BUILDING ENERGY LABELLING IN SPAIN (CALENER): TECHNICAL BASIS

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ABSTRACT

The European Community SAVE Directive 76/93, makes mandatory, among other things, for member states to implement an action called Energy Labelling of buildings. This labelling should consist of a description of the energy characteristics and some information about energy efficiency; and is aimed at reducing CO_2 emission by means of a parallel reduction in energy consumption. The European Union allows each country to adopt the most suitable methodology according to weather and building industry characteristics and socio-economic context. The Ministries of Public Works and Industry, the latter through the Spanish National Energy Agency (IDEA) are responsible for carrying out the directive. The work has been developed in two phases, the first being Energy labelling in Officially Protected Dwellings (CEV). "CALENER" program is the second phase and it includes all kind of buildings.

KEYWORDS

Energy labelling, Building Simulation, Efficiency Standards, Energy regulations.

INTRODUCTION

The main goals of the Directive 76/93 of the European Community are: to preserve Environment, to ensure a prudent and rational utilization of natural resources and to limit carbon dioxide emissions. In response to this Directive the Spanish Government, through the Ministries of Public Works and Industry, has decided to implement an Energy Labelling of buildings. This task has been developed in two phases: first one, called CEV, applies to Officially Protected Dwellings, and the second one, CALENER, extends to the entire building sector.

It is expected that in the course of this year a new Directive concerning Energy Performance will be adopted by the European Parliament. If so, all member states will have to implement measures based on the integral energy performance, that is, the improvement of the energy performance of buildings taking into account the climate, the building envelope and the mechanical systems. New regulations will be implemented and minimal targets will be set by all member states in order to comply with this new Directive.

CALENER is the Spanish development of an appropriate energy performance assessment procedure and is in full consonance with this new directive. It may calculate different numeric indicators for the energy efficiency of a building, taking into account envelope and orientation of buildings, system characteristics and other factors in the directive.

DIRECTIVE OBJECTIVES

Main purpose of the directive 76/93 is the reduction of carbon dioxide emissions by the improvement of the building energy efficiency. In consequence, it is an attractive framework for achieving energy savings in the whole building sector. Other secondary objectives are to improve transparency of the real-state market and to encourage investment in energy savings. Because of this, it has been necessary to implement consistent energy policy measures and to provide clear, concise and easy information to the unqualified end user. According to the directive Energy labelling must consist of:

_ A description of the energy characteristics of buildings.
_ Information concerning energy efficiency of the building.
_ Some recommendations for the improvement of energy performance.

The directive sets up some general guidelines and each member state must implement its own measures to adopt it. In other words, the directive says “what to do” but does not say anything about “how to do”.

SPANISH ANSWER: “CALENER”

To comply with the directive the Spanish Government together with the Department of Energy Engineering of University of Seville have developed a tool for energy labelling of all kind of buildings called CALENER, initials of “Calificación Energetica”. Calener is capable to assess the integral energy efficiency of a building and entirely meets the directive requirements because:

_ It will reduce carbon dioxide emissions since it establishes “reference levels”
_ It will improve market transparency since the end user will receive an easy index “percentage of emissions reduction”
_ It provides a report describing the energy characteristics of the building “Administrative report”
_ It offers some results and energy efficiency measures through the “Results tool”

MAIN COMPONENTS OF CALENER

CALENER is comprised of several applications and reports. Main components (represented schematically on figure 1) are described hereafter:

_ **Windows interface to input/edit data:** This application allows the user to enter easily the building and systems description. The program uses an elaborate set of default values for certain input data and includes a modifications tool oriented to input variations on an existing project.

_ **Database:** The program includes a database (also called library) to reuse components. It includes frequently used materials, constructions, glass types, weather files, etc. and is accessible through the windows interface.

