SOFTWARE TO IDENTIFY OPTIMAL SOLUTION FOR RESIDENTIAL BUILDINGS

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Abstract – The present paper presents a software solution, usable for calculating the necessary heat and for the identification of the energy source which qualifies the production of heat for small energy consumers.

Keywords: software, heat demand, hot water demand, cost analysis.

1. INTRODUCTION

Nowadays because of constantly rising power consumption and depletion of fossil energy sources the energy price increases. Consequently the energy consumption of buildings and reduction of heat losses is a current problem for our contemporary society.

At the same time, due to the recent development of technologies of renewable sources, new solutions are sought for economical heat supply of buildings.

Therefore a more accurate calculation of thermal energy demand and a comparison of solutions to be able to choose the best option for energy source.

To calculate the heat demand and to determine the technical characteristics of heating appliances in order to have a constant internal temperature, we must take into account the fact that buildings have different destinations, shapes and structural characteristics and the heat transferred by rooms in the environment can be different, and also the climatic zone related to the location of the building [2].

A "small consumer" of thermal energy the consumer with an installed thermal power less than 100 kW. Domestic consumers belong to this category.

The calculation methods of heat demand for heating needs are given by regulations and are applied to all types of civil and industrial buildings with a few exceptions [3].

2. BASIC PRINCIPLES FOR THE CALCULATION OF THERMAL ENERGY DEMAND

The heat demand for heating a room is expressed by the following equation:

$$Q = Q_T\left(1 + \frac{\sum A}{100}\right) + Q_I \qquad (1)$$

Where:

- Q_T – is the heat flux transferred through the transmission, considered in stable regime, corresponding to the temperature difference between the inside and the outside of the building elements that separate the room
- Q_I – thermal load for heating the cold air got inside through infiltration from the outdoor temperature to the indoor temperature
- ΣA – the sum of the additions to the thermal flux transferred through transmission.

The phenomenon of heat transmission takes place in three ways: thermal conduction, thermal convection and thermal radiation. In general, in a real process of heat transmission all three modes of heat transfer occur simultaneously, but often the heat transmitted through one or two mechanisms is small enough to be negligible.

Thermal conduction is the mechanism by which heat is transmitted inside a body, regardless of its state of aggregation. Transmission of heat through thermal conduction is performed through close heat propagation among the system particles, on the basis of the impacts among them, caused by their free movement inside the body or system.

Thermal convection is the way in which heat is transmitted between a solid wall and a fluid (compressible or incompressible) in free or forced movement.

Thermal radiation is, in fact, electromagnetic radiation which produces thermal effects in materials when the radiated thermal energy reaches the level of the material. Significant thermal effects are produced by the electromagnetic radiation in the infrared spectrum (wavelength $\lambda = 0.01 \div 7\text{x}10^{-5}$ cm) and in the visible spectrum (wavelength $\lambda = 7\text{x}10^{-5} \div 4\text{x}10^{-5}$ cm).

In the study of heat transfer processes it is necessary to know the temperature inside the studied systems. The temperature values are different inside a system, so any system that suffers a heat transfer process is in a non-balanced state. Temperature is considered a scalar value. The value of the temperature in all points of the system is called a temperature field.

If within a system the temperature varies in time, we say that we have a non-stationary temperature field, otherwise, that is if it does not vary in time, the temperature field is stationary. The locus of all points in which the temperature has the same value is called isotherm surface. Isothermal surfaces can take any form in space, and temperature surfaces have no tangent or intersection points.

For a constant internal temperature, the required thermal power depends on climatic conditions specific to the area for which the heating plant is designed. Outdoor (ambient) temperature t_{ext} is the main parameter that determines power requirements. To assess the thermal energy potential of the source in relation to the energy level given by the ambient temperature at a given moment, we need data that related to the climate of the region studied. Besides the thermal energy potential of the source, these data are also needed to estimate the thermal energy consumption.

