ALLENERGY® - ROMANIAN SOFTWARE APPLICATION FOR THE COMPUTATION OF THE BUILDING ENERGY PERFORMANCE

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Abstract. The Law no. 372/2005 transposes the European Directive 2002/91/CE into Romanian legislation which has in view to improve the energy performance of the buildings, taking into consideration the climatic conditions, the building location, the interior comfort requirements and the energy and economic efficiency. IPCT INSTALATII SRL, by its own authorized energy auditors, together with Algorithm +SRL have cooperated to develop AllEnergy ® software application, application very useful to compute the energy performance of the buildings, in accordance with the Romanian Methodology MC001/1,2,3. –2006. In 2009 the software application was registered by State Office for Trademarks and Patents in Romania. The paper presents the structure of AllEnergy ® software application and how the application determines the building energy consumption profile, generates the energy performance certificate, computes the energy savings resulting from the proposed measures for the improvement of the energy performance and performs the economic analysis of the adopted measures in the framework of the energy audit.

Key words: energy performance of the building, energy audit, software application, energy savings.

1. Introduction

The increase in the energy performance of buildings is a requirement laid down by Directive 91/2002/CE on the energy performance of buildings, transposed in the Romanian legislation by Law no. 372/2005[1,2]. As a result of the Law 372/2005, the methodology Mc 001/1,2,3 – 2006 – Calculation methodology for the energy performance of the buildings has been developed, which has the objective to establish a coherent method for the evaluation and certification of the energy performance both of the new and existent buildings, having different destinations. [2]

To promote the improvement of the building energy performance, in connection with the reduction of the environment pollution is one of the major objectives of the Romanian society at local and national level [1],[2]. In the frame of the thermal rehabilitation and energy modernization of the existent buildings and taking into consideration that the Energy Certificate is mandatory also for new buildings, the energy auditors have to meet complex tasks [2]. In such conditions, specialized software applications, complying with the Methodology provisions, have become an urgent need.

IPCT Instalatii (Bucharest) and Algorithm+ (Galati) have cooperated to develop a software application called AllEnergy ®, application very useful to calculate the energy performance of a building in accordance with the provisions of Mc001methodology. [3]

2. Paper content

AllEnergy® software application is developed in Delphi 2005. It can run using: Windows 98/2000/XP/Vista operation systems. In order to view the application reports and the Energy Certificate, it is necessary to set up Adobe Reader program, the newest version preferably.

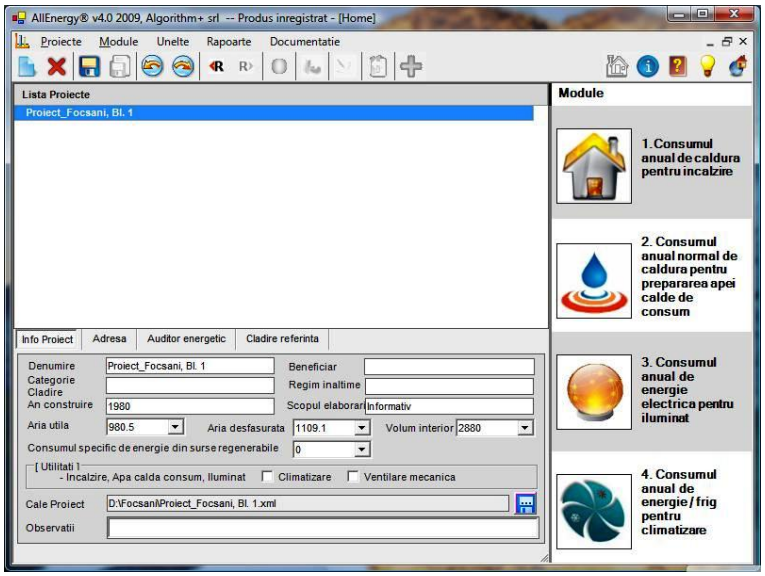

Fig. 1 – **AllEnergy**® – Main window

The main window of the software application (figure 1) contents information connected to the project and data regarding the energy auditor.

AllEnergy ® software application is structured in seven modules:

- Energy annual consumption for heating
- Energy annual normal consumption for sanitary hot water production
- Electrical energy annual consumption for lighting
- Energy annual consumption for cooling in air conditioning systems
- Energy annual consumption for mechanical ventilation
- Penalties for the certified building
- CO_2 equivalent emission index.

Each of the first five modules consists in two parts: input data, specific for the module and intermediary computation.

Energy annual consumption for heating

The first module, "Energy annual consumption for heating" has data regarding the locality where the building is located and data regarding the building features and the building envelope, as input data [6],[7].

