

PRODUCT RELATED DEDICATED SOFTWARE DEVELOPMENT BASED ON TRNSYS AND TRNSED

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ABSTRACT

Many building related products and systems such as insulation, solar shading, reflective roof coverings have an important impact on the energy performance of the building where it is installed. The commercial departments of these manufacturers get more and more inquiries about the energy related advantages of their products. They need specific tools to answer these questions. The goal of the tools is to assess the comfort, energy or power impact of using the product in an independent and reliable way.

This paper presents the development of user-friendly dedicated software tools for building products based on dynamic simulations with a TRNSED like front end for TRNSYS. The forefront enables the simulation of any TRNSYS model, the user being able to change predefined parameters. The package includes a user specific post-processing, automatic report generation and interlinked help files.

These software applications enable manufacturers to demonstrate the environmental, economical or comfort impact of their products based on independent simulations with a validated building component. This presents significant advantages for the manufacturer: no required knowledge of TRNSYS, low initial cost, no software installation required and easy update implementation for a web-based version, and better control of independency (towards their clients).

This paper presents the main characteristics of the new development and of the resulting dedicated software tools. Practical examples are given including screenshots of the interface and the post-processing.

INTRODUCTION

Nowadays, the manufacturers of building products are not always able to prove the positive impact of their products in terms of energy saving and comfort improving. They need a tool dedicated at evaluating and measuring the energy and comfort related impact of their products.

So as to answer these requests, a dynamic simulation tool based on TRNSYS has been developed for such enterprises. This tool can be completely web based, enabling pay per run business models.

There are a lot of benefits for the clients :

- No need to invest in software acquisition, users' knowledge and maintenance, in the case of a web-based version
- No need for a highly specialised expertise in thermal , energy or building simulation
- Results and support provided by an independant expert
- Tool based on a validated software

This application allows to simulate several variants of a building so as to evaluate the product impacts.

The tool is a stand-alone application based on the TRNSYS 16 dynamic simulation software package. It's a TRNSYS dedicated model built-up to compare and to simulate different building products and to evaluate their performance in terms of energy and comfort.

The TRNSYS license agreement allows any TRNSYS user to distribute a stand alone TRNSYS executable, and a TRNSED input file describing the model and interface to others. The user of this software tool does not need a TRNSYS license nor knowledge of the TRNSYS simulation software.

This tool provides a refined interface in which selected inputs may be viewed and/or changed and simulations run.

This presents the architecture and capabilities of this tool. The composition of this article is the following :

- General description of the tool, presenting the objectives, the methodology for the tool development, the interface development and an explanation on the TRNSYS simulation
- Description of two applications of this tool : effect of external blinds and effect of white roofing membrane with high reflectivity. These two applications evaluate the temperatures and loads of a single zone building
- Presentation of the results provided by the tool and visualisations of the interface: tables and graphs results, report automatically generated

A conclusion and a discussion end this paper.

GENERAL DESCRIPTION

Objectives

This tool has been developed to propose a stand-alone software, easy to use, based on a validated and detailed calculations via TRNSYS simulations.

It is a flexible solution, using all the features the most advanced of TRNSYS (even the building can be modeled via the type 56). This tool includes a user-friendly interface while keeping all of the TRNSYS capabilities. It is a great advantage for the customer who doesn't have a lot of parameters to modify in order to realise a simulation.

The interface lets the user to define all the parameters very quickly. The simulation is then launched and all the results are automatically generated in the tool via graphs and tables.

With this tool, it is possible to offer software fully adapted to customer needs and fully configurable.

It is also able to simulate several variants simultaneously in order to compare different solutions with just one simulation.

Tool calculation development

A TRNSYS project is typically setup by connecting components (referred as type) graphically in the Simulation Studio. Each Type of component is described by a mathematical model in the TRNSYS simulation engine and has a set of matching Proforma's in the Simulation Studio. The Simulation Studio generates a text input file for the TRNSYS simulation engine. That input file is referred to as the deck file (a *.TRD file).

The first step of the tool development starts with the Simulation Studio model.

