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« ONLINE »

A THERMAL BALANCE TOOL FOR ARCHITECTS : MODIFY THE ENVELOPE OF YOUR BUILDING AND HAVE AN ONLINE FEEDBACK ON HEATING AND COOLING DEMAND

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Abstract

This project, financed by the OFEN (Swiss Federal Office for Energy), consists of developing a computer-tool for parametric studies and optimisation of the thermal behaviour of a building in real-time. The tool intends to give immediate information on the effect of any parameter on the heat balance. A direct access to several tools and catalogues facilitates input. The software is designed for large scale dissemination in technical schools, universities and among architects. It shall equally be useful to calculate the heat balance according to the Swiss national standard.

INTRODUCTION

Experience has shown the interest of computer assisted design in the field of thermal modelling throughout the building design and decision process. Heat balance calculation is now used in most European countries as thermal predesign tool and for application and control of national heat demand standards.
Based upon the experience of the DIAS[1] database developed at the CUEPE since 1991 that already includes a heat balance tool, a survey was made upon the active users so giving hints and ideas to a completely new approach for a thermal balance tool.
Indeed several, factors are limiting in most available software:

- input is fastidious,
- calculation even though fast, does not allow for intuitive parametric studies,
- comparison between variations of the project or with other building projects is not available,
- the amount of visible and available data are often predefined or limited.

Also the implementation of passive solar devices, such as transparent insulation (TWD), greenhouses and other passive solar devices are rarely taken into account.
The aim of ONLINE is to provide a user-friendly input of building data and immediate feedback on the effect of each choice implemented in the global thermal balance of the projected building or renovation project.
A draft of CASA[2], a simplified real-time thermal balance tool, developed by Prof. Heidt at the NESA Software-Labor at the University of Siegen in Germany, gave additional inspiration for the project.
The software mainly aims architects and teaching in technical schools or universities. For this reason, the user interface must be explicit and didactic at one time. In order to allow for clearness and understanding, the amount of visible information on the screen must be reduced to the minimum and depending only on the complexity of the building itself.

GENERAL CONCEPT AND STRUCTURE

ONLINE is based on the trial and error method. No user-guide is required and the user is allowed to try out different components, materials and some of the technical devices (e.g. ventilation). The idea is to make the user 'feel' the projected building from the thermal point of view through a game-like approach. An appealing, easy to use and didactic graphical user-interface is the key part of the software .

With the help of interactive dialogue-boxes, the user is guided from the general building-description to the construction-detail. In order to accelerate the input at the predesign stage and rapidly give a first impression on thermal behaviour, the software proposes default-values at each level (e.g. u-values, glazing, etc. but also complete windows, walls, thermal bridges). From this basis the user is invited to refine the building envelope description in order to optimise the heating energy demand.
Each level of detail contains a summary of its' related components and the most important and characteristic thermal data. A special effort has been made to avoid useless intermediate keyboard or mouse events.
In order to facilitate the overview when working on large and complex projects, the user can define names and short descriptions at each level of input.

ALGORITHMS AND DATAFLOW

The calculation method of this tool is mainly based upon the European CEN832 and the Swiss SIA380/1, allowing to

