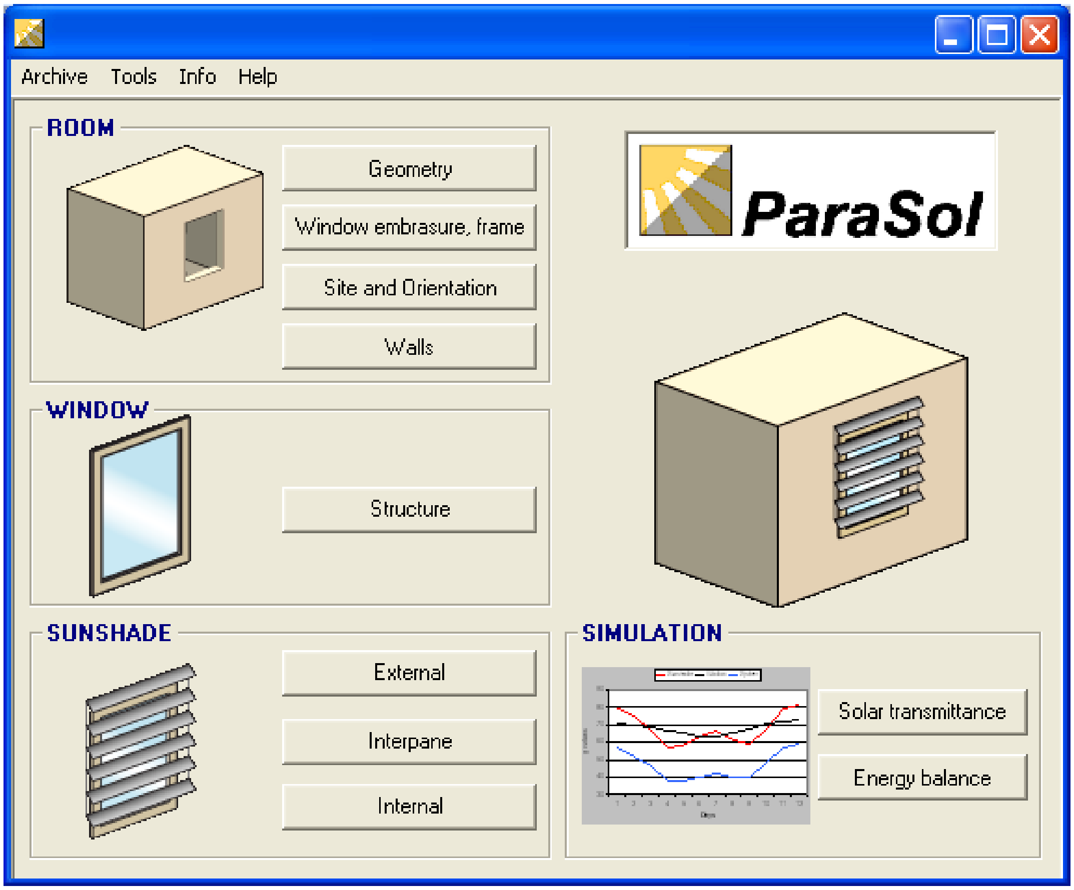
Parasol



Background

Energy efficient buildings are a concept and a philosophy which, after all the discussions about energy demanding buildings, the shortage of energy and the harmful effects of energy production on our environment, must be accorded greater consideration when buildings are designed.

It is essential that this approach should be adopted at an early stage of conceptual design. It is at an early stage that decisions can be made concerning the fundamental and relatively simple, but interacting, energy efficiency measures that can be taken, such as siting, building form, facades, windows, constructions. At the same time, the energy efficiency measures must consider the effects on the indoor climate.

It is only after these measures have been thoroughly analysed that the remaining energy needs can be satisfied by energy efficient building services installations.

Utilisation of solar energy is an important part of energy efficient strategies. Solar radiation entering through transparent building components such as windows and glazed areas provides an important contribution to heating, but can also give rise to excessive temperatures or large cooling demands.