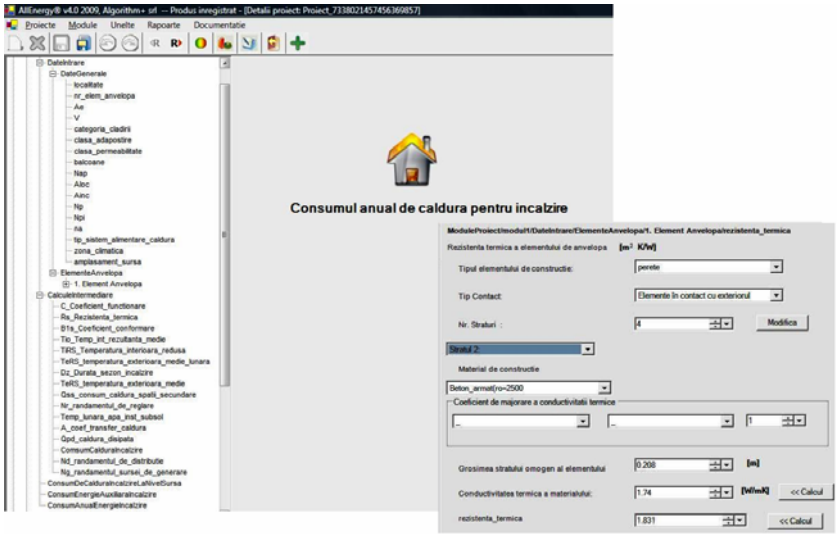

Fig. 2 – Energy annual consumption for heating / Thermal resistance of the building envelope elements

As regards the envelope elements of the building, the application computes the thermal resistance (m^2K/W), taking into consideration the element (wall, floor, terrace etc), the number of the element structural layers, the construction material and the width of each layer and undertaking the material thermal conductivity from the application data base. [5]

The application computes the exterior temperature on the exterior part of each envelope element, in each month of the year, based on the exterior average temperatures specific for the locality. [8]

For the envelope elements which separate the heated zone from unheated areas (staircase, basement, attic), the application computes the temperature on the element surface towards the unheated area based on some supplementary data which have to be inserted and selected by the user. [4]

After filling in all the data regarding the envelope elements, the next step is the to open and perform the intermediary calculations, referring to operation coefficient, the average thermal resistance of the envelope, the interior reduced temperature, the corrected average exterior temperature, the heating period duration (figure 3) and the exterior average temperature. Based on these data and computations, the application determines the energy annual consumption for heating, at heated areas level.

The annual energy consumption at heated areas level is computed using the formula [3]:

$$(1) \quad Q_s = \frac{24}{1000} \cdot C \cdot \left(\frac{A_E}{\overline{R}_s} + \frac{1}{3600} \cdot \rho_a \cdot c_a \cdot n_a \cdot V \cdot B_{1s} \right) \cdot \left(\overline{\theta}_{iRS} - \overline{\theta}_{eRS} \right) \cdot D_z$$

where:

Q_s - heat consumption at heated area level [kWh/an]

24 – means number of hours/day – continuous heating

A_E - building envelope surface [m^2]

$\overline{R}_s$ - corrected average thermal resistance of the building envelope [m^2K/W] in accordance with [4]

n_a - area ventilation rate [h^{-1}]

ρ_a - air density [kg/m^3]

c_a - air specific mass heat [J/kg K]

V - free volume of the occupied area [m^3]

$\overline{\theta}_{iRS}$ - reduced interior temperature [°C]

$\overline{\theta}_{eRS}$ - corrected monthly average exterior temperature [°C]

D_z - heating period [days]

C - correction coefficient depending on the reduction of the interior temperature during night [8]

B_{1s} - compliance coefficient

Inserting the corresponding values for ρ_a and c_a in formula (1), we obtain:

$$(2) \quad Q_s = 0{,}024 \cdot C \cdot \left(\frac{A_E}{\overline{R}_s} + 0{,}33 \cdot n_a \cdot V \cdot B_{1s} \right) \cdot \left(\theta_{iRS} - \theta_{eRS} \right) \cdot D_z$$

