

# Educational Software on Solar Energy development

Jordi de la Hoz, Santiago Nieto, Alfredo de Blas, Oriol Boix

Department of Electrical Engineering

E.U.E.T.I.B, Polytechnic University of Catalonia

Comte d'Urgell, 187, 08036 Barcelona (Spain)

Phone: +34 934137319, fax: +34 934137401, e-mail: [Jordi.de.la.Hoz@upc.edu](mailto:Jordi.de.la.Hoz@upc.edu)

## Abstract

A "Renewable Energy Course" has been offered for several years at the Technical Engineering School of Barcelona (EUETIB). To improve the results of this course, and help a better evolution of the PBL methodology used, we decided to develop educational software. This paper is to be about the relation of the educational software inside the course methodology and their potentialities.

## Key words

Educational software on solar energy, Solar domestic hot water systems, Problem Based Learning methodology.

## 1. Introduction

The "Renewable Energy Course" has been offered at the Technical Engineering School of Barcelona (EUETIB) since 1999.

In the beginnings of the course we used master class methodology to reach theoretical objectives, but in the course 2002/2003 PBL methodology was introduced in order to improve knowledge about renewable energy and students' attitude during the course.

Within framework of the new methodology, we defined two kinds of course's objectives, the objectives related to the affective domain and the cognitive objectives. The cognitive objectives are developed in four areas:

### A. *First area: Renewable energy*

The students have to be able to know about existence of different types of renewable energy and their principal characteristic.

### B. *Second area: solar domestic hot water systems (SDHWS)*

In order to understand the basic principles of the SDHWS students almost has to identify parts of the system and know how these parts work.

### C. *Third area: SDHWS calculation*

Assuming knowledge on solar domestic hot water system, students have to be able to know how to calculate SDHWS.

### D. *Fourth area: Legalization process*

At the end of the course students will have to be familiarized about how to legalize SDHWS.

By means of PBL methodology students must:

- 1) Evaluate their knowledge and their need for increasing this one.
- 2) Draw up a self learning process where contents and how to organize their time were equal significant.
- 3) Evaluate self learning planning results in order to improve process quality.

## 2. Motivations for the development of the educational software

When we decided to introduce PBL methodology we were conscious about one of the great difficulties, the time limitation.

In the third area, we give to the students a calculated project of a SDHWS in order to use it as students reference guide due to the short length of the course.

The students use the project to be familiarized with the calculation procedure of a SDHWS and, through the obtained project data, will make a description of the principal calculations to accomplish in a SDHWS project.

Nevertheless, we have verified that, once this work it is ended, students do not have the necessary capacities to develop a SDHWS project by their selves. So we have decided to develop educational software that permits the students to calculate SDHWS and to show at the same time all the steps followed in this calculation process.

## 3. Software's structure

In order to reach one the course's objectives, to know how calculate SDHWS, we decided to provide an easy software structure where the most important thing should be to follow the calculation procedures recommended by the Catalanian administration. Our intention was to develop software that allowed students to consolidate the calculation processes of SDHWS.

We can group the software structure in fourth blocs and only one of them, the first bloc, is accessible to the user. The fourth blocs are:

### A. *First Bloc: SDHWS data introduction.*

In this bloc the user must introduce and choose, when it will be necessary, the SDHWS data:

- 1) The SDHWS site
- 2) What kind of SDHWS we want to calculate
- 3) Collector main characteristics

*B. Second Bloc: SDHWS needs calculation*

Defined the SDHWS by the user, the educational software calculates the monthly energetic needs of the system.

*C. Third Bloc: SDHWS energy production*

Defined the SDHWS site and the main SDHWS characteristics by the user, the educational software accomplishes an estimate of energy provided by the system.

*D. Fourth Bloc: Results*

Accomplished all the calculation process, the educational software generates a file where it can be observed all the results as the SDHWS suggested solar collector area, and the energetic shortage of the system.

