Engineering Assessment made Easy: The ‘Energysave’ Approach

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Abstract: Whilst naturally ventilated buildings are currently considered to be the ideal solution to low energy design there remain a large proportion of buildings for which air conditioning offers the only practical solution. This project is intended to provide a means to assess design options for such buildings at a very early stage in the design and in particular address the selection of the most appropriate system. The form of the interface is still developing and while it has been demonstrated to designers no third party tests have yet been carried out. This paper reports on a project that aims to show that a general description of the building can be used to generate sufficient data to drive a valid analysis using a detailed thermal model at the early sketch stage of the design process. It describes the philosophy, methodology and the interface developed to achieve this aim. The interface guides the user through the input process using a series of screens giving options for keywords used to describe the building; comprehensive default data built into the software are then attached to these keywords. The resulting data file is a building description that is the best possible interpretation of the design intent. This can then be used to assess options and guide towards a final design.

Keywords: Architecture, Engineering, Energy, Assessment, Sketch stage, Design process, Data transfer, XML

Introduction

At present, during the early design stage of a building, different options are assessed using simple tools (tables, graphs and software) that contain a large number of assumptions the very nature of which can bias choice or possibly lead to an inappropriate solution. It can be argued that the only way to provide a rational assessment of options is to use calculation methods that represent in detail the physical processes involved; this usually involves the use of dynamic thermal models. Many designers are of the opinion that, because not all details are known, then such tools are not suitable for application at early stages in the design. This view can be challenged because, even at the concept stage a great deal is known about the building, for example:

- Size;
- Number of floors;
- Occupancy;
- Preferred glazed areas;
- Insulation standards;
- Thermal mass;
- Required internal environmental conditions.

Not withstanding this there is still resistance to the application of simulation, typical reasons given are:

- Too time consuming to input the necessary data;
- The program is not user friendly;

• Manual methods are quite adequate;

• Programs cannot be trusted;

• Do not understand how the program works.

Arups had already recognized the need to address these issues and encourage the use of simulation throughout the life cycle of the building and so, at their own expense, joined the International Energy Agency (IEA), Building and Community Systems, Annex 30 (Bringing Simulation to Application). Arup Research and Development was the official UK Participant.

The IEA project demonstrated the value of simulation throughout the design process, the value of good quality default data and the need for software validation. However despite identifying user friendliness as an important issue in increasing the uptake of simulation throughout the construction industry, it did not make a serious attempt to address that issue. The objective of EnergySave is to redress this.

State of the Art and Related Work

There have been a number of projects that aim to provide simple interfaces to assist the designer, for example:

• The 'NATVENT' project (Natural ventilation for Offices. BRECSU March 1999);

• The 'Office Design Tools' (Building Services Journal, December 1999);

• The 'Building Design Advisor (BDA)' (Papamichael, K. et al. Decision making through use of interoperable simulation software, Building Simulation '97. Fifth International IBIPSA Conference, Prague 1997).

The complex nature of ventilation, and the very uncertain nature of the boundary conditions (wind environment, pressure coefficients, for example) justify the simple nature of the analytical models used in the first two examples. The third is a way of using a detailed thermal model to analyse design options. The main difference between this work and the BDA lies in the interface. The BDA uses a graphical tool that requires each space to be specified in some detail. It is therefore close to a conventional analysis tool and as such is not suitable for studies at the sketch stage of the design. The method by which results are presented is however one example that will be examined during the project. Members of the EnergySave team have visited the Laurence Berkley Laboratory in California and are therefore fully aware of the strengths and weaknesses of the BDA.

The intention of the EnergySave project is to make use of available software and skills. In particular, whilst a detailed thermal model is necessary for the implementation of the method there is no intention to develop that model. It is however important that the source code of that model is available to the team. The model selected is ENERGY2. This program has been developed in Arup Research and Development and has been exposed to the International Simulation Community by means of the IEA Annex 21 (a task shared project related to quality assurance and validation of thermal models).

In order to facilitate energy calculations it was necessary to develop generic system models. These are based upon those described in the CIBSE Energy Code 2, 'Energy demands for air conditioned buildings'. Arup Research and Development were involved in the drafting of this code and made significant inputs into the building description application of climatic data and testing of early versions. Although these models are very simple they capture the essential features of the systems. This means that the major inefficiencies are accounted for.