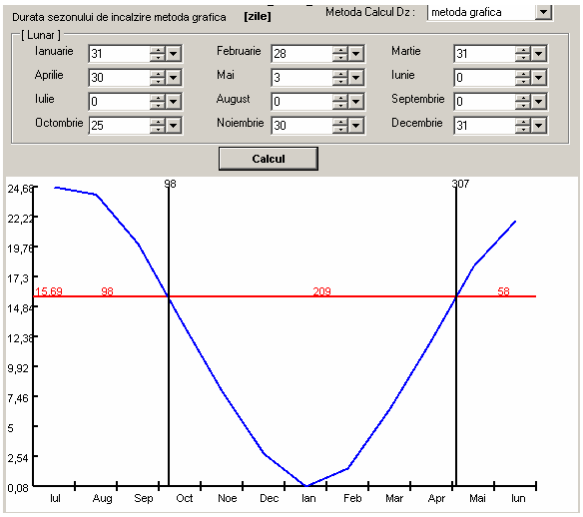

Fig. 3 – Heating season duration

The energy annual consumption for heating at thermal source level is determined with the formula:

$$Q_{\hat{i}} = \frac{Q_s + Q_{ss}}{\eta_r \cdot \eta_d \cdot \eta_g} + Q_w \quad (3)$$

where:

Q_{ss} - heat consumption of the secondary areas, [kWh/year]

Q_w - auxiliary energy consumption for heating (electrical energy) [kWh/year]

η_r, η_d, η_g - energy efficiency for adjustment, distribution and generation

Energy annual normal consumption for sanitary hot water production

The software application computes the annual energy consumption for sanitary hot water production [kWh/an] and the specific annual consumption [kWh/year·m^2], value which is taken by the Energy Certificate.

The input data are: building destination, sanitary hot water production system, the average number of occupants in the building, the sanitary hot water specific need, sanitary cold and hot water temperatures, constructive and operational data of the piping system, water heater and storage, heat generator.

The module contains a data base with the sanitary hot water specific consumption depending on the building destination and the use type. [3],[11]

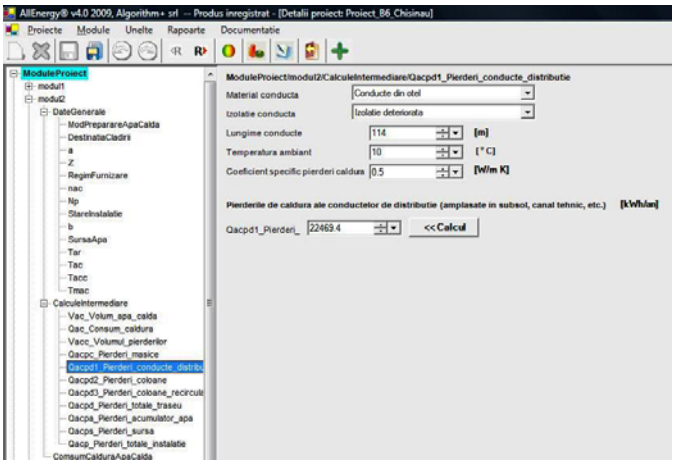

Fig. 4 –Computation of the energy annual consumption for sanitary hot water

The annual energy consumption in kWh/year for sanitary hot water production [3] is determined with the formula:

$$Q_{ac} = \frac{V}{3{,}6 \cdot 10^6} \cdot \rho \cdot c \cdot (\theta_{ac} - \theta_{ar}) + Q_{acp}\,. \quad (4)$$

where:

V - the annual consumption of sanitary hot water [m^3/year]

ρ - water density at the average temperature value of θ_{ac} and θ_{ar} [kg/m^3]

c - specific mass heat of water [J/kg °C]

θ_{ac} - sanitary hot water temperature [°C]

θ_{ar} - cold water temperature [°C]

Q_{acp} - heat losses of the sanitary hot water installation [kWh/year]

Using: the daily specific need of sanitary hot water "a" in [l/person day], the annual number of days for sanitary hot water use "Z" [days], the number of occupants in the building "N_p" [persons], inserting the values of the water density and specific mass heat and operating the transformations of the measurement units, formula (4) becomes:

(5) $$Q_{ac} = 1{,}142 \cdot 10^{-3} \cdot a \cdot Z \cdot N_p \cdot \left(\theta_{ac} - \theta_{ar}\right) + Q_{acp}.$$

(6) $$Q_{acp} = Q_{acpc} + Q_{acpd} + Q_{acpa} + Q_{acps}.$$

where:
Q_{acpc} – heat losses due to sanitary hot water delivery to consumer ("mass losses")
Q_{acpd} - heat losses of the sanitary hot water installation consisting in heat losses of the distribution pipes in the basement, heat losses on uprising pipes, connections and circulation pipes,
Q_{acpda} - storage tank heat losses,
Q_{acps} - heat losses at the thermal energy source for sanitary hot water production.

Electrical energy annual consumption for lighting

The software application determines the annual energy consumption for lighting and the annual specific consumption [kWh/year·m^2]. The input data are structured in two categories: block of flats and other type consumers.