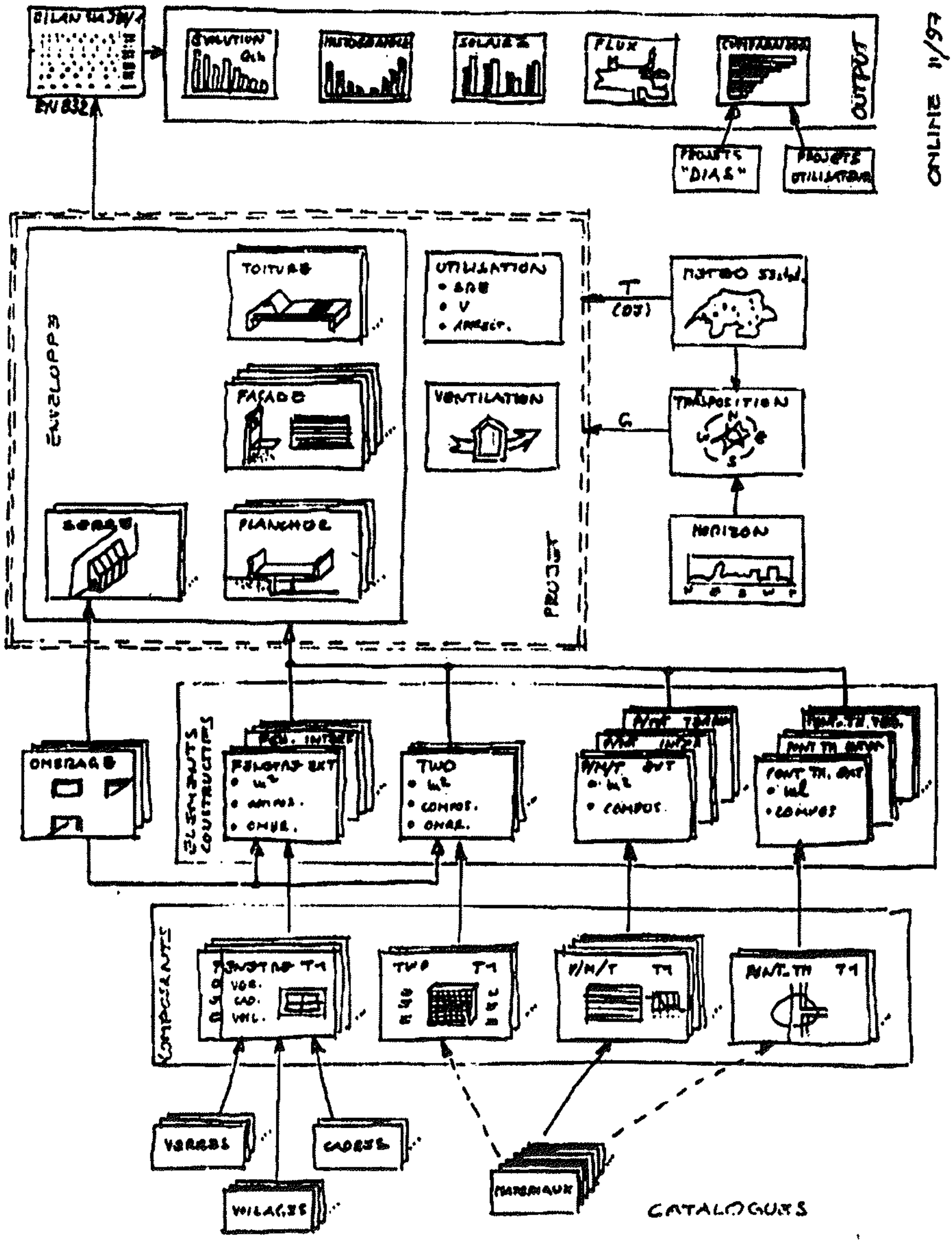

Figure 1 : Flowchart showing the general structure and flow of data in ONLINE. The user defines the building, beginning from the general description, then the building envelope that refers to several construction elements. These refer to pre- or user-defined components referring themselves to the four material catalogues that contain all basic physical data. Each level of information includes precalculated intermediate data, allowing for fast feedback as only related information has to be recalculated.

take into account the effect of passive solar devices such as transparent insulation (TWD), greenhouses, tromb walls and more. Explicit and well documented program scripts allow for easy updating to new energy-standards and calculation algorithms. Future additional predesign tools, such as simulation of solar collectors and photovoltaics, will be based on simplified calculation methods. Data structure ONLINE is based upon a modular structure allowing future tools or new complementary modules to be added.

Origin of data

Three levels of data are required for building description :
1. general building data,
2. facade / roof / floor data,
3. quantitative description of envelope-components used on each facade and their references to the components libraries and the shading tool (windows only).

Two levels are available for physical data :
1. All basic physical data are provided by 4 catalogues (each catalogue is devised into four categories: default / standard / suppliers / user data):
    - building materials,
    - glazing,
    - frames,
    - masks.

2. Two libraries of predefined components provide precalculated intermediate results required in the thermal balance algorithm :
    - windows (composed of glazing, frame, masks),
    - walls, roofs, floors (composed of materials from the building material catalogue),
    - linear and local thermal bridges.

All data is easily editable and explicit external files allow for easy update through diskette or Internet.