Solar protection in buildings such as special glass in windows can, when properly used, play a great part in reducing heating and cooling demands, and its use is therefore an important strategy for energy efficiency that should be evaluated at an early stage of design.

ParaSol, which has been developed within the framework of the research project "Solar protection of buildings" at Lund University is a relatively simple tool that may be of assistance in this type of analysis. It has been essential to combine ease of use with advanced simulations. The tool is chiefly intended for simulations of offices, schools, hospitals and blocks of flats, and has been developed for target groups such as students, researchers, architects and energy consultants.

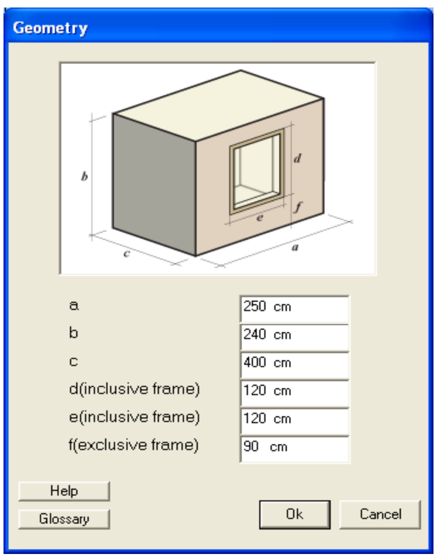
Principal functions

Work in ParaSol is divided into four principal functions, Rooms, Windows, Sunshades and Simulation. When ParaSol is started, it opens with a predefined room model together with a number of preselected input data. It is thus possible to go directly to a simulation without entering or altering any data. Generally, more detailed information is given in each window.

- **Rooms**

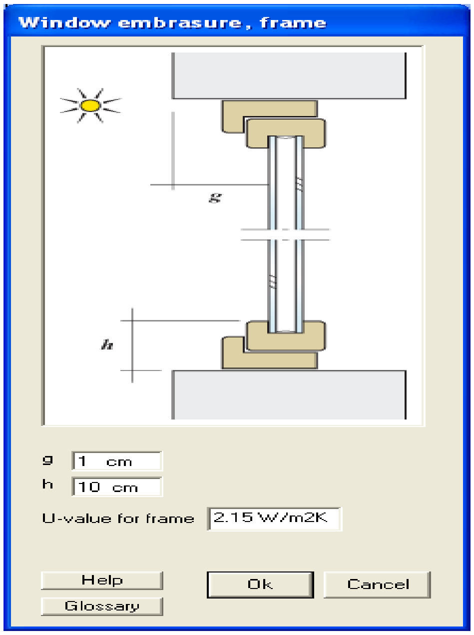
  The function Rooms contains the following window.

Geometry



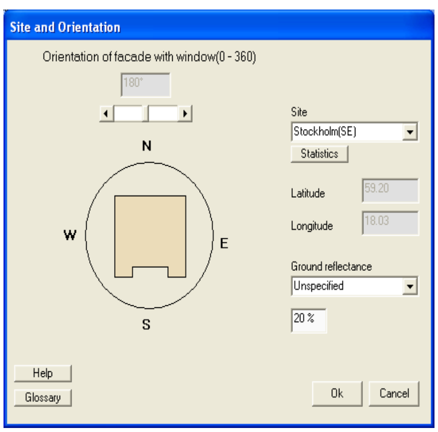
The geometrical model represents a rectangular room model with one window. The module or room is assumed to be surrounded by other rooms with similar thermal conditions. The wall in which the window is situated is an external wall exposed to the outside climate. It is important to note that the window frame is not an integral part of the window but is treated as a separate part of the facade. The name window therefore refers only to the glazed portion. The input parameters a – f determine the dimensions of the module and of the window.

