



Energy Rating Software with a Life Cycle Approach

Abstract: *This paper describes the on-going process for the development of a new software tool, SOFIAS (Software de Funciones Integradas para una Arquitectura Sostenible), partially funded by the Spanish Ministry of Economy and Competitiveness. This tool is developed to assist building professionals on the sustainable design of buildings, with particular emphasis on reducing the environmental impact through the building life cycle assessment (LCA). Throughout this paper are explained the general objectives, the innovative points, the working methodology and the different type of results that can be generated by SOFIAS.*

As summarized in the conclusion section of the paper, the main objective of SOFIAS is to develop an innovative rating system based on the assessment of the sustainability of new and rehabilitated buildings with life cycle perspective.

Keywords: *LCA Software, Environmental Building Declaration, Life Cycle Assessment, Life Cycle Cost, LCA Database, Rating system, certification*

Introduction

The environmental assessment of buildings with a life cycle approach still seems new for most professionals involved in the construction sector. However, due to new regulations and environmental quality requirements of the European market, LCA is becoming more present in their activities. Evidence of this is the intense normative work on the assessment of the sustainability of buildings carried out by the European Committee for Standardization and specifically, the technical committee TC/350 [1]. The European market has different LCA tools for modelling and impact calculation (Simapro [2], Gabi [3], Umberto [4], EcoQuantum [5], etc). However, these tools require expert knowledge in building definition and assessment with LCA perspective and do not have specific national environmental databases for construction products.

Along with the problem of the complexity of this type of tools, one of the main reasons for the development of this software is focused on providing a solution to the fact that the current Spanish energy certification tool, Calener [6], only quantifies the environmental impacts associated with the use stage of the building. When full life cycle impacts of a building need to be assessed, a second and completely independent study is required which increases efforts and costs.

This paper describes the development of an experimental prototype tool compatible with the standard CEN 350 to respond to different needs of professionals regarding full life cycle assessment of buildings, such as

1. **Need for evaluation of environmental aspects** in the design, construction and refurbishment of buildings considering the full life cycle. It is important that professionals can have this new environmental vision from the beginning of the design process. Need of **reference values to allow** definition and evaluation of the



environmental and economic performance of the building during the different stages of life cycle.

2. Need of **free generic environmental data** of materials and processes related to the Spanish construction sector. Currently, the professionals have the possibility to get this kind of information from Environmental Product Declarations (EPD) or from Data Base like Ecoinvent. However, difficulty to access and interpret this information means that in many cases the user dismisses the option to continue their work.
3. Need to perform environmental calculation of all building stages and obtain the Environmental Building Declaration (EBD) with **very little work and** without duplicating work from energy rating.

To respond to these needs, SOFIAS tool has been developed making possible to analyze, quantify and optimize environmentally and economically each building throughout their life cycle, and to obtain an EBD and a rating result, which will be a further incentive for the design and development of innovative and differentiated buildings.

SOFIAS Innovation in relation to other tools

The proposed tool SOFIAS has a great potential to be used on a large scale by construction agents, mainly designers, such as architects or engineers. In addition, given its clear focus on providing information on compliance with environmental quality standards, SOFIAS could be used in green public/private procurement, in the development of new regulations and in voluntary assessment (Environmental Building Declaration and Rating).

The tool can link to national energy rating tools and is presently directly related to the Spanish energy labelling tool Calener. Through the communication between the “xml” file generated by Calener and the software of SOFIAS, the user automatically could import most of the building information simulated by Calener, becoming SOFIAS as a new extension of the current official tool.