3. THE SOFTWARE SUPPORT. VISUAL BASIC FOR APPLICATIONS

Visual Basic for Applications (VBA) is closely related to Visual Basic and uses the Visual Basic Runtime, but can normally only run code within a host application rather than as a standalone application. It can, however, be used to control one application from another using OLE Automation. For example, it can be used to automatically create reports from Excel data. VBA code interacts with the spreadsheet (Excel) through the Object Model, a vocabulary identifying spreadsheet objects, and a set of supplied functions or methods that enable reading and writing to the spreadsheet and interaction with its users. VBA is an extensible programming language that is made up of a core set of commands and extended on a per-application basis to be able to work directly with objects in that application. This means that VBA for Excel knows about things like workbooks, worksheets, cells and charts and more. The core can even be licensed for use by 3rd party companies to permit it to be used with their application(s). VBA can probably be best described as an object-based (but not a true object oriented) language that is event driven.

In fig.1 the interface of the VBA is presented where the program codes can be written and the visual objects can be created.

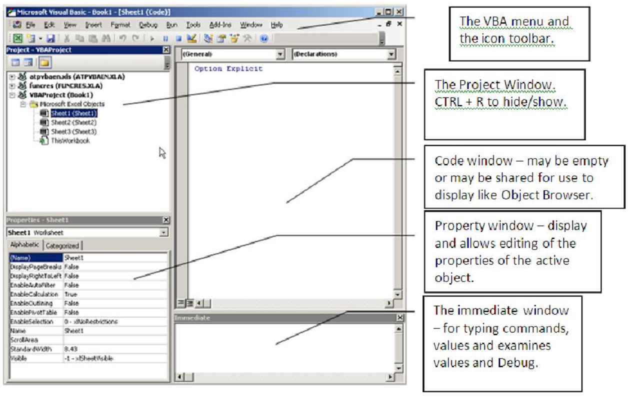

Fig.1 VBA programming interface

4. DEVELOPED SOFTWARE PROGRAM.

The program uses as support for the database excel file spreadsheets in the program. Thus, based on norms and standards in force, i.e. after the data were collected on materials used in building and insulating buildings, these worksheets were made with all the values required for subsequent calculations.

Usage of software program observes the logic as it is shown in the figure Fig.3.

After the program file was loaded in Excel (macros must be enabled), the main user screen (located on the first worksheet) is shown Fig.2, with the main buttons in the left part, according to run the associated modules presented in the logical diagram (Fig.3). The order of browsing through those buttons can be changed (as all of the inputs will be stored in excel cells permanently) but it's recommended to meet the logical sequence presented above.