Window embrasure and frame



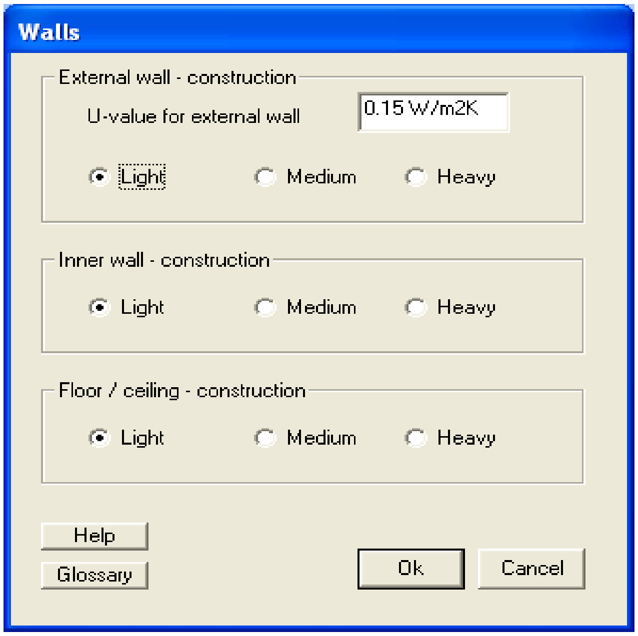
The window embrasure and frame are needed for the description of the way the window is mounted in the wall. The U-value for the frame can be varied.

Site and orientation



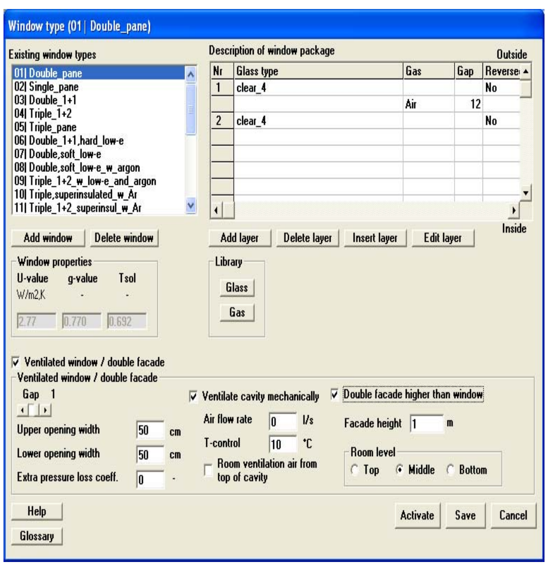
With a few keystrokes, the building can be rotated and the appropriate climate selected. The window is facing south when the building is rotated 180°.

Walls



The options low, medium or high are available for the thermal inertia of the wall, floor and roof structures. It is only the external wall whose U value can be varied.

- ### Windows



This window has input fields for configuring types of glass and gas. The window package is built up of panes, and fill gas in the gaps between the panes, from separate libraries. New window packages, panes and fill gases can be defined and added to the library concerned as required.

The glass library contains types of glass with different functions such as clear glass, absorbent glass, energy glass and solar control glass. The optical properties with spectral resolution (wavelength by wavelength) are given for some glass types. All simulations for glass and windows take account of the variation in optical properties depending on the angle of incidence of solar radiation on the window. Both uncoated and coated glass can be selected. For windows with an air gap, the window considered may refer to a window or a double glazed facade with ventilated air gaps.

In the window for configuring windows, it is immediately apparent how efficiently the window selected prevents the entry of solar radiation. The U value for the window package is also shown. Calculations are made for boundary conditions in accordance with the standard ISO 15099. Boundary conditions can be varied by the function Tools in the main form.

Windows are activated by a keystroke in the window for windows. The activated window is thereafter included in subsequent calculations and simulations.

