED standard. LEED is a voluntary certification scheme regarding all aspects of the building and the context in which it stands, from design to construction and operation (lifetime), and it's applicable to many types of buildings, both residential and commercial. It was created by the American USGBC but it's available in Italy thanks to GBC Italy, that created the national standard **"LEED 2009 Italia"** [1].

This rating system is related to the Italian constructive scenery, standards and production and it's recognized onto global market. LEED certificate indicates the requirements to obtain an environmentally sustainable edifice taking into account the whole life cycle of buildings, from the point of view both of energy consumption and environmental resources consumption in construction process. It's based on pre-defined requirements which correspond to specific weights and scores, whose sum indicates the level of energy and environmental sustainability of the building. These requirements can be classified into seven categories:

- sustainable site

- water efficiency
- energy and atmosphere
- materials and resources,
- indoor environmental quality
- innovation
- regional priority

LEED rating system has different fields of applications:

- new residential and no-residential buildings (Building Design & Construction – Schools – Core & Shell)
- existing buildings (Existing Buildings Operation & Maintenance)
- urban areas (ND - Neighborhood)

For each of these categories are evaluated different aspects, including CO_2 emissions from the processing of construction products to the energy consumed by the tenants/end-users. According to the total score achieved, it's possible to obtain a basic, silver, gold or platinum level of certification.

Figure 1 - Different levels of LEED certificate in Italy

Moreover, GBC Italy has produced another tool, according to the American "LEED FOR HOMES", known in Italy as **"GBC HOME"** [2]. This tool is focuses only on residential building, taking into account constructive characteristics and models typical of Italian constructions. As LEED 2009 Italia, the tool GBC HOME is based on defined requirements classified into seven categories, which correspond a specific score for each one. In order to obtain the issue of a certificate, a verification by a notified body has to be implemented. This verification stage aims to check the validity of the documentation and, after that, GBC Italy can implement the final checks.

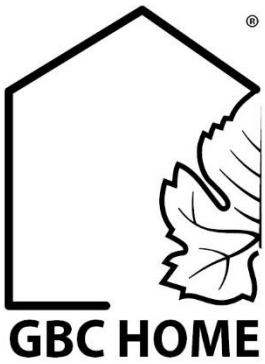

Figure 2 – Icon of GBC Home certificate for residential buildings in Italy

Another world leader in sustainable buildings certifications is the BREEAM certification system - *Building Research Establishment Environmental Assessment Method* – created by the British BRE - Building Research Establishment – in 1990 [4]. Since 2008, protocols **"BREEAM International"** expand the applicability of the certification outside the UK borders and now BREEAM is used in more than 70 Countries, with several ones in Europe, some of which have developed own country-specific BREEAM schemes operated by National Scheme Operators (NSOs) [5].

Italy doesn't have own BREEAM certificate version, but Italian buildings can be certified by BREEAM International. Several standards are available for different application fields: BREEAM New Construction, BREEAM Refurbishment & Fit-out (for new constructions and refurbishments), BREEAM In-Use (for existing buildings) and BREEAM Communities BeSpoke (for master planning). As for LEED, the certification is based on the sum of total scores awarded for each following environmental category:

- Health & Wellbeing,
- Energy,
- Water,
- Materials,
- Land Use & Ecology,
- Pollution,
- Transport,
- Waste,
- Management.

Each of the nine environmental categories has a different weight on the final score depending on the impact that the same category has in the reporting country. (*"weightings"* process). The maximum level is outstanding with a score higher than 85%. After that there are: excellent with

70%, very good 55%, good 45%, 30% and unclassified pass less than 30%. Each level represents the building's performance based on the overall score. Evaluation of CO_2 emissions is part of the parameters analyzed for score awarding.

Currently, in Italy 41 buildings have obtained the BREEAM certification; first Italian certified building was the commercial center Nave de Vero in Venice, which obtained a rating of Very good.

In addition to the environmental sustainability certificates developed on international level, in Italy are increasing alternative certificates. One of the most important is **ITACA Protocol**, national tool for the assessment of buildings environmental sustainability [6]. This Protocol was developed by ITACA's Inter-Regional Group – "Istituto per l'Innovazione e la Trasparenza degli appalti e la compatibilità ambientale" – and it was adopted for the first time on 2004 by Italian Region and Local Public Administrations. Each Region could be adopted own Protocol, but all were characterized by means of equal technical-scientific requirements.

Thanks to the development of ITACA Protocol on national level, the Institute issued the National Reference Practice UNI/PdR 13:2015 [7], which replaced the ITACA Protocols for residential buildings, in order to align the regional protocols to national technical standards. At the same time, ITACA National Protocol was adopted for no-residential buildings on 2015. ITACA Protocol is based on international assessment tool "SBTool", developed in the context of "Green Building Challenge" research project. The project and the tools are related to Italian territory, legislations and environmental characteristics and were developed by ii-SBE Italia. ii-ISBE Italia, together with ITACA and CNR-ITAE, manages ITACA Protocol at national level.

In order to estimate environmental sustainability level of building, the Protocol fixes several criteria to measure the building performance, basing the evaluation on a "score evaluation method". Evaluation criteria are subdivided into five environmental categories:

- sustainable site,
- resources,
- environmental weights,
- indoor environmental quality,
- service.

In order to calculate performance indicators required by ITACA Protocol, the online **tool Proitaca** is used. Thanks to this application is possible to estimate CO_2 emissions, water consumption, waste production and other key environmental parameters [8].

