ENERGY CERTIFICATION PROCEDURE FOR EDUCATIONAL BUILDINGS

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ABSTRACT

Energy conservation represents a main concern for the environmental, economical and social problems. In this field, educational buildings are large consumer of energy and in many countries need retrofits.
In this paper, we propose an energy certification procedure for educational buildings which aims to improve learning and teaching environment while reducing energy consumption. The developed procedure is composed of different levels including a phase of diagnosis and then a phase of calculation of the energy consumption and the energy conservation possibilities. After describing the developed tools for that purpose, we illustrate the procedure on an existing school located in Rhône-Alpes Region (France).

KEYWORDS

Energy conservation, educational building, energy certification, energy consumption, diagnosis, energy analysis

INTRODUCTION

With the growing trend towards environment protection and achieving sustainable development, the energy conservation in buildings becomes an important concern. An especially large group among these buildings is the group of educational buildings. In France, this sector represents 158 millions of heated m^2 (in 1997) with an average heating energy consumption of 148 kWh/m^2y [Annex 36]. In many countries, educational buildings are large consumer of energy and have problems with the indoor environmental quality. However, decisions often made do not accurately take into account energy saving aspects. This is due to a lack of information and tools given to decision makers regarding the efficiency of such aspects. Moreover it is still difficult to consider simultaneously energy saving, comfort and environment protection.
In this context, the group of annex 36 of the International Agency aims at promoting, for educational buildings, efficient measurements on energy level. In the same time, in France, the Rhône-Alpes authority leads actions for retrofitting educational buildings.
In this work, we propose a PRocedure for Energy Certification of Educational Buildings PRECEB which provides decision makers, building managers and professionals with an energy certificate and an energy plan for existing educational buildings. The Energy Certification of educational buildings can be considered as a particular energy label of a particular product. The example of an educational building located in Rhône-Alpes Region is then presented.

PRESENTATION OF THE ENERGY CERTIFICATION PROCEDURE FOR EDUCATIONAL BUILDINGS (PRECEB)

PRECEB is an extension of EC-Pro (Energy Checking procedure) for single family houses developed within a SAVE project [Richalet & al., 2000]. New in PRECEB is not only the type of building but also the consideration of the indoor environmental quality and the division into levels (table1). This division into levels gives the possibility to use this procedure for different applications:

Table 1
Different levels of PRECEB and the correspondent applications

Level number	**Level designation**	**Applications**
Level 1	Global enegy performance indicator	Giving indication about the various energy end-uses Informing decision makers about the energy performance of an educational building Ranking the building on a specified scale Comparing energy performance of different buildings
Level 2	Indoor Environmental Quality	Collecting information about the indoor environmental quality Identifying related problems
Level 3	Diagnosis	Collecting detailed data concerning the building components, systems, lighting and equipment Measuring some important parameters for calculation
Level 4	Calculation	Calculating annual energy flows and energy consumption Proposing detailed energy conservation measures with costs and pay-back time
Level 5	Energy certification	Delivering an energy certificate and an energy plan

Level 1: Global energy performance indicator

This level provides decision makers with a simple tool for determining energy performance of an educational building. It also permits to rank the energy consumption of the building on a national scale. For France, we consider a range from A (< 50 kWh/m^{2}y: low consumption) to F (> 250 kWh/m^{2}y: high consumption). The required input data is simple and easy to get (see figure 1). A knowledge of data entry and an understanding of building science are needed for using this level. This level is based on a matrix form and a database which contains different existing projects. The entered educational building can after be added to this database.

Level 2: Indoor environmental quality

The educational process is strongly influenced by the indoor environmental quality [High performance schools, 2001]. Studies have indicated a correlation between the way educational building are designed and used, and student performance [Cantin R., 2002]. In PRECEB, problems with the indoor environmental quality are defined to be basically origin from six issues, namely: humidity, noise, thermal comfort, air quality (and ventilation) and lighting. For the identification of these problems, we developped a questionnaire dedicated to the users.