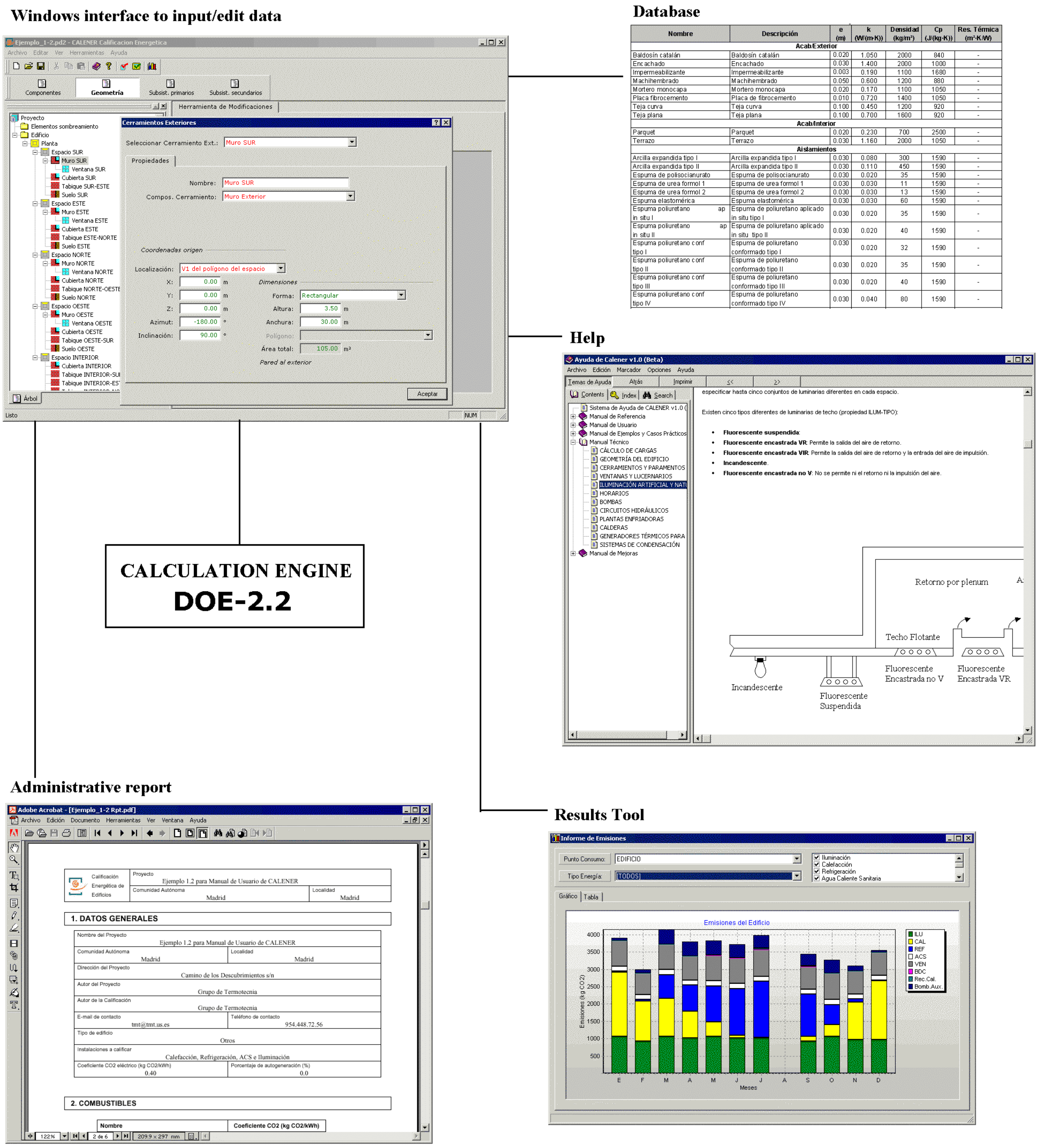

Figure 1: Main components of CALENER

- **Help:** The help system includes all the program manuals (User's guide, Reference, General and Examples). The software also includes an online Help system including a context-sensitive system.

- **Calculation Engine:** The calculation engine performs the building hourly simulation to calculate energy consumption (by end use and by energy source) necessary to obtain CO_2 emission. DOE-2.2 has been used since it is a reference program, widely used and fully validated.

- **Administrative report:** The program offers a PDF report with all the relevant building and systems characteristics for the project and the result of the energy labelling procedure.

This report is generated automatically by the windows interface and it is used for administrative procedures.

_ **Results Tool:** An independent application allows the user to check the main project results, which can be displayed individually or compared with previous labelled projects. After analysing them, the user can go back to the modification tool to change the original project in order to improve its energy labelling. An economic analysis tool that assesses the economic viability of the entered modifications is also implemented.

ENERGY LABELLING METHODOLOGY

Once the user has entered a project (building shell, HVAC systems, domestic hot water and lighting), CALENER obtains the energy labelling as follows:

1. Hourly simulation of the "user defined" building to obtain the energy consumption for each end use and energy source.
2. CO_2 emissions calculation for the "user defined". All energy sources are considered.
3. "Reference" building definition. Calener will make some changes on the "user defined" building to create the reference one. This procedure is later explained.
4. Hourly simulation of the "reference" building to obtain the energy consumption for each end use and energy source.
5. CO_2 emissions calculation for the "reference". All energy sources are considered.
6. Building energy labelling is obtained by comparing the emissions between "user defined" and "reference" buildings.

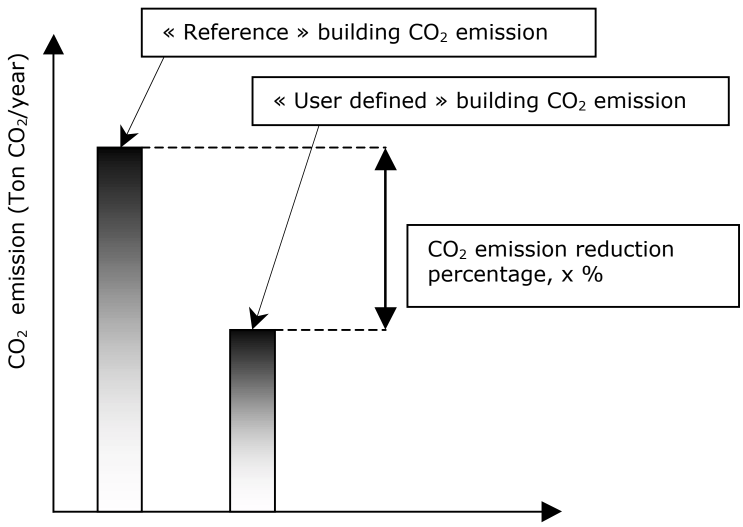

Figure 2: Building energy labelling, defined as the CO_2 emission reduction percentage.