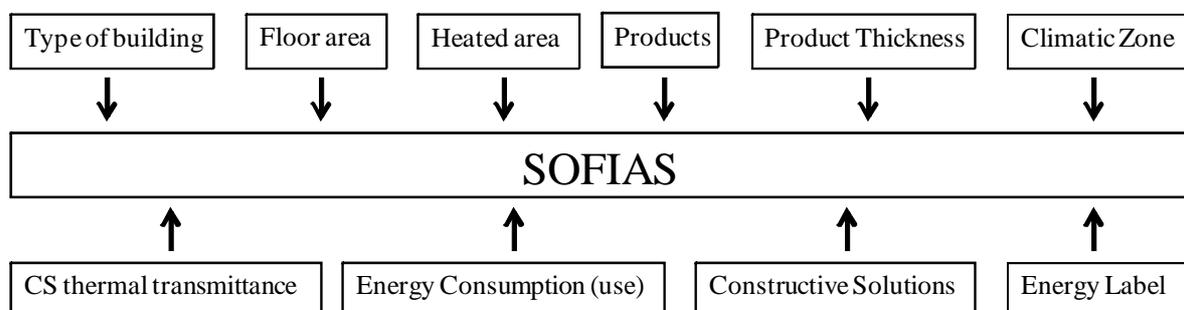


Imagen 1 Parameters imported from Calener to SOFIAS

EPD and Generic Environmental Data Base: One of the main efforts during the tool development has focused on generating an open and generic environmental database of building products and constructive solutions for Spain. This database is based on values from EPDs complying with ISO 14025 [7] and 15804 [8] structure, and on generic values obtained and validated by the SOFIAS consortium. Until now, users had to search for environmental information through various private and public sources. However, through SOFIAS, the user can get generic values of environmental impact for products, constructive solutions and some energy systems from the integrated database for Spain.

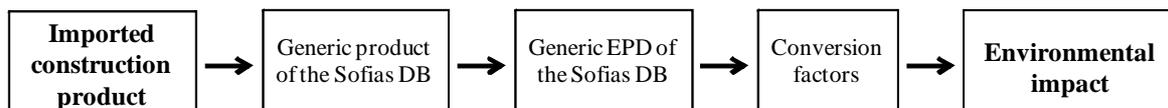


Imagen 2 Outline of the methodology to calculate automatically the environmental impact of the product imported from Calener (more information in the Paper Number 612)

The algorithm of SOFIAS allows relating the materials imported from Calener with the generic environmental impact of that material. For this, it has developed a new system of codification for the construction sector in Spain, linking all inputs and equations within SOFIAS. In case that the final user has precise data of a manufacturer EPD, SOFIAS allows to link manually this EPD to the imported construction product.

New algorithm: SOFIAS has developed a new algorithm to implement the calculation logic in the software and to carry out the validation of the software by AENOR (Spanish Association for Standardisation and Certification)

Working at different Levels: SOFIAS is not a static tool. It has been scheduled to be part of the dynamic development of the architectural project, defining 3 different working levels, from a very general Design level until an After Project Level with highly detailed information. This definition of levels provides the possibility of making decisions at each stage of the project. During the first level, “Design Level”, SOFIAS provides large part of the building definition information, obtaining a global environmental impact of the building. It is during this stage when still the building will not be fully defined and the user may detect critical points and propose general changes. During the second level, “Project Level”, the definition of the building is more accurate, using fewer default values and the implementation of the algorithm is more complete. Finally, if SOFIAS users want to obtain Environmental Building Declaration (EBD), they should use “After-Project Level”.

Environmental rating tool with life cycle perspective in Spain: SOFIAS results on an environmental rating of the analyzed building, enlarging the scope from the actual energy rating to include detailed environmental impacts over the full life cycle of the building. This rating allows professionals to assess the environmental impact of their building through the comparison against a reference building.

SOFIAS Certification: following the Certification Regulation defined by AENOR, the data quality requirements and the correct application of the algorithm of calculation are checked amongst other factors, offering the end user the possibility to obtain the environmental Certification SOFIAS, if minimum data quality requirements are met.

Economic input. In conjunction with the environmental analysis, SOFIAS enables the user to perform an economic analysis of the different stages of the building: 1-construction of the building (materials/systems and construction stage), 2-Operational Stage, where the user may evaluate various energy scenarios defining the energy price and proposing different price increases and 3-Management of end of life.

SOFIAS methodology and its application

The general structure of the SOFIAS tool is mainly based on 4 sections:

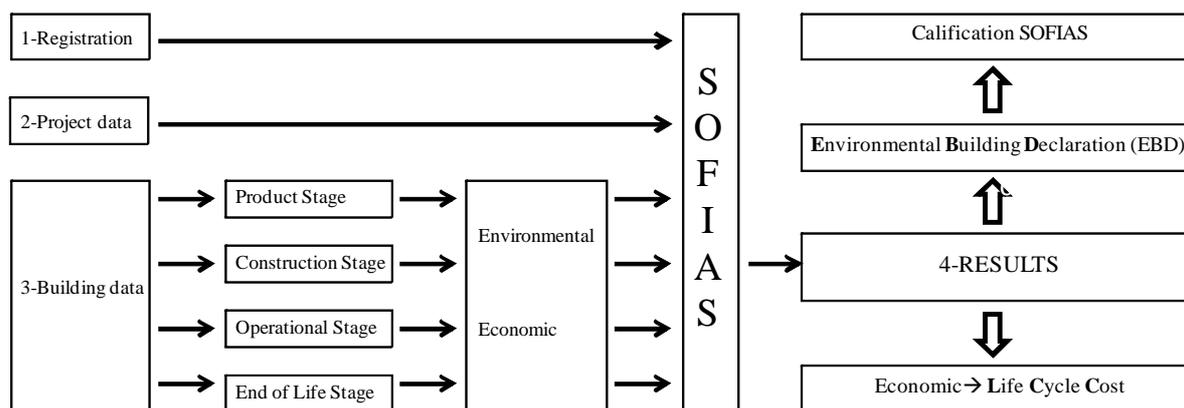


Imagen 3 General outline of the SOFIAS Structure

Registration: data regarding the final user (without influence in the calculations).

Project: general characteristics of the project. Between these data are defined the Type of Project (new construction / renovation) and Working Level (design / project – after Project), whose election will influence directly on how to insert the data of the building, in the calculation and in the environmental requirements defined by SOFIAS. In an initial evaluation of the building is recommended to select the Design Level, being able work in a very simplified form. However, when the definition of the project is sufficiently advanced, it will require the following working levels.

Building: it is the most complete section, where according to the data defined in the “Project”, the user will define with different degree the building characteristics along its 4 main stages.

During the first stage, Product Stage, SOFIAS quantifies the environmental impact (Initial Embodied Energy) of the constructive solutions (facade, roof, internal partitions, walls in contact with the ground and windows), structural elements (foundations and pillars) and

installations (renewable and non renewable). Importing the “xml” file generated by Calener and with the reference values defined by SOFIAS, the user automatically may obtain the required values to calculate the environmental impact of constructive solutions.

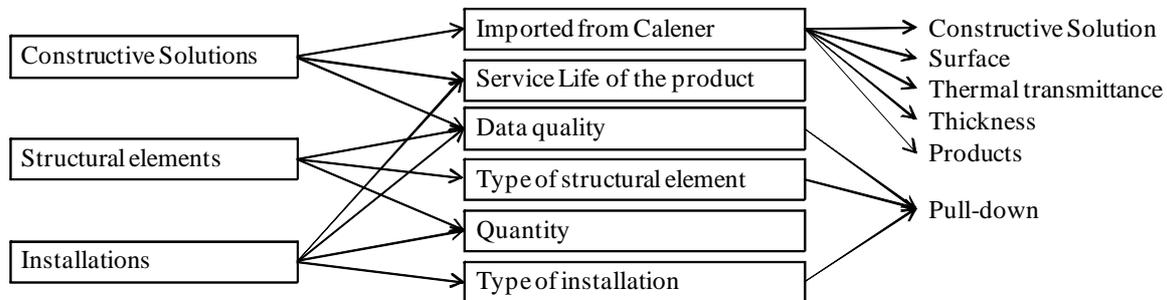


Imagen 4 Outline of the Product Stage methodology

During the second stage, Construction Stage, SOFIAS quantifies the environmental and economic impact of the construction process, transport of the materials and earthworks. For the Design and Project working Levels, SOFIAS provides automatically information for each constructed square meter: energy consumption (MJ/m²), water consumption (m³/m²) and waste generation (kg/m²). For the After Project Level, the user should define all these data.