Level 3: Diagnosis

The main objective of this level is to identify the main building characteristics and problems related to energy and comfort issues. This covers the building characteristics concerning material and construction (U-values, facade, windows, etc), systems and consumptions (HVAC, thermal and electrical energy consumption, etc), size and floor use (volume, floor area, kind of use, etc) and building occupation. This data is useful for the calculation and for the proposal of energy conservation measures (level 4).
Data collection: The first data collection task involves identifying the characteristics of educational buildings. Some of this information may be already available or easy to obtain i.e. plans and specification documents, previous types of renovation/additions, the operation and maintenance practices and maintenance contract.
- Visit & monitoring: A quick building walk-through is necessary to complete the building data. Obvious energy waste are noted, as are items in need of maintenance or replacement.
- Monitoring needs to select the rooms and the measuring devices. Preference is given to devices that do not require a large installation time and do not disturb the users of the building. Measurements are divided into short term monitoring and spot measurements. The measured parameters concern the building, the thermal, acoustical and lighing conditions, the comfort and the air change rate. We give in table 2 some of these parameters with an example of the used measuring devices.

Table 2
Examples of measured parameters and the used measuring devices

Parameter	Type of measurments	Example of measuring devices
Internal temperature	Short term monitoring	Tinytag, Hobo
External temperature	Short term monitoring	Tinytag
Relative humidity	Short term monitoring	Tinytag, Hobo
Building dimensions	Spot measurement	Infra-sound metering,
Walls materials	Spot measurement	Checkscope
CO_2 level	Short term monitoring	MultiWarm Dräger
Lighting conditions	Spot measurement	luxmeter, FJ-meter, luminance-meter, fish-eye lens
Air flow rate	Spot measurement	Ventury head associated with thermoanemometer
Thermal comfort parameters	Spot measurement	Bruel and Kjaer thermal comfort analyser

Level 4: Calculation

In this level, we use all the previous data for the analysis of energy consumption thanks to a computer tool (figure 1). The energy analysis is based on the New French Regulation [RT 2000] and European Norms [CEN, 1998]. To achieve this analysis the energy of the educational building is considered under two headings:

- heating energy including the space heating and the domestic hot water
- electrical power needed for lighting, equipment and HVAC.

This level calculates the annual energy flows and the energy consumption and propose energy conservation measures. It also gives the energy savings when these measures are applied together with cost and payback time.