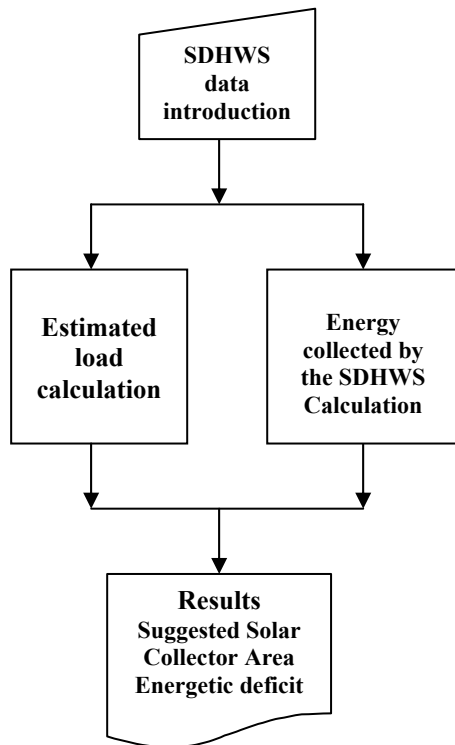


Figure-1. Software's structure

#### 4. Software's description

The developed software is formed by five screens, project's data, location's data, housing's data, collector and solar system losses, and file generation, where in each of them the user must introduce or select the SDHWS' data (see Figure-2).

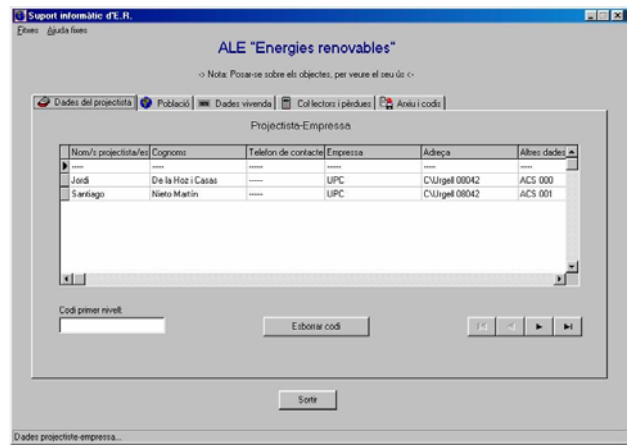


Figure-2. Software's screens

*A. First screen: project's data*

In the first screen the user will have to introduce his name that will appear when the file results will be generated. Also, the software allows to create a users' list protected by password.

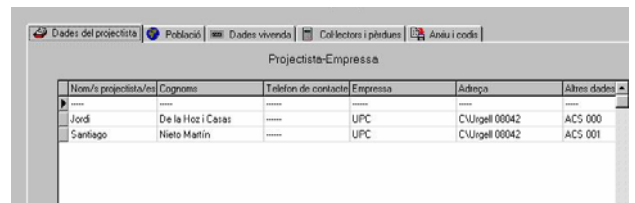


Figure-3. Screen of Project's data

*B. Second screen: location's data*

In the second screen the user will select all the data related to location where SDHWS is wanted to develop. There are three main steps to do in order to define properly the location data:

- 1) The user will have to select the town where SDHWS is wanted to develop. Once the user may have selected the location, automatically the software selects for each month of the year the monthly average daily ambient temperature, the monthly average daily cold water temperature and the monthly average daily number of sun hours.
- 2) When location is selected the user will have to choose SDHWS azimuth.
- 3) Finally the user will have to choose the slope of the collector, so he/she obtains the monthly average daily solar radiation in the plane of collector.