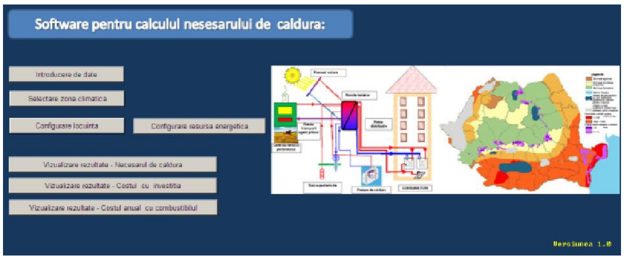

Fig.2 The main user screen interface

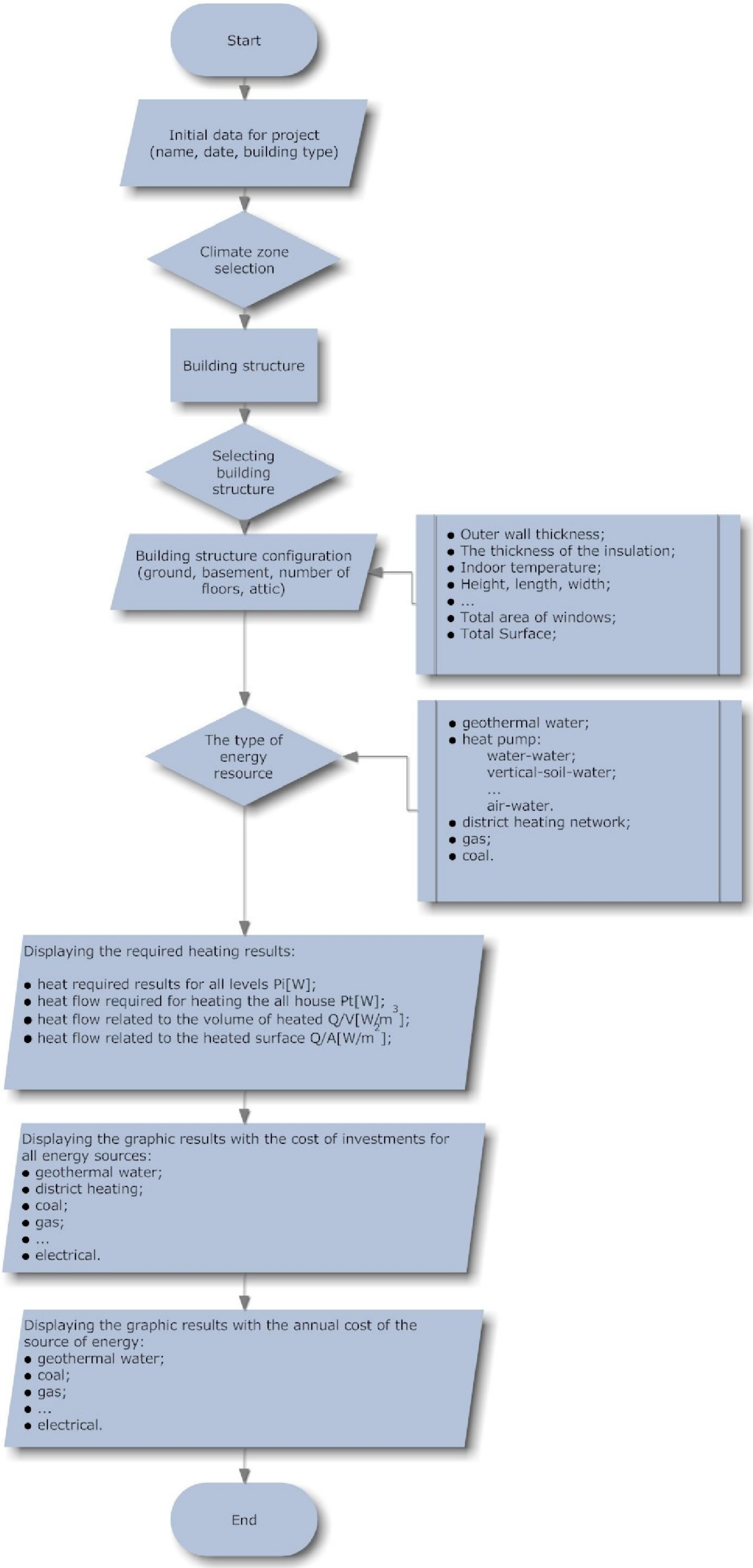

Fig.3 The operating logical diagram of the software

By selecting and clicking on the first button from that user screen, button called [Introducere date], the first input section can be found on the screen where the general details can be introduced, Fig.4.

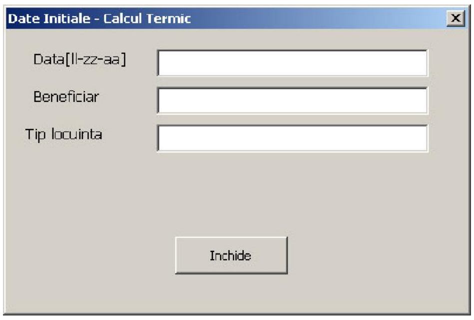

Fig.4 General details window

The next step is [Selectare zona climatica], where according to the map of Romania with the conventional outdoor temperatures (t_e) **[2]**, the location can be selected by using the pull-down menu, as it shown in the capture below in fig.5.

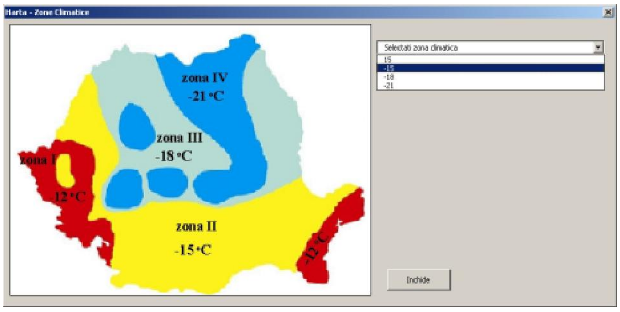

Fig.5 Selection of the conventional external temperature t_e.