Moreover, with reference to the sustainability of construction materials, one of the most used environmental label to the Italian market is the **ANAB-ICEA** label. This label identifies

construction products which have a lower environmental impact, according to the environmental parameters required by LEED or ITACA certifications, among which CO_2 emissions level.

Another Italian certification system is "CasaClima", very diffused in the northern of Italy. This Protocol is mainly known for buildings energy certification by means of energy classes, related to total energy demand of building. In addition to this certificate, recently has been developed a new one environment-related: **"CasaClima Nature"**. This certification allows to evaluate buildings not only for what concerns energy efficiency, but it considers also the environmental and human health impact, taking into account environmental indicators related to construction materials and constructive solutions. In order to achieve the certification, the CO_2 emissions evaluated from raw materials extraction to construction process, have to be lower than a defined threshold [9].

3. Most common tools for carbon footprint calculation used in Italy

For what concerns the carbon footprint of materials, several rating systems and calculation tools are available at European and international level. These tools are based on LCA methodology in order to evaluate the equivalent CO_2 emissions associated to materials processing. For this reasons, the assessment takes into account the CO_2 emissions in the whole production process, from the storage of raw materials, to the transport and the production.

Currently in Italy, carbon footprint evaluation is commonly calculated referring to European tools and database. Mainly, the most used calculation tools for CO_2 emissions are **SimaPro** (from Netherlands) and **GaBi** (from Deutschland) [10].

These tools were originally used in other European country, but now they represent the world's most widely used LCA software. The concept and features available are very similar, due to the main aim to collect and evaluate information about environmental performances of construction materials in their whole life cycle. In particular, these software allow to calculate carbon footprint and water footprint emissions, and provides data necessary to elaborate environmental product declarations.

In data rating process, these tools exploit specific information provided from material's manufacturers, but refer also to reference databases on materials with still defined environmental performance. Recently, the *European Platform of LCA* was created in order to foster the collection of representative data from the whole Europe. The reference database at European level is the *European Reference Life Cycle Database* (ELCD). It collects environmental indicators of several materials/products evaluated by means of life cycle assessment methodology, in order to allow an evaluation of the environmental quality of products [11].

The Italian situation about this topic is still on late. Currently, the only existing database for Italian construction products was developed on last 2009 by ITACA and is referred only to the ITACA Protocol [12]. In this database, the evaluation of CO_2 emissions and embodied energy of construction materials takes into account the extraction of raw materials, the transport and the construction process, according to the LCA methodology. Currently, Italian LCA database counts of about 150 products, with technical datasheets reporting their environmental characteristics. Moreover, the Ecoinvent database is commonly used for the calculation of environmental impact indicators [13]. It collects materials information from Germany, Austria and Switzerland, but often it's used as reference in Italy.

With reference to "open source software", the most known in Italy is **openLCA** [14]. This tool was created by GreenDelta GmbH (Deutschland), but thanks to the partnership with the Italian *"be*LCA" company, it's now well-known and used also at Italian level. The software allows to estimate the carbon footprint of products by the application of the LCA methodology. Its key-feature is the possibility to apply different reference databases, guaranteeing wide availability of data and information about materials and their environmental performance. In order to simplify the database implementation into the software, some existing databases have been modified into adaptable versions, available into the platform openLCA Nexus[1].

Currently, also some Italian tools for carbon footprint calculation focused on construction materials are available, even if their application is still not widely developed. One of these, **eeVerde**, is an open source software developed by ENEA - *Italian National Agency for New Technologies, Energy and Sustainable Economic Development* – with the partnership of several European countries [15]. This software is the results of the "*eLCA2"* project, co-funded by UE in the context of *eContent* programme, in order to foster the development of sustainability in construction materials. The tool is available by means of an online platform[2] and it's addressed to small and medium-sized enterprises (SMEs), in order to increase the application and diffusion of LCA methodology. Through this software is possible to calculate CO_2 emissions together with other environmental impact indicators, in order to determine an overall environmental impact level of materials. The assessment is made by means of a reference database, which contains material's datasheets with pre-defined characteristics and parameters, obtained by combining data from other European databases. The current version of the tool is updated to 2015 [16].

Another software developed at Italian level is **Primus LCA** (by Acca sotware) [17]. This software represents an important tool to evaluate the environmental impacts of buildings in their whole construction process. Indeed, it combines the list of materials used during a construction project to their environmental performances. This process is possible thanks to a reference database

[1] https://nexus.openlca.org/databases
[2] www.ecoSMEs.net

that contains, for each building component, several environmental parameters. In this way, for each material used in a building project, it's possible to known CO_2 emissions, evaluating them "from cradle to gate", according to the LCA methodology.

At local level, some calculation models for the evaluation of carbon footprint were developed and are now available for free online. For instance, the model developed by "Comune di Reggio Emilia" with the partnership of ARPA - *Regional Agency for Prevention, Environment and Energy of Emilia-Romagna* – represents one of the first case study of the implementation of CO_2 emissions calculation in building sector at local administration level [18]. This calculation models aims to estimate the CO_2 emissions into new buildings and it represents a case of urban regeneration. This free tool was realized on December 2015 and it is now available for other local administrations of the Emilia–Romagna Region. The tool calculates CO_2 emissions of new buildings during their planning and provides also information in order to minimize the carbon footprint and CO_2 emissions associated with the whole construction process.

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