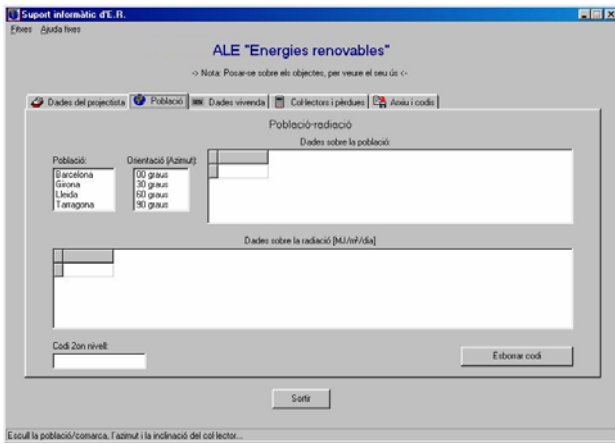


Figure-4. Screen of Location's data

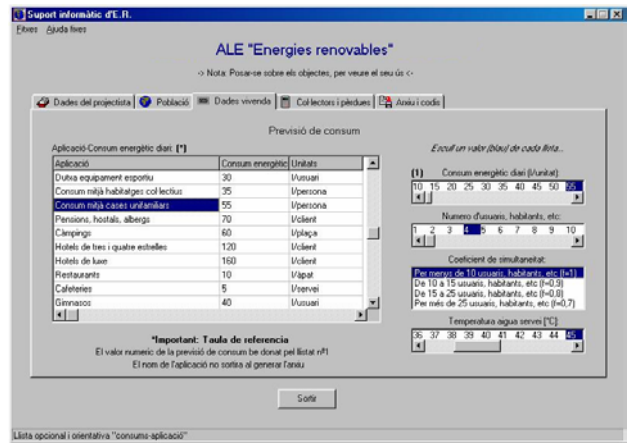


Figure-6. Screen of Housing's data

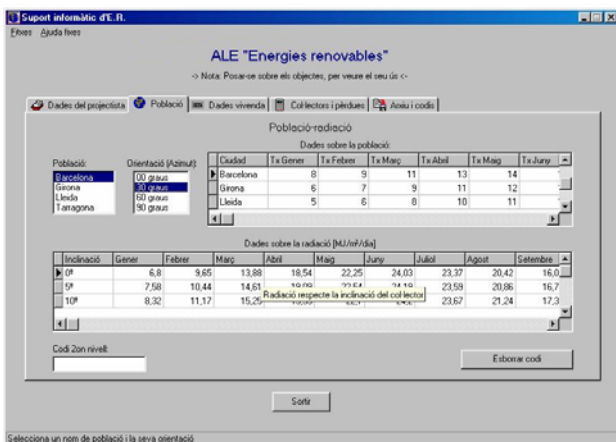


Figure-5. Selection process of the location

### C. Third screen: housing's data

In third screen the users will select the required amount of water, according to the type of system to calculate, and the required hot water temperature. In order to define properly the housing's data, the users would have to:

- 1) Select the type of system they want to calculate. The software has a list of required amounts of water according to the type of systems used. The values of the list are always used by the software, although the user can introduce another one if it is necessary.
- 2) Select the number of inhabitants of the installation.
- 3) Select the correct value of the coefficient of simultaneity according to the number of inhabitants.
- 4) Select the required hot water temperature.

### D. Fourth screen: collector and system's losses

In the fourth screen the user will have to select the collector of the SDHWS, and the losses associated with SDHWS.

The software has a list of collectors and also permits to introduce a new one.

Finally the user will have to define the losses associated with SDHWS. Exists, in the software, three kinds of losses to define:

- 1) The losses by residual radiation
- 2) Collector's losses
- 3) System's losses

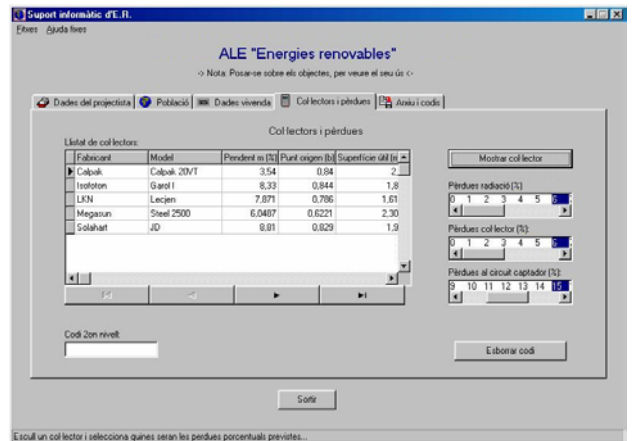


Figure-7. Screen of the Collector and System's losses

### E. Fifth screen: file generation

In the fifth screen the user will have to write the name of the "txt" file where it will be find the results of the calculation process.