After the proper location was selected, the next step refers to the configuration of the building as it is shown in Fig.6.

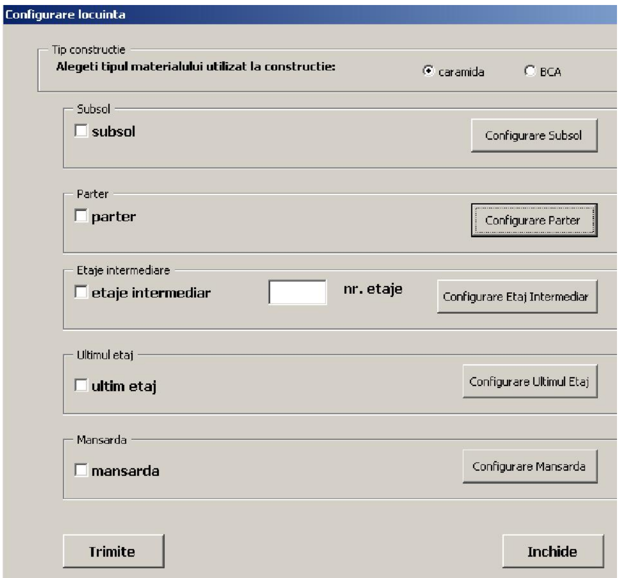

Fig.6 Building configuration (ground, basement, intermediate floors, last floor and attic).

With the buttons according to the desired floor from the right, the user can access the detail configuration input window, where the dimensions of the current floor can be specified, such as, length, width, height, total length of the outer wall, etc., Fig.7.

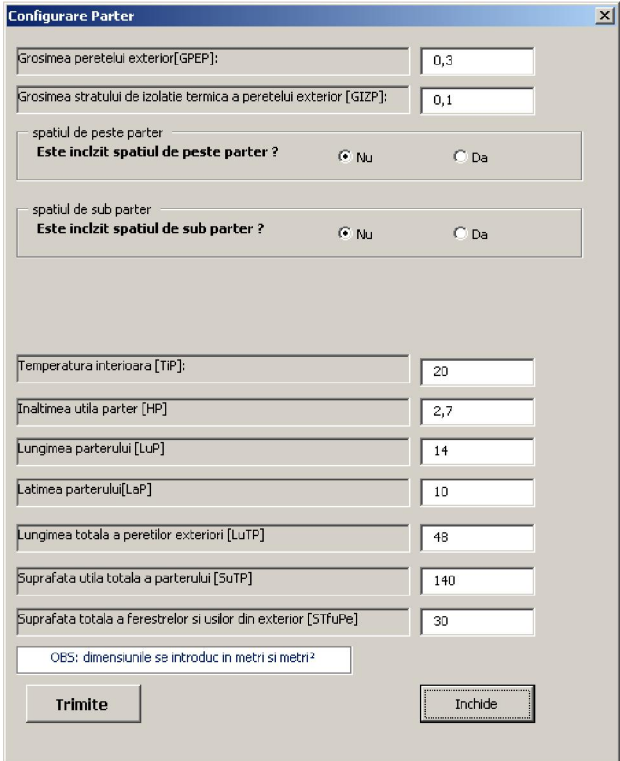

Fig.7 Details configuration window (ground floor)

The next step is to specify the type of energy source that will be used. Consulting the map of Romania's renewable energy can be helpful.

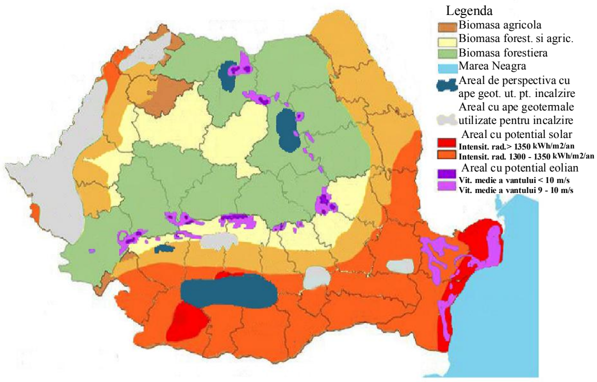

Fig.8 Map of Romania's renewable energy

The window (Fig.9) where the user can choose the type of energy source for which calculations are made, as shown in the map from Fig.8, [4].