In short, the building energy labelling in CALENER is defined as "CO_2 emissions reduction percentage of the user defined building when compared with the reference one". Thereby, a 0% label means no reduction of reference emissions, a building with a 50% energy labelling will have one half of the reference emissions and a 100% label is possible if the building does not emit CO_2 (photovoltaic generation).

REFERENCE EMISSIONS

The key question for energy labelling is how to define the "reference" level to asses a particular project quality in terms of energy. Following sections describe how CALENER solves this problem. The reference building CO_2 emissions are obtained independently for the lighting, domestic hot water and HVAC systems energy consumptions.

Lighting reference emissions

CO_2 emissions due to lighting consumption are only considered for non-residential buildings, because for residential ones lighting system input data (luminary types, lamp types, etc.) are usually unknown. Lighting system for the "reference" building will:

_ Have the same operation period of the "user defined".
_ Have the same lighting level (lux) of the "user defined".
_ Not have artificial lighting control as a function of natural lighting.
_ Have the necessary installed power (W/m^2) to meet the lighting level requirement (lux) with an average fixed value for the Energy Efficiency Index, EEI^{ref} (W/m^2 · 100 lux)

$$P_{Light}^{ref}\ [\mathrm{W/m?}] = P_{Light}^{user} \bullet \frac{EEI^{ref}}{EEI^{user}}$$

Domestic hot water reference emissions

The "reference" building will:

_ Have the same domestic hot water energy demand of the "user defined".
_ Have a DHW consumption calculated using the average seasonal (η_{DHW}^{ref}) efficiency of the medium domestic hot water system.

$$E_{DHW}^{ref}\ [\mathrm{kg\ CO_2}] = \frac{D_{DHW}^{user}}{\eta_{DHW}^{ref}} \bullet k_{co2}$$

HVAC systems reference emissions

The emissions associated to the HVAC system consumption are affected by two different elements: building shell and HVAC systems. So, the "reference" building must be obtained changing both aspects in the "user defined" one.

_ The "reference" building is in the same locality, has the same shape, the same external shadings, the same zoning and the same operation schedules of the "user defined" one.
_ The thermal quality of the building shell elements (exterior walls, roofs, windows, underground walls, etc.) is changed to usual average elements depending on the climatic zone in which the "user defined" building is placed.
_ The energy demand for space cooling and heating is calculated for the "reference" building using the operation period and the space thermostat setpoints of the "user defined" building.
_ The energy consumption is calculated using the average seasonal efficiency (η_{HVAC}^{ref}) of the most usual cooling and heating system.

$$E_{HVAC}^{ref}\ [\mathrm{kg\ CO_2}] = \frac{D_{HVAC}^{ref}}{\eta_{HVAC}^{ref}} \bullet k_{co2}$$

CONCLUSIONS

Building energy labelling is an appropriate assessment procedure for energy performance and meets most of the SAVE directive requirements. “Label” is a very interesting figure to represent the energy efficiency of the building and systems, easily understood by non-experts and capable to become a new market indicator and reference.

The Spanish experience (CALENER) has demonstrated the need of two basic elements:

_ A calculation procedure (hourly or not) for the energy consumption with an acceptable accuracy and difficulty level. This is not an easy problem, because there are few validated methods with the needed scope (all kind of systems and buildings) and with a “not too complicated” user interface. Europe should work to define the level, interface and scope of this kind of tool mandatory to comply with the new “Energy Performance Directive”. Otherwise, a successful implementation of the directive by the member states is not evident and each country will take its way provoking discrepancies at national level. European Commission should support efforts addressed to the development of an “European Building simulation tool”

_ “Reference” building or “reference” figures define the standard for assessing the energy quality of buildings by comparison. How to derive the “reference” is a complex problem, with different solutions at national levels. If you use a “reference building” based on the “user defined” one, the degree of similarity between them is a socio-technical-political issue that must be defined by consensus between Energy Agencies, University Laboratories and manufacturers and engineers associations. Europe should work in this field also, to define something similar to ASHRAE 90, that is, a global Energy Standard for Buildings in Europe.

Energy labelling can be done in terms of CO_2 emission (Spanish option), primary energy consumption, final energy consumption, or any combination between them. In the first case we are expressing an Environmental qualification interesting for the whole planet, the second one targets on Energy policy and Utilities and the third one is the citizen main concern when translated to economic figures. In this point, Europe's decision is the reduction of CO_2 emissions clearly expressed in Kyoto protocol.

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