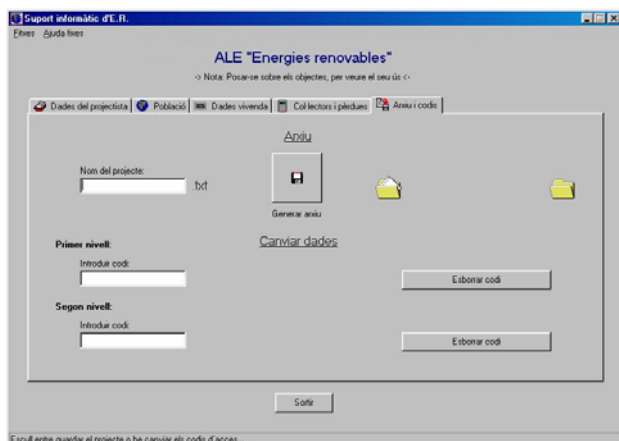


Figure-7. Screen of the file generation

## 5. Report of the results

The information generated by the software will be presented in fourth blocs, project's data, radiation and location's data, SDHWS's data and energetic deficit of the SDHWS.

### A. First bloc: project's data

### B. Second bloc: radiation and location's data

In this bloc the software will provide us the following information, where the SDHWS is located, the solar azimuth angle and the angle between the plane of the collector surface and the horizontal (slope).

For each month of the year the software also will provide the:

- 1) Monthly average daily solar radiation in the plane.
- 2) Monthly average daily effective solar radiation in the plane.
- 3) Monthly average daily cold water temperature.
- 4) Monthly average daily ambient temperature.
- 5) Daily number of sun hours.

### C. Third bloc: solar domestic hot water system data

In this block the data of the installation are grouped in two tables. In the first table, or consumption's table, we can find for each month of the year the:

- 1) Daily required amount of water.
- 2) Daily estimated load.
- 3) Monthly estimated load.
- 4) Annual estimated load.

Previous to second table the software details the principal characteristics of the collector used in the calculation process.

In the second table the software shows us the:

- 1) The collector efficiency.
- 2) Daily energy collected per unit collector area.
- 3) Daily energy collected by the system per unit collector area.
- 4) Monthly energy collected by the system per unit collector area.

### D. Fourth bloc: necessary auxiliary energy

Finally the software provides us the values of the suggested collector area, the number of the collectors, and the monthly auxiliary energy of the SDHWS.

## 6. Conclusion

Within improvement process of the Renewable Energy course we have developed educational software. This software has been developed to help the students to reach the necessary knowledge in the calculation process of a SDHWS.

We wait that this software permits the students to accomplish the calculation of several SDHWS, as tool for the development of their capacity and ability in the SDHWS' calculation field.

We believe that the simplicity of the developed software will help the students to reach the wished objectives. Furthermore, a user's handbook it has been written in order to help students in their first steps with the software.

## References

- [1] Jordi de la Hoz i Casas, Alfredo de Blas, Ramón Bargalló. (2004). "The Renewable Energy course at the Technical Engineering School of Barcelona (EUETIB/UPC)". International Conference on Renewable Energies and Power Quality.
- [2] Willie Yip. "Students' perceptions of the technological supports for Problem-Based Learning". *Education and Information Technologies* 7:4, 303-312, 2002.
- [3] Madeleine Abrandt and Gunilla Öberg. "Questioning to learn and learning to question: structure and function of problem-based learning scenarios in environmental science education". *Higher Education* 41: 263-282, 2001.
- [4] Duffie J. A. and Beckman W. A. (1991). *Solar Engineering of thermal processes*. John Wiley, New York.
- [5] Beckman W. A., Thorton J., Long S. and Wood B. D. (1994) Control problem in solar domestic hot water systems. *Solar Energy* 53, 3, 233-236.
- [6] Hollands K. G. T. and Brunger A. P. (1992) Optimum flow rates in solar water heating systems with counter flow exchanger. *Solar Energy* 48, 1, 15-19.