The Energysave Approach

The objective for the EnergySave interface is to capture the essential elements of a design in an unambiguous way to enable a valid energy analysis at the concept stage of a design. Of equal importance is that any data output should be in sufficient detail to enable the use of a detailed thermal model ***1*** for the prediction of energy consumption. This model would also be used at later stages in the design process so bringing a consistency to the analysis through out design. A second and equally important objective is to provide a mechanism to bring simulation to those who believe it to be too complex for their needs and far to difficult to use. This is done in several ways:

• The use of extensive, intelligent defaults to minimise the amount of data that are required;

• The use of a pictorial based input system to identify the main input parameters;

• The use of minimum data to describe building;

• A critical assessment of the most significant features that can affect the energy consumption of the building.

An example of the later is the way solar shading is described. In the case of passive buildings it is particularly important to ensure that the effect of any purpose built shade is accurately represented. In the case of air-conditioned buildings this is less necessary because energy consumption is far more closely related to systems and controls. EnergySave does not ignore external shade but on the other hand does not encourage users to be obsessed with complex representations. The form of the building is simplified, at present to a rectangle. While this is recognised to be a limitation it is also felt that the majority of buildings can be adequately represented. EnergySave is intended to apply to the norm. Section 4 (Overview of the interface) demonstrates the principles described above.

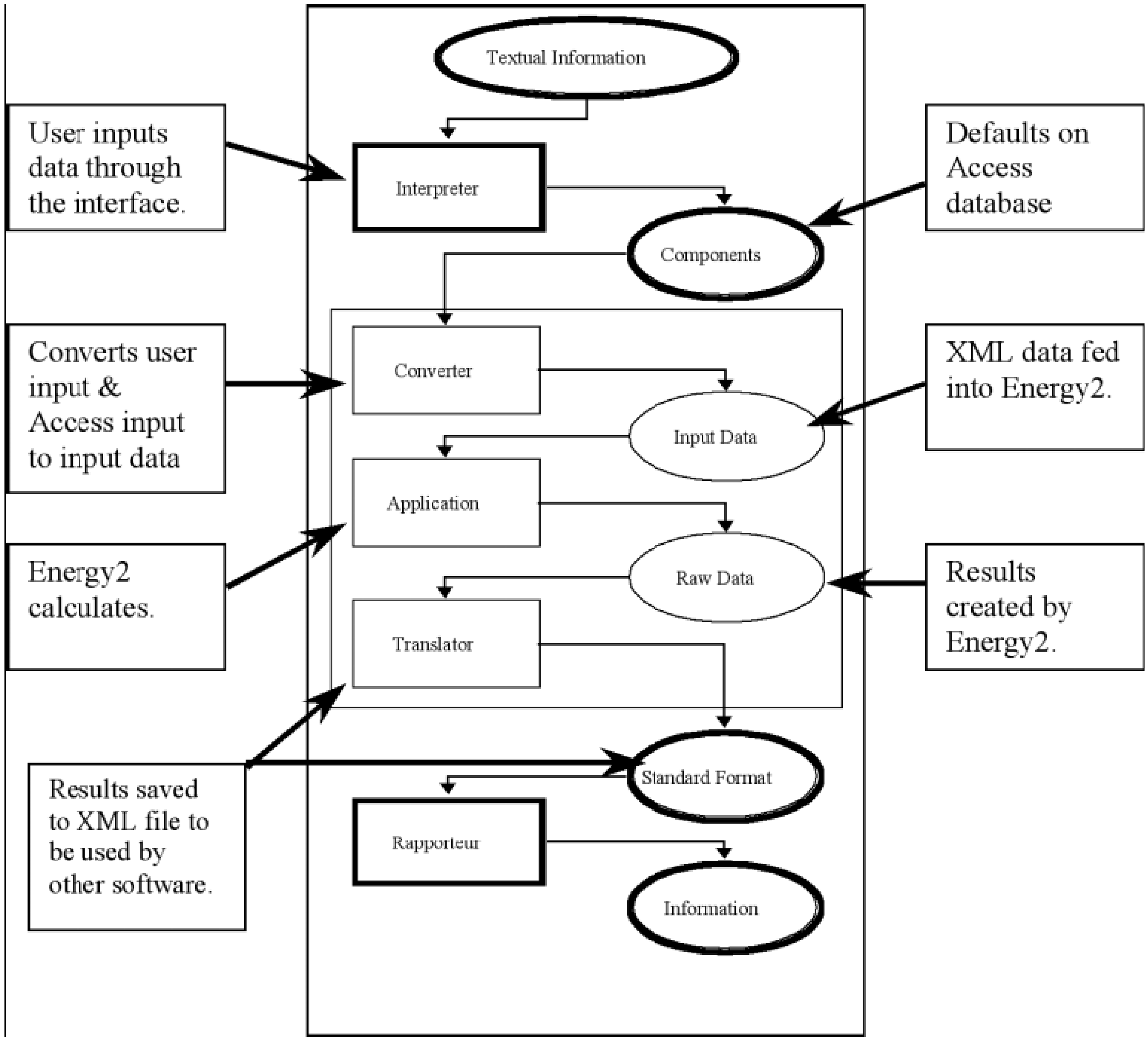
A second fundamental to the system is to use what is already available, thus the main database used is a commercial product chosen because the majority of PC users will have access to it. Intermediate data transfer uses an XML Schema taken from the public domain (Green Building Schema).