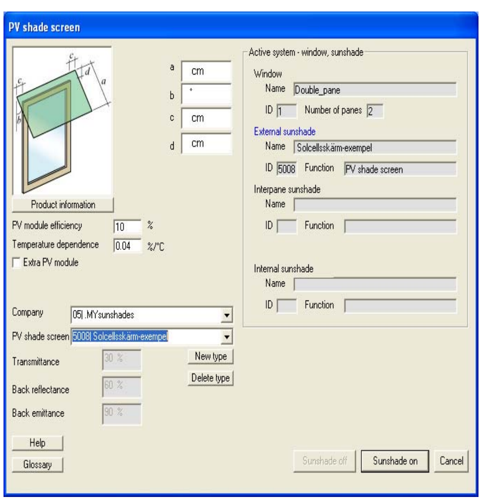
- **Sunshades**

Detailed optical and thermal properties have been determined for a large number of sunshade types. The sunshades and their properties make up a sunshade library which is accessible in ParaSol. Sunshades are grouped in external, interpane and internal types. The types of sunshade include awnings, articulated awnings, venetian blinds, roller shutters/shutters, curtains and screens incorporating photovoltaic cells. New sunshades can be defined and entered in the library as required. External sunshades can be combined with interpane or internal ones.

In the window for interpane or internal sunshades, it is immediately shown how efficiently the selected window in combination with the selected sunshade prevents solar radiation. The U-value for the combination is also given. Calculations are performed in the same way as for windows in accordance with ISO 15099. Boundary conditions can be varied by the function Tools in the main form. In the case of internal curtains, it is now assumed that the space between curtain and window is open and thus ventilated by natural convection. This means that a larger proportion of the heat absorbed in the curtain is transferred to the room air than if the space were closed. For internal curtains it is also possible to assume that the space between the inner pane and the curtain is closed.

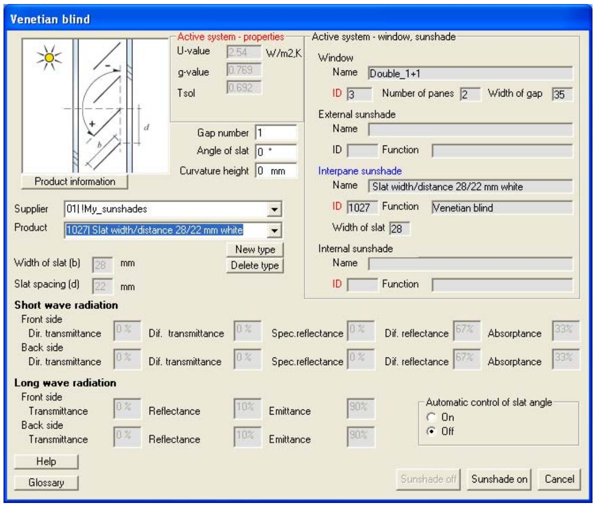
Sunshades can be mounted/demounted with a keystroke in the sunshade window.

External sunshades



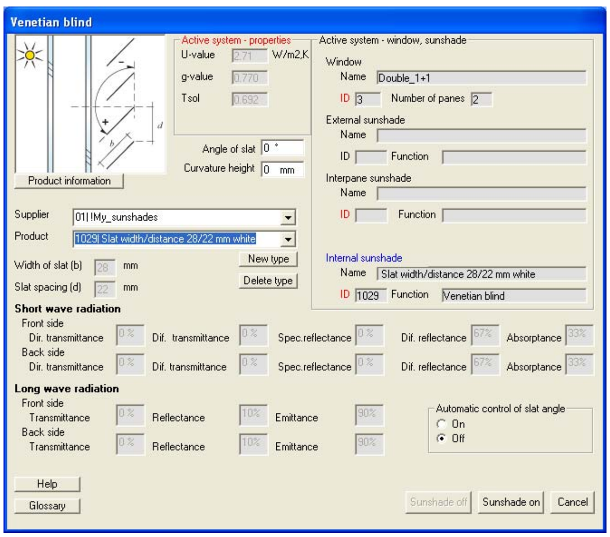
Example of external sunshade – screen incorporating photovoltaic cells.

Interpane sunshades



Example of interpane sunshade – venetian blind.

Internal sunshades



Example of internal sunshade – venetian blind.