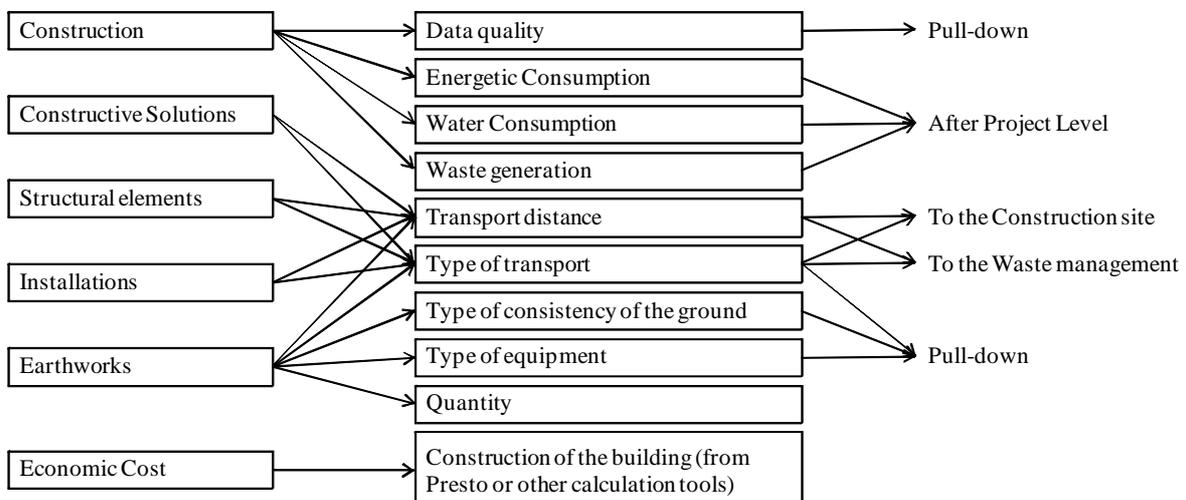
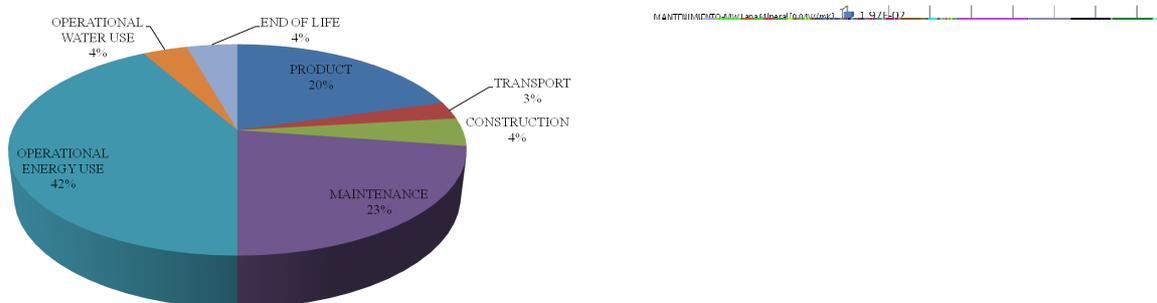


Imagen 5 Outline of the Construction Stage methodology

During the third stage, Use Stage, SOFIAS quantifies 2 types of impacts. On the one hand there is the impact related to operational energy consumption of the building, which can be calculated by other simulation tools (Design and Project Level) or introduce the values of the actual receipt (After Project Level). Through this last option, SOFIAS facilitates optimizing the actual environmental performance of the building during its use phase. On the other hand there is the impact related to the recurrent embodied energy (REE), which represents the sum of energy inputs associated with the energy required to manufacture and replace materials across the useful life of the building. In SOFIAS materials are replaced at the end of their service life.

Finally, during the End of Life Stage, are defined the different waste management systems related to end of life of each element of the building. Large percentage of the information is focused on the data base values, where SOFIAS contains information about different end of life scenarios. However, during the After Project Level, the user will have to introduce the data for their case study.

Results After entering data in each section, Sofias automatically performs calculations, showing the enviromental/economic impact and the new energy rating of the building. For the cases analyzed by After-project Level, SOFIAS shows the data quality and the possibility of opting to the Certification Sofias. It should be clarified that the energetic mix applied is the Spanish energetic mix with lifecycle perspective.



SOFIAS offers the possibility to display the results in different formats, adapting to the needs of each user or project:

- **Breakdown:** visualise the impacts throughout the life cycle stages (general), for each group or for each product (detailed), enabling to optimize each decision.
- **Functional Unit:** visualise the total environmental and economic impact of the building or per 1m² heated/year.

- **Indicators:** SOFIAS performs the calculation for indicators marked by the 15978 regulations. However, in order to facilitate the reading of the results, the user can select the indicators which want to display in the interface.

	GWP impact (kgCO ₂ /m ² *heated*annum)	
	Case Study Building	28.6
	Reference Building	32.4
SOFIAS RATING	★ ★ ★	

Imagen 8 SOFIAS final result (GWP indicator) and Rating

Discussion and Conclusion

The main objective of SOFIAS is to develop an innovative software tool for evaluation and rating of the sustainability of new and rehabilitated buildings. After a study of professional needs, the software integrates new features such as linking with national energy rating tools and with generic LCA databases. The software includes an environmental rating methodology and offers the possibility of certifying the environmental rating. The current version will be further improved with input from users, new standards, new softwares and Databases. Furthermore, results from real projects will be used to create a benchmarking database in order to evaluate new materials, technologies, standards, rating systems and define Best Available Technologies with Life cycle perspective.

Acknowledgements

This paper has been developed from the results obtained in the frameworks of SOFIAS (Ref. number IPT-2011-0948-380000) project co financed by the Spanish Ministry of Economy and Competitiveness. Thanks also to the Basque Government for their financial support given to xxxxx in the PhD research works.

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