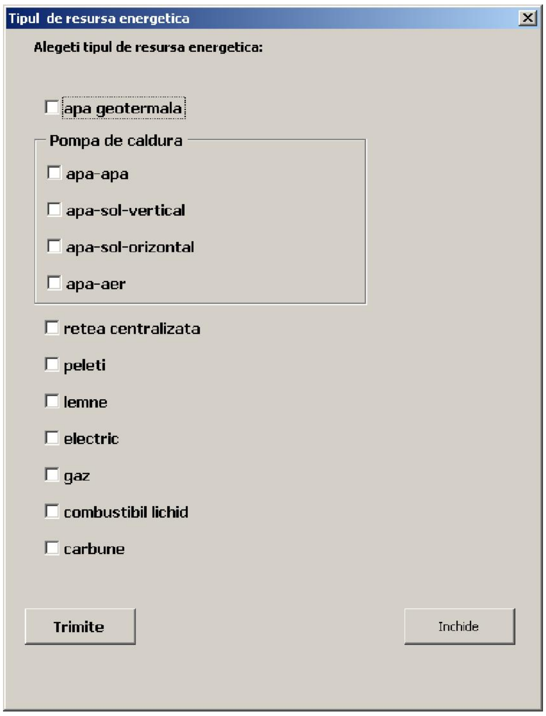

Fig.9 The choice of energy source

The following primary energy sources are used in the presented software is:

- geothermal water;
- heat pump (water-water, water-soil-vertical loop, water- soil-horizontal loop, water to air);
- district heat from combined heat and power system fossil fuel;
- wood pellet;
- wood;
- electricity;
- natural gas;
- liquid fuel;
- coal

By clicking the button [Vizualizare rezultate - Necesarul de caldura] located on the left of the main user interface window it is possible to display the general results directly through one special designed Form (fig.10), from where also it can be printed [Print] the complete report including the details for all intermediate levels, ground, basement and the attic:

- the heat required for all intermediate levels of the building Pi[W];
- the heat flow required for heating the complete building Pt[W];
- the heat flow related to the volume heated Q/V[W/m^3];
- the heat flow related to the heated surface Q/A[W/m^2].