For block of flats, the input data with respect to lighting system are: the number of the apartments in the building for each category of 1÷5 rooms, the total glazing surface of the building, the total surface of the rooms floor using artificial lighting – on which base the application computes "c1" factor = glazing surface and the existing or not of the exterior windows in the bathrooms (to settle "c2" factor – increase coefficient for the average specific energy consumption for lighting) [3].

For other type of consumers, the following data have to be inserted: building destination, the useful total area of the building floors using artificial lighting, the lighting features installed power, lighting control type. The lighting use time is computed based on the above mentioned data.

Finally, the application computed the annual energy consumption for lighting, expressed in kWh/year.[3]

Energy annual consumption for cooling in air conditioning systems

The software application determines the annual energy consumption for cooling in air conditioning systems and the annual specific consumption [kWh/year·m^2]. The input data are:
- general data, regarding the building and the location [10];
- data regarding the envelope elements, in principle the same information as in heating module.

In many cases, it is necessary to have in view that the cooled area in a building is not the same with the heated area, so not all the envelope identification data settled at heating module are valid for cooling.

The data base included in this module refers to climatic information for different localities such as: intensity of the solar radiation, exterior temperatures, number of monthly sunny days. The user has also the possibility to insert its own data.

The application computes the thermal resistance of the cooled volume, the equivalent exterior temperature, the sensitive cool need for building cooling, the latent heat, the latent cool consumption and finally the annual energy consumption for cooling [3].

Energy annual consumption for mechanical ventilation

The software application computes the annual energy consumption for mechanical ventilation [kWh/year] and the specific consumption [kWh/year·m^2]. The energy consumption for mechanical ventilation consists of the thermal energy for the heating/cooling of the fresh air till the temperature of the interior air and the electrical energy used by the inlet and exhaust fans [3]. The input data specific for cold and warm season are: the flow rate of the fresh air [m^3/s], the interior air temperature [°C] and the operation time of the ventilation system [hours/day, days/month].

Penalties for the certified building

The penalties for the certified building are in accordance with the Methodology Mc001 and they are selected by the user from the given values, depending on the observation done during the building inspection on site.

Emission index CO_2 equivalent

The CO2 equivalent emission index are computed independently for each energy consumption type, selecting the type of the fuel (gas, liquid, solid)/energy source (district heating, electrical energy) used [3].

3. Results and discussions

The software application generates the Energy Certificate of the analyzed building and its Annex using the date taken from the base modules.

In order to establish the consumptions of the reference building, necessary to complete the Energy Certificate, the application allows to export the computations file of the audited building, in ".xml" format, rename it as reference building file, import it in program and perform all the changes as regards the input data, in accordance with the reference building features 3]. The next step is to upload the file corresponding to the reference building into the analyzed building file. Thus, the data regarding the reference building can be found in the Energy Certificate and it can be generated, preview and save in ".pdf" and ".doc" file.

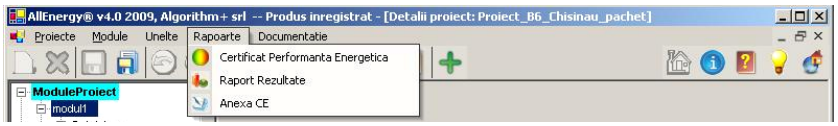

Fig. 5 – Reports

The Energy Certificate Annex contents some other information referring to the heating, ventilation, air conditioning, sanitary hot water and lighting installations. This information has to be given in module no. 7 (CO_2 equivalent emission index) at "Report data". The software application gives also a Results Report, in ".pdf" format containing input data regarding the building, intermediary results of the computation and energy annual consumptions and specific consumptions.

Another output of the application is the economical analysis of the recommended solutions for the improvement of the energy performance of the building, respectively the economical efficiency indicators:

- the net present value of the supplementary investment, ΔVNA [Euro];
- the payback period of the supplementary investment, N_R [years];
- the cost of the energy savings unit, e [Euro/kWh]

The results of the economical analysis, for each recommended solution or pack of solutions are presented in a ".pdf" format table.

4. Conclusions

AllEnergy®, being at version 4.0 now, is a software application which determines the building energy performance. It is in continuous process of development and improvement, trying to reflect as closely as possible the regulated calculation methodology and to adapt to the user needs regarding the simplicity of implementation, facilities provided and the accuracy of calculations.

The main advantages of using AllEnergy® software application in the energy audit activity are:

- diminishing the time to perform an energy audit;
- automatic generation of the Energy certificate, of its Annex and of the technical and economical result reports;
- possibility to perform quickly comparative analysis of solutions in the frame of the energy audit;
- guiding users to the application of technical regulations in the field.

5. References

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