It is important to realise the EnergySave does not contain a calculation engine. It is intended that the XML file be described in sufficient detail to allow the use of third part ‘engines’. This is direct contrast to the development of public domain engines in the USA.

1 *A detailed thermal model is usually a simulation program capable of calculating the performance of both building and HVAC systems at hourly intervals for the period of a year. In the UK context design programs based upon the CIBSE Admittance method are not considered to be detailed thermal models.*

Structure of the System

The following flow diagram shows the form of the system.



The interface between EnergySave and the application is the XML file. This Section briefly describes the system.

The Interpreter

The written descriptions are converted into components using rules developed from discussions with designers from the industrial partners who have also provided default data based upon previous projects. These are combined with user specific data into building and system components and written to a standardised data file. The data structure produced by this process is to be specified in sufficient detail to allow any developer to use their model in conjunction with this system. One function of the interpreter is convert simple descriptions into physical layers that are suitable for use in a detailed thermal model. Examples are:

• Opaque walls. Input U value and response time – output layers in the construction and the physical properties of those layers.

• Glazing. Input shading coefficient – output layers and basic properties such as transmission and absorption at normal incidence for each.

• The ‘Interpreter’ combines the default data taken from the database and combines that with the user input to write the XML file. It is important that a single XML file contains ALL options investigated. This can be done by specifying each as a new building on the same site (campus in the Green Building Schema).

The Converter

This is specific to the simulation model used it would be written by the application vendor to convert the data on the XML file to that required by the program.

The Application

In this case the Arup ENERGY2 program will be used. It could however be any appropriate model.

The Translator

This is specific to the program used in the analysis and is used to convert the predictions (raw data) into a standard format. This format is specified in detail to allow the system to be used by other software developers. The output from the ‘translator’ is to the XML file.

The Interface

This Section shows some of the essential elements of the interface and where appropriate how they can be used to set defaults. It is intentional that the screens – or forms –presented to the user do not have the appearance of a conventional Windows interface. It is inappropriate to display the complete interface, the sample ‘forms’ presented here are intended to highlight the main principles behind EnergySave.

Input data

This is an XML file containing:

• Location and climatic data information; • A full geometrical description; • Thickness and properties of the walls;
• Transmission, reflection and absorption characteristics of each element within a window. • Shading details;
• The configuration of the HVAC plant.