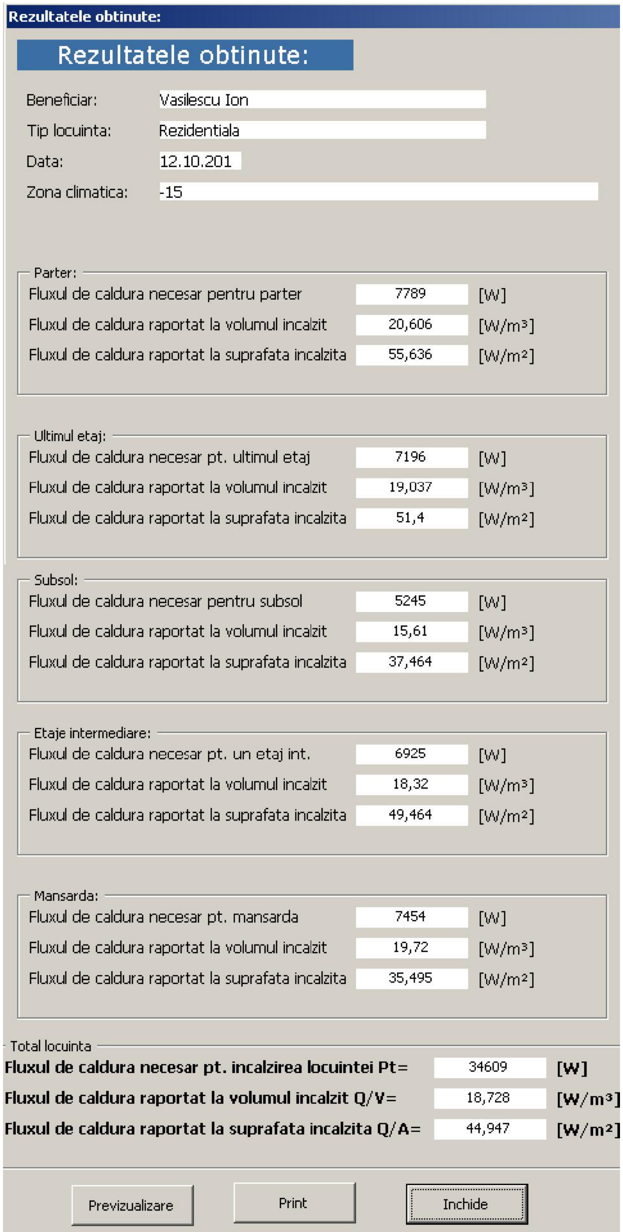

Fig.10 The window of general results

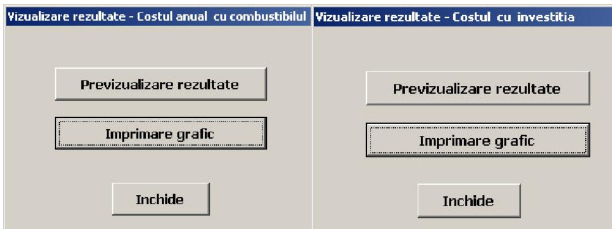

Fig.11 Opening the graphic reports

The presented software can either present a *graphic report* with all energy source included to allow the choice of the optimal solution in relation with the annual cost of the fuel (*Euro*) (Fig.12) and the cost of the investments (*Euro*)

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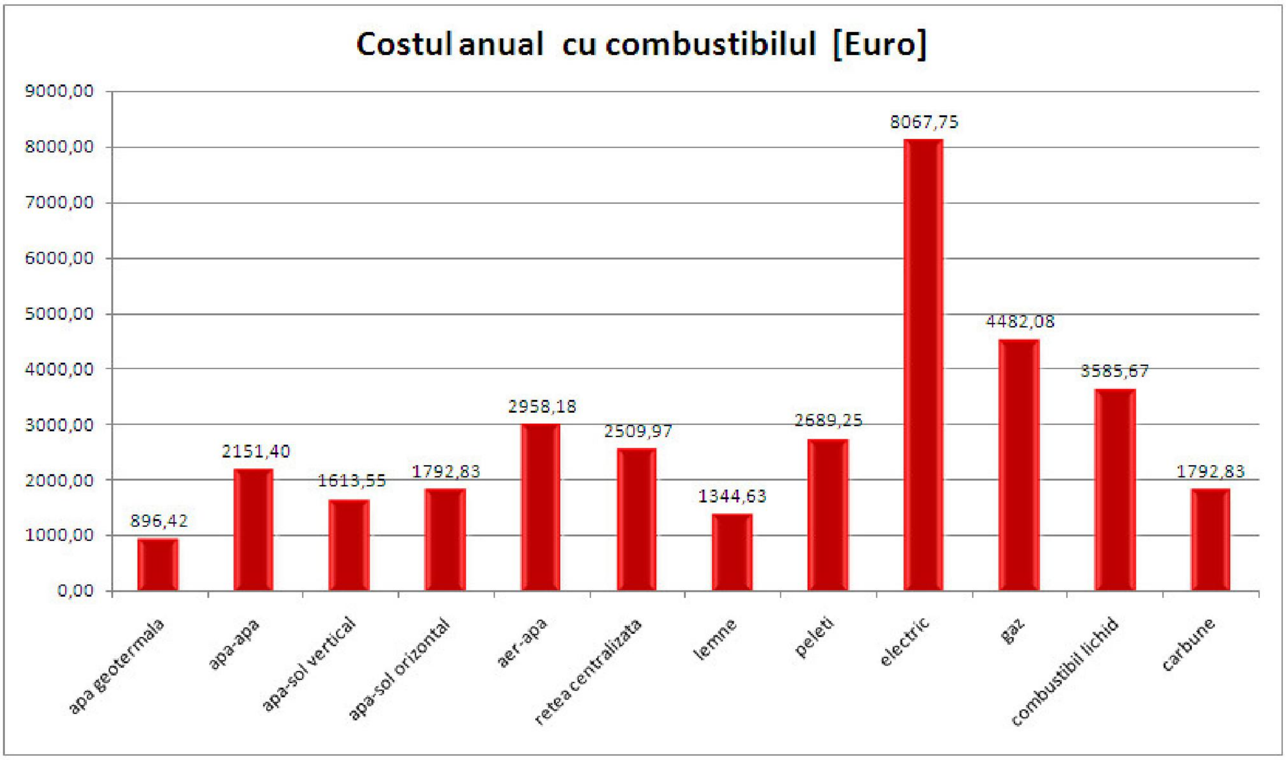

Fig.**13**). These two reports are available to preview (*draw the graphic in the grafice workbook*) or to print out directly to the printer (Fig.11).