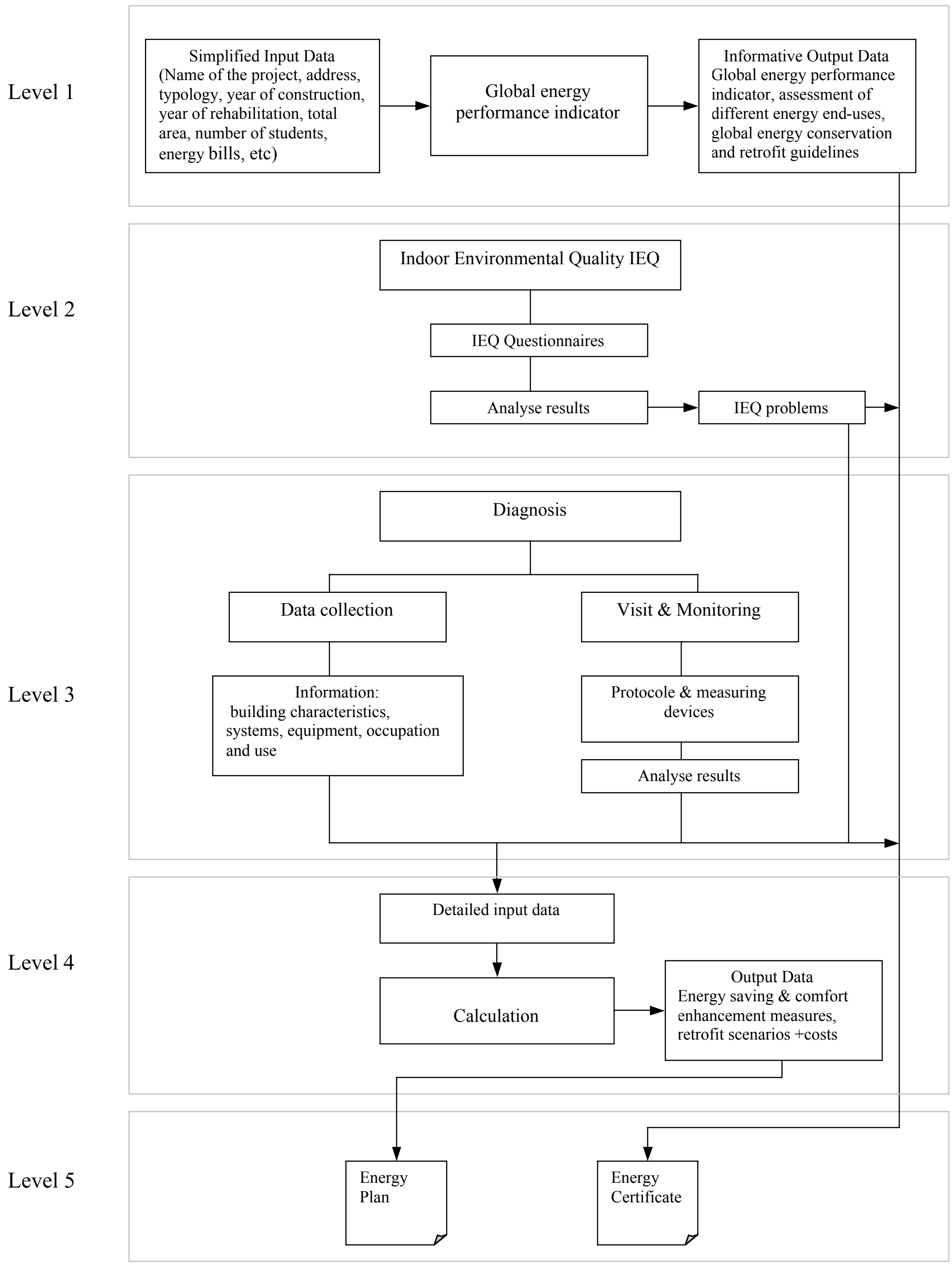

Figure 1: Organigram of the energy certification procedure

Level 5: Energy Certification

This level permits to deliver to decision makers, building managers or professionals a report including:

- an Energy Certificate presenting the building components and systems, the energy performance indicator of the educational building and the main results of the indoor environmental quality evaluation, and
- an Energy Plan giving the possible energy conservation possibilities with cost and calculated savings.

A STUDY CASE

We present hereafter the application of the three first levels on a secondary school (Gambetta) for technical teaching located in the Rhône-Alpes Region. The school was built in 1930 and refurbished in 1995. The total area is 9213 m^2 with 540 students.
We give hereafter some energy saving aspects of the school: insulated vertical walls, double glazing, 3 boilers (gas) for heating, mechanical ventilation, BMS to manage heating and ventilation, fluorescent tubes, lighting controls and external solar protection.
Level 1: The energy bills were provided by the Rhône-Alpes Region and the head master. The energy consumption for heating is 79 kWh/m^2y and electrical power is 25 kWh/m^2y for the year 1997. The energy performance indicator is B (figure 2).
Level 2 : We distributed the questionnaires in 3 classrooms. 74 students have answered**.** Analysis of the answers shows that:
About indoor air quality, 58% think it is acceptable. Sensation of enclosed space for 60% people, 60% feeling dusty. Strong smell sometimes for 31% people, dusty for 20%. About thermal comfort, there is sometimes some problems of low/high temperature probably linked to the control of the heating system (Level of temperature is good for 31% people, and acceptable for 54%), overheating problems: for 65% people in the afternoon and 70% because of the sun.
About the quality of daylight and artificial light: Overall satisfaction, 31% have quoted sometimes problem of poor light at the blackboard and 49% problem of reflections or glare from the blackboard.
About acoustics: No problem was reported about the equipment, but dissatisfaction relative to noise from outside (82%), noise from corridors (50%) and noise from neighbouring rooms (38%).
Problems of indoor environmental quality have been reported by the surveyed people for the toilets (50%), the gym and the changing rooms (41%). This can be a result of the used ventilation strategy.
Level 3 : The data was collected thanks to documents provided by the architect, the head master of the school and two on site visits.
The diagnosis includes internal temperature and relative humidity recordings in 4 classrooms between the 9th and 16th of October 2001 thanks to Tinytag sensors. The analysis shows that the set-back temperature is too high (between 20°C and 24.5°C) and that the relative humidity is acceptable (between 40% and 60%).
A lighting diagnosis has been conducted in 4 classrooms (2 computer rooms located in the first floor and 2 classrooms in the second floor). The opening index (ratio glazing/total area) is between 11% and 22%. We also noticed the following problems:

- unsufficient daylighting level at the deeper areas of the rooms where the daylighting factor is below 2%.
- deficient or unsufficient solar protection systems
- the power of artificial lighting installed (average 16 W/m^2) is above the recommended value by the French Requirements (15 W/m^2).

Level 4: This level together with the energy plan were not applied because the main objective of this study was to analyze the building energy performance and indoor environmental quality.
Level 5 (Energy Certificate): The energy certificate of Gambetta school is given in figure 2.

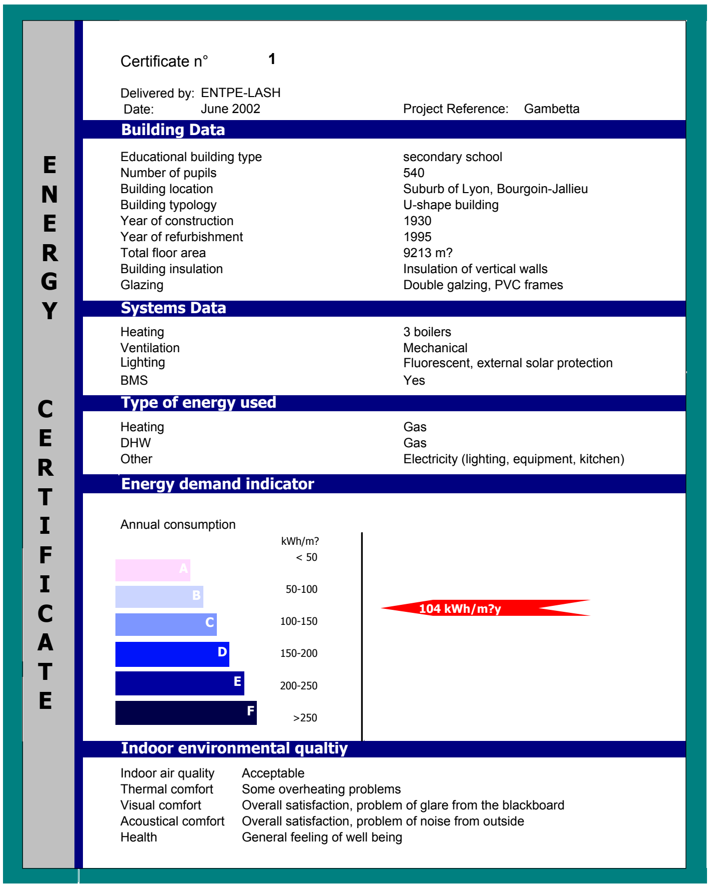

Figure 2: Energy certificate for Gambetta school

CONCLUSION

We proposed in this paper a PRocedure for Energy Certification procedure of Educational Builings PRECEB. The originality of the developed procedure is the multi-levels approach, the consideration of indoor environmental quality and the certificate delivering. It provides tools and guidelines for decision makers and professionals to save energy while improving the learning and teaching environment of educational buildings. It can be applied for the energy certification of the educational building or for a retrofitting process. The example of a study case of a school showed that it is possible to apply the different levels separately and to evaluate a retrofitting project. This work can be completed by taking into account environmental impact and high environmental quality features.

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