Project Definition

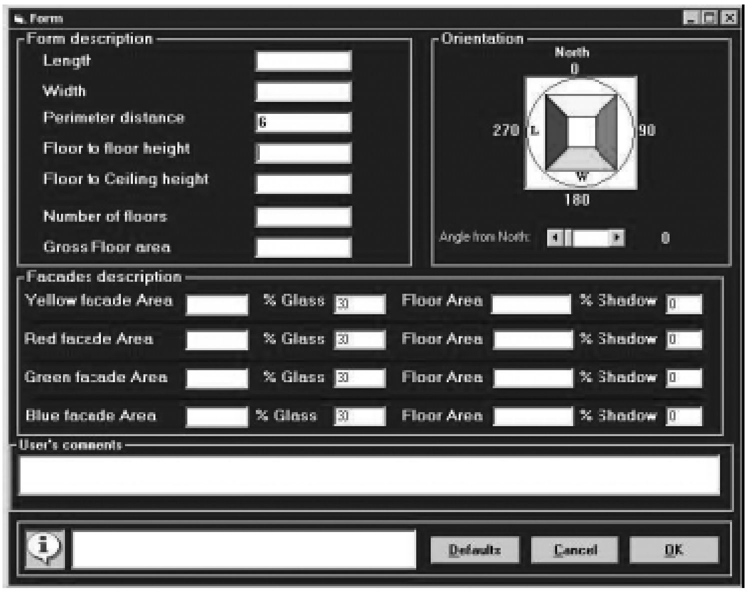
In addition to capturing the standard inputs such as project description and user, the location and function of the building are defined. Location sets insulation standards via local building regulations and occupancy patterns and internal gains are set by the function. A default building is generated.

Location

The country map is displayed. Each region contains a link to a climatic data file. Software vendors can enter their particular file names on the database. Exposure is also identified. Because this can be done in several
ways, an advanced option allows an alternative definition, terrain type. This is intended to provide data for software that requires some means to describe wind shading for infiltration and ventilation calculations.

Building's form

A simple model of a building is created, using zones based on the façades. The user inputs the length, width, floor-to-floor height, and the number of floors. Simple solar shading is also set here, another input (not included) allows for individual window shade to be entered.

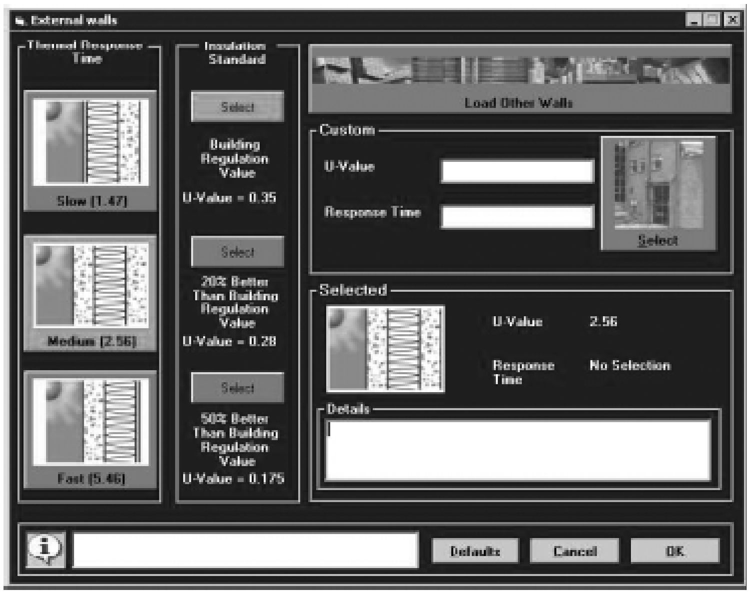


Internal Gains

Internal loads are defined by 'level', very high to very low. The defaults corresponding to these levels are displayed and it is possible for the user to make changes.