Meteorological data are provided through external files that can be generated from monthly or hourly data (an import filter for use with METEONORM[4] is projected, so allowing to use ONLINE throughout Europe).

Organisation of the user interface

Data input is organised in an always increasing degree of detail.
The user starts entering data on the general information page. From there, one or several facades, roofs, floors, may be defined, each composed of different subtypes. Each subtype makes reference to predefined or user-defined building-components, such as multilayer walls, roofs or floors, complete windows or linear and local thermal bridges.
Each building component is itself composed of one or several material-resources defined in the related catalogues. They can be easily edited by means of the integrated component editors (u-value calculator, window design editor, shading tool).
At each user event all dependent data is instantly recalculated, giving an 'online' feedback on the effect of any modification :
As each level of information is referenced to the underlying level, the modification of a parameter is automatically related and taken into account in all dependent descriptions. This allows for parametric studies at each level of detail : choice of whole building components (according to the predesign stage where the building structure and details are not yet defined) or choice of specific building materials and their physical properties (e.g. the effect of changing the thickness of thermal insulation, effect of changing between different types of glazing, etc.).

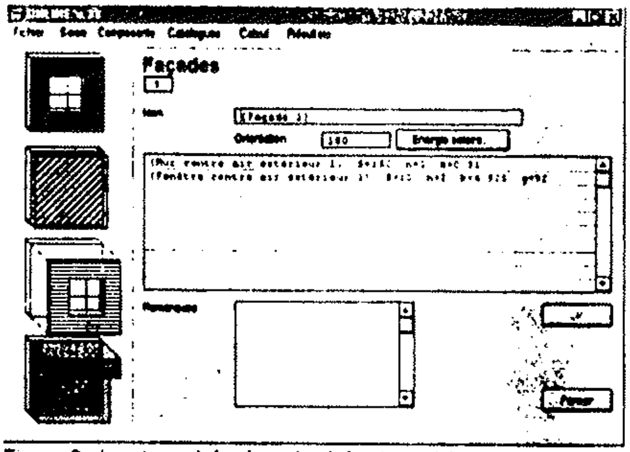

Figure 2 : Input mask for facade-definition, giving access to several types of envelope-components.

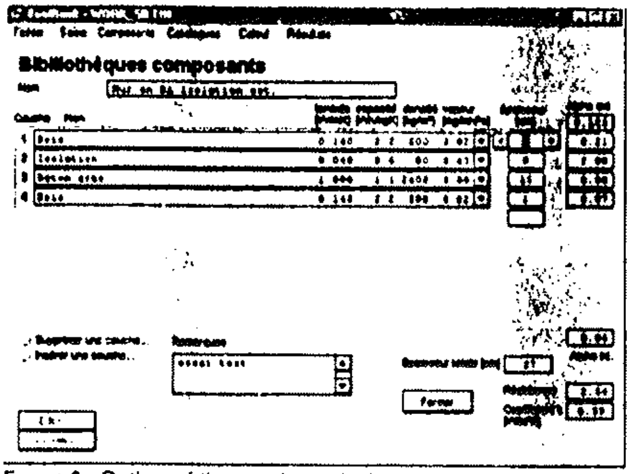

Figure 3 : Outline of the u-value calculator.

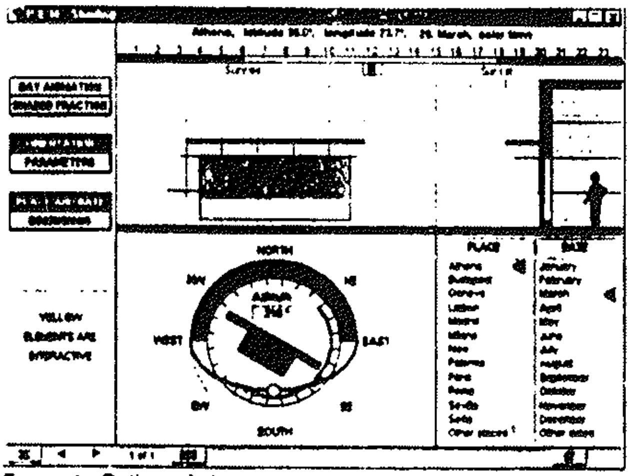

Figure 4 : Outline of shading tool, to be completed with vertical shading devices, allowing for design of passive shading taking into account solar geometry.