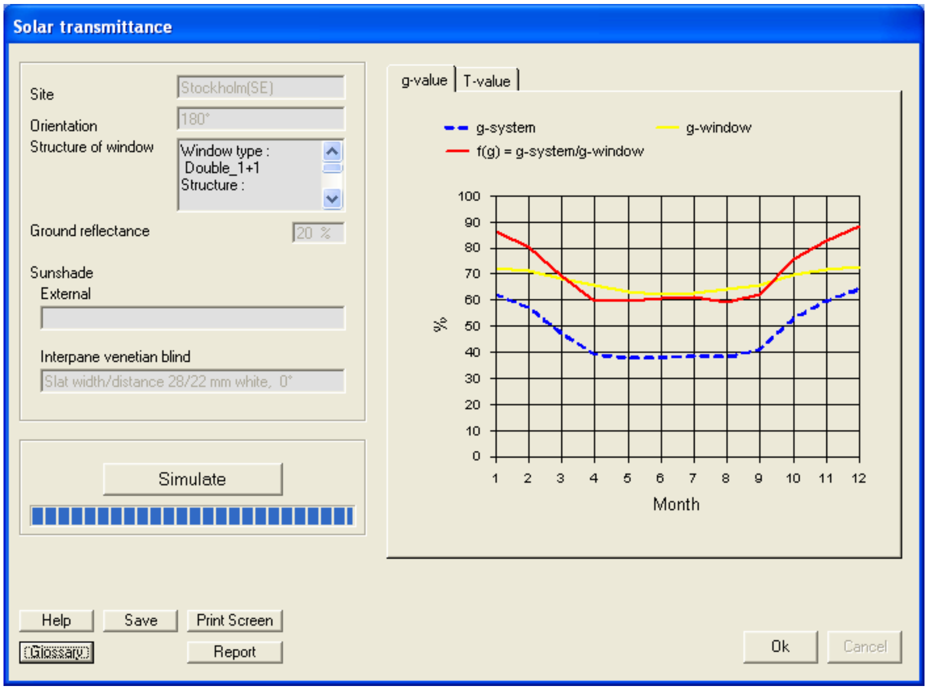
- **Simulation**

Solar transmission and energy balance are two different kinds of simulation that can be performed with this function. By simulating solar transmission, the efficiency of the individual sunshade in combination with the window package can be studied, and by simulating the energy balance, it is possible to study what effects a selected combination of sunshade and window package has on the indoor climate in the room. In both cases it is necessary for the appropriate input data to have been entered in the functions Rooms, Windows and Sunshades.

Solar transmission

Simulation of solar transmission calculates the monthly mean values of the indices of effectiveness *g* and *T* (total and primary solar energy transmission) for the active combination of sunshade and window package, and the individual window package. The effectiveness of the active sunshade is the quotient g-system / g-window. The results are presented in different diagrams, but can also be saved to a file for import to other programs.

Example of simulation of solar transmission



The index *g-system (blue dashed curve)* shows the share of the solar irradiation on the glazing that is transmitted to the room for each month.