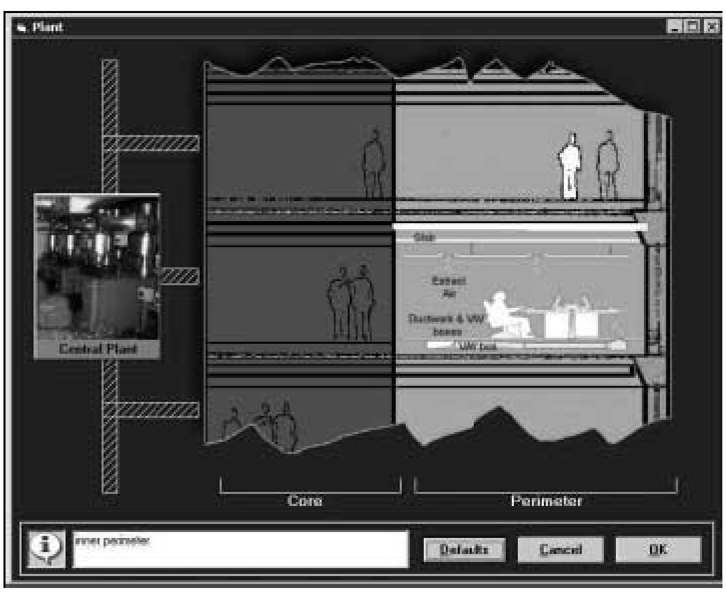
External Walls

Materials used in external walls can be selected. The variations are labelled by their U-Value and thermal response time (Admittance). The user can select the closest type of wall or alternatively create a custom wall using the advanced option



HVAC Systems

A side view cut out section of the building is split into the core, inner perimeter and outer perimeter. Each section can be 'filled' with heating and cooling systems. This is shown in the green section with the under-floor VAV system. As the user enters data, options are limited for other sections so that inappropriate combinations cannot be selected.



The Rapporteur

The nature of the output from an energy simulation requires specialist knowledge for a valid interpretation, in particular where comparisons are to be made. The rapporteur provides a facility to compare and interpret design options. It is hieratical in nature so the user is first offered overall energy (and CO2 figures). It is then possible to delve deeper to looking order to develop an understanding of the performance indicated. Automatic comparison of options will be available. The rapporteur allows comparison of results for up to 4 options. The parameters covered are:

• Carbon dioxide production;

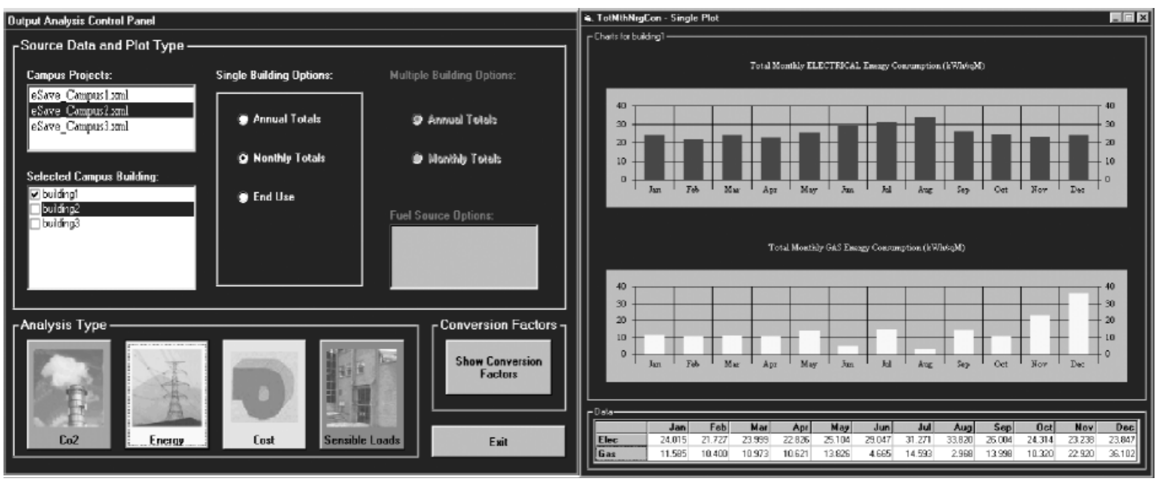
• Energy consumption in terms of electricity and gas;

• Energy consumption in terms of cost;

• A breakdown of the loads on the building (solar, infiltration etc.)

• An ‘end use’ breakdown – fans, boilers, chillers humidification etc.

The data are presented as both annual monthly totals.



Conclusion

The EnergySave project is intended to bring simulation to a wide range of building design professionals. To do this it has been necessary to make many simplifications to the description of a building and the associated HEVAC systems. These are based upon the relative importance of each element upon energy consumption. It is believed that the weightings used will result in meaningful predictions. EnergySave differs from other approaches to simplified energy analysis in that simplifications are made in the way data are described to the analytical engine and not in the engine.

Acknowledgement

EnergySave is part funded by the United Kingdom Department of Trade and Industry.

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