Output

Once a basic building description has been defined, one or several output-windows are available at a time :

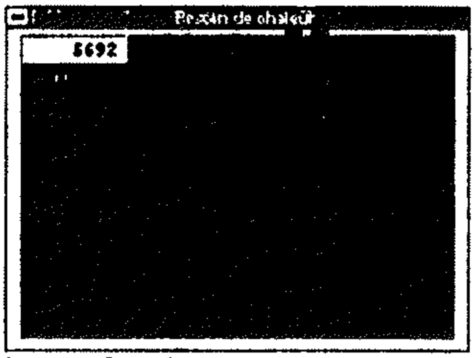

Figure 5 : Graph for trend of heating energy demand for increasing thickness of thermal insulation (0-22cm thickness).

- monthly heat-balance (numeric and graphical output),
- annual heating energy-consumption,
- trend of the effect of succeeding modifications,
- flow-chart giving more detailed information as to where heat goes,
- analysis of solar gains versus heat losses for windows,
- hardcopy giving a detailed building description, intermediate calculation results and the mean u-value as required for construction authorisation.

A more sophisticated comparison-tool, to be developed for a future release of the software, shall give the possibility to compare user-defined projects and reference-buildings from an integrated database. Analysis will be available in form of graphs (e.g. orientation of glazing, useful solar energy, shape-factor, heating energy demand, etc.).

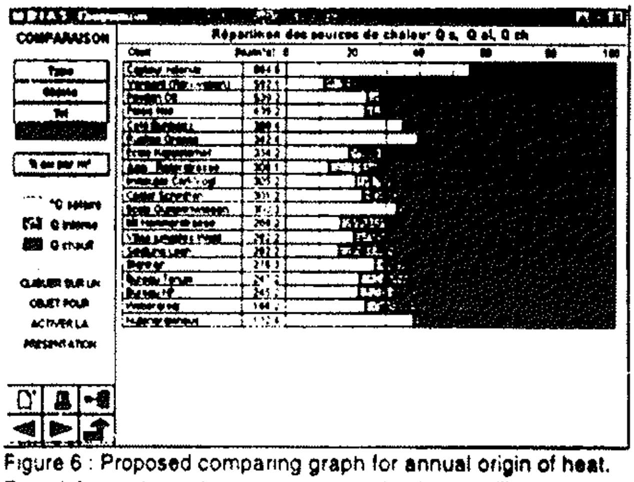

Figure 6 : Proposed comparing graph for annual origin of heat. From left to right : solar energy, internal gains, auxiliary heating.

All numerical data can be instantly converted from the most commonly used units. Reference values should help the inexperienced user to situate his project.

Comparison as a basis to better understanding

The only self-comparing heat-demand analysis is necessary but yet not sufficient. The aim is to invite the user not only to comply with local or national heat demand standards : a to comply with local or national heat demand standards : a link to existing and readily available environments including tens of case-studies such as DIAS[1] or PEM[3] is planned for a future version and shall give inspiration and a realistic base for comparison.

CONCLUSIONS AND OBJECTIVES

The architect has a most critical role in the building design process. Although energy savings and additional costs for passive solar design are difficult to quantify, energy savings must first be implemented in the building concept itself. It only makes sense to consider technical installations and active solar heating or cooling once the building envelope has been optimised.

ONLINE intends to assist the architect and engineer in this task and if possible in the most efficient and helpful way. This can only be achieved by speaking the architects language (textual and graphical) and by organising information according to the architects' way. This is why the software is being developed by an interdisciplinary team of architects and physicists, both with a long experience in the field of building-energy-systems.

Advancement and date of release

A beta-version of the software is available. The first commercially available version will be ready by September 1998.
The software shall be introduced through seminars and conferences but also through information in specialised technical journals.

Future developments

ONLINE foresees the addition of two 'external' tools : predimensioning of hot-water collectors and predesign of network-coupled photovoltaic systems. Future extensions may also include summer-comfort, vapour-condensation, urban solar geometry, catalogues of commercially available materials... or integration of detailed information concerning building-energy and ecology.

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