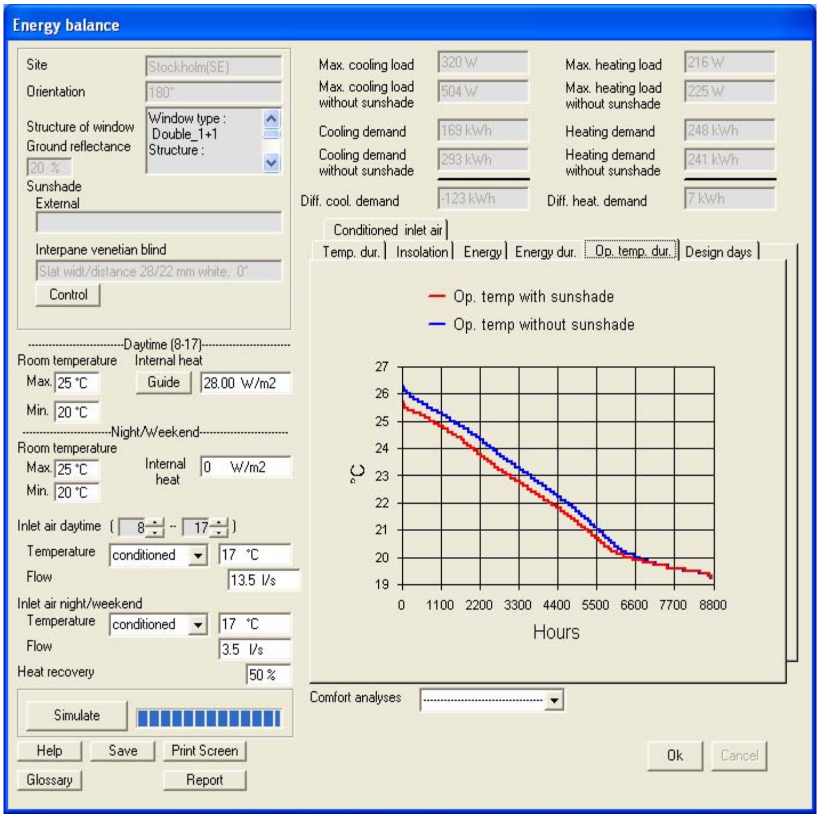
Energy balance simulation

In the energy balance simulation, a number of indices are calculated for the thermal performance of the room on the basis of the selected sunshade and window package. The sunshade can be controlled by a flexible function to build different control strategies. For venetian blinds the slat angle can also be automatically calculated for each hour. The simulation is also controlled by input data for max- and min-temperature in the room (i.e. the set points for cooling and heating), heat gains due to occupants and equipment, ventilation flow, preheated inlet air and the efficiency of FTX ventilation (balanced ventilation with heat exchanger). Boundary conditions for energy calculations can be varied by the function *Tools* in the main form. Examples of performance indices are solar radiation, maximum demand for heating and cooling, monthly and annual heating and cooling demand, and load duration curve for air temperature and operative temperature in the room. The day that constitutes the design criterion for heating and cooling is also shown. The results are presented in different diagrams, but can also be saved to a file for import to other programs.

After an energy balance simulation, it is possible for a postprocessor to be activated for further study of a number of performance indices for thermal and visual comfort, such as global operative temperature, PMV and PPD. These indices describe the situation at a selected time above an optional horizontal plane in the room.

After a simulation, the model description concerned can be saved in a library. The description can later be activated, perhaps modified and used again.

Example of simulation of energy balance



The figure shows, inter alia, duration curves for the operative temperature in the room for the cases when the sunshade has, and has not, been applied. Even though ParaSol is easy to use, it should be noted that minor changes to the input parameters may have a relatively large impact in the results. It is therefore an advantage if the user is familiar with the implications of the input parameters and also has an understanding of how these can interact.

Downloading of ParaSol

The program is free of charge and can be downloaded from the address: **http://www.parasol.se/.** On the download page there are instructions for the program.

Bibliography

[1] M.Wall, H.Bülow-Hübe, (Eds), **Solar protection in buildings, Report TABK-01/3060**, Lund, Sweden: Div.Building Science, Lund Institute of Technology, Lund University 2001.

[2] M.Wall, H.Bülow-Hübe, (Eds), **Solar protection in buildings Part 2: 2000-2002, Report EBD-R..03/1**, Lund, Sweden: Div.energy and Building Design, Lund Institute of Technology, Lund University 2003.

[3] H.Bülow-Hübe, M. Lundgren, **Solskydd i arkitekturen. Gestaltning, inomhusmiljö och energianvändning**, Arkus 2005.

[4] Hellström B., Kvist H., Håkansson H. and Bülow-Hübe H. (2007), **Description of ParaSol v3.0 and comparison with measurements.** Energy and Buildings ***39***, *279–283*.