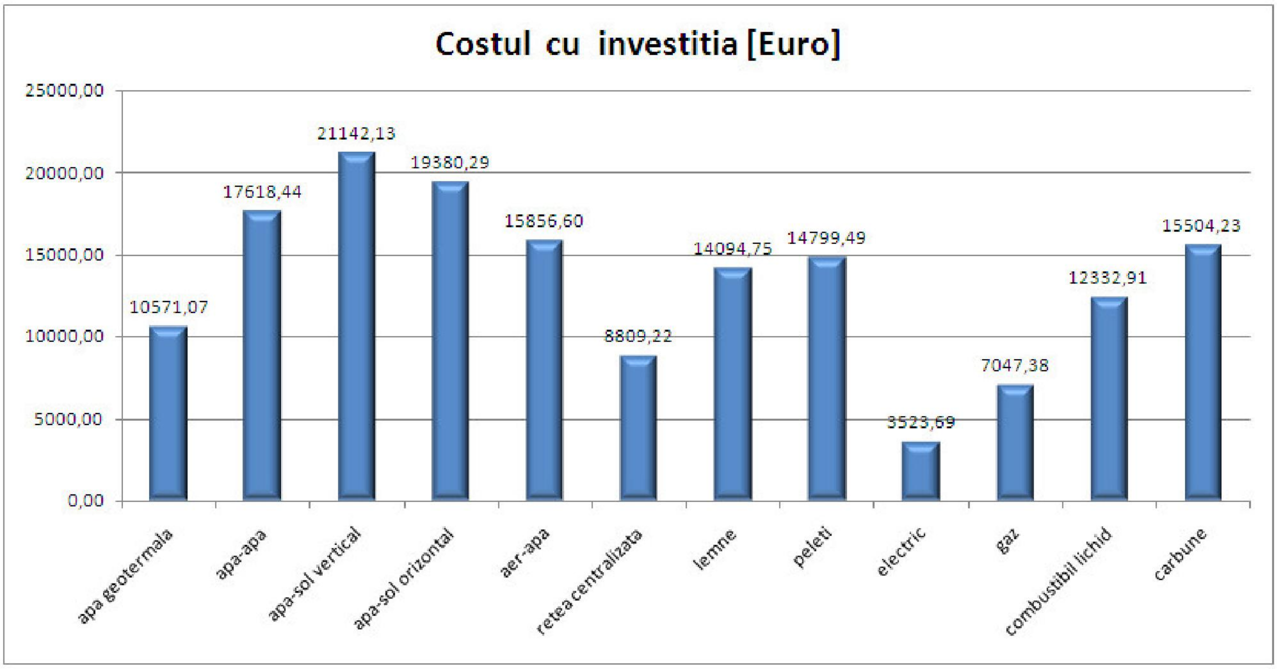

Fig.12 The annual cost of the fuel

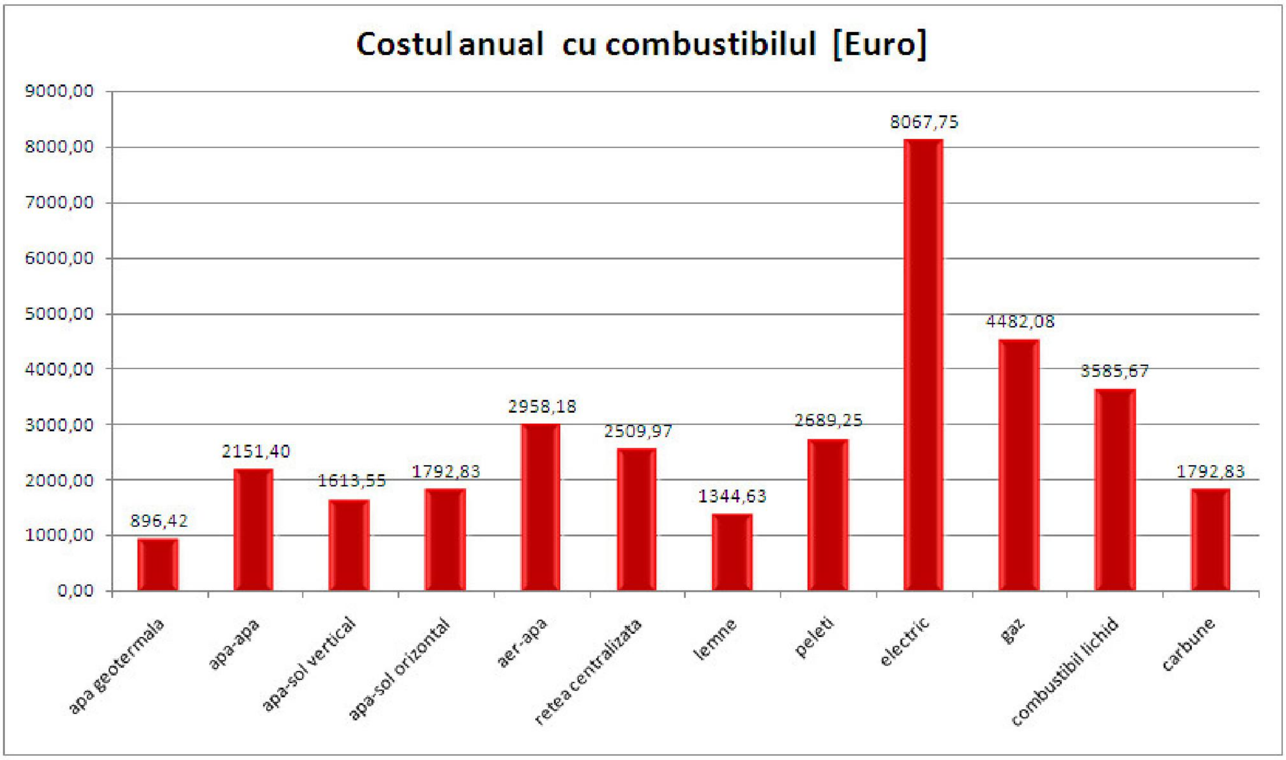

Fig.13 The cost of the investments

5. CONCLUSIONS

The main advantage offered by this software program for determining the heat demand and for choosing the optimal solution of energy supply on the basis of calculations, is translated through the decreased time necessary to introduce the technical parameters that characterize the building from energy point of view and through obtaining results.

By predefining calculation relationships and by storing the values in the existing norms and STAS, respectively through the simplicity of introducing the parameters for each calculation, the time necessary to obtain the results is of some minutes, and the technical data can be collected and introduced using the user friendly interface even by non-specialists.

Notable are also the advantages of using Visual Basic for Application – Excel, an environment in which the program was developed, such as:

- one of the main advantages of using VBA in Excel applications is that it allows working at higher speeds than the speed of executing data in Excel applications. In other words, it gives the opportunity to execute data in VBA forms;
- easy user interface (excel facilities) to work with implemented formulas, creating a table or graphical representation of results;
- excel also supports multi-core processors to help the user to calculate formula-intense tasks;
- no installation procedure is required. Since the Microsoft Office packages are installed on a computer practically there's no other software needed to run programs made in VBA;
- easy browsing or using existing Excel spreadsheets as database support;
- high flexibility. The ability to modify and add further improvements, even for end-users;

Besides the advantages presented in order to use Visual Basic for Application in Excel, also must be pointed a major disadvantage of using this solution which refers to the limited number of lines (65 000) for use spreadsheets and databases. But this can be solved by using multiple spreadsheets if are required.

Since the presented software package was designed and developed in order to be used by non-specialized persons too, with a friendly interface and it is easy to use, does not allow a 100% precise calculation, but the accuracy of heat load is high enough that user to assess the space heat load, heating power, annual energy costs, the degree of insulation of the building, etc.

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