Once the Studio Simulation model is created, a *.TRD file is generated. This file is a text file containing all data and informations about the project.

In order to be able to modify the parameters of the projects within the interface, a new *.TRD file is created replacing the numerical values by codes (under the following format : <#NameCode#>).

These codes are then automatically replaced by the values entered in the interface of the tool.

It's possible to integrate new components in TRNSYS and this powerfull capability allows the simulation of any specific building products. New components can be added using any development environment capable of generating DLLs (FORTRAN, C, C++, ...). Any building product of a manufacturer can be developed and added in the TRNSYS model.

The second step of the E-Tool development concerns the creation of the *.BUI file which is a readable ASCII text file containing all the TRNBuild data.

The program TRNBuild generates then the *.BLD and *.TRN files which are used by the Type 56 in TRNSYS Simulation Studio.

The *.BUI file is created in the same way as the *.TRD file, using codes to replace numerical values.

This file contains as many zones as there are variants of comparison for the product studied. Generally, 3 variants (and thus 3 zones) are proposed.

Each parameter is defined by a code. All the data entered by the user in the tool interface will be copied to replace the codes.

Interface development

The TRNEdit program allows to develop stand-alone distributable TRNSYS (called TRNSED applications) but doesn't allow the simulation of modification of the Type 56 component.

Consequently, we choose to develop an interface able to create the *.BUI and *.TRD files. This interface has been developed to allow the user to enter all the informations related to the project.

This file allows to define all the tabs and settings that make up the interface.

Within the interface the user can change all the parameters that determine the characteristics of the building and/or product.

This interface allows the user to fill in all the parameters for the simulation via the different controls. Controls can be text boxes, dropdown boxes, or dropdown comboboxes, in which predefined dropdown choices can be overruled with any number. Some controls affect the appearance of other controls.

When a control is activated it's possible to jump to the appropriate help section by pressing F1.

The interface contains several tabs and subtabs containing all the project informations. It also contains various menus allowing to open and save a project, to change the language and units and to open a help file.

The configuration and development of the interface is fully configured by an XML set-up file that allows for fast prototyping of other types of applications.

TRNSYS simulation

The simulation can be started via the menu "Simulation/Start simulation".

The files *.BUI and *.TRD are created automatically when a new simulation is start up.

After starting the simulation an external program, TRNSED, will be started up to run the simulation.

When a simulation is started, the correct parameters are loaded in the TRNSYS model with corresponding building model. The simulation normally runs for a complete year (8760 hours).

The progress of the simulation can be followed on the TRNSYS built-in online plotter. The simulation can be paused and resumed but as long as a simulation is running or the online plotter is active, it is not possible to turn back to the interface. This interface will come available only when the online plotter is closed.

EXAMPLES

Effect of external blinds on the temperatures and loads of a single zone building

A model was built-up to simulate the effect of external blinds on the temperatures and loads of a single zone building. A special interface is foreseen so the user can define a single zone, choose weather data and user profiles and can change all the parameters that determine the solar protections for the windows

The application enables the simulation of 3 identical single zone buildings with different solar protections. Everything except the solar protections is identical for the 3 cases. The simulation runs a complete year with standard meteorological data for the city of your choice.

The building is modeled as a single zone, rectangular or trapezoidal, with a flat roof. Orientation and building geometry can be chosen freely. It is possible to define each wall, ceiling or floor as internal or external surfaces. For internal surfaces, no windows are considered, and the boundary condition is set to “equal temperature” by default, meaning heat transfer is not possible through internal surfaces. Wall and window construction can be chosen from predefined compositions.

The tool enables the simulation of vertical blinds or horizontal blinds as external solar protection for the windows in external walls. The user can enter the width of the blind, number of blinds, distance between blinds, inclination and reflection coefficient. For horizontal blinds (overhangs), the user can additionally define the horizontal and vertical gap between the protection of the blinds and the window, and the left and right overhang.

For vertical blinds, the number of blinds and distance between them determines the part of the window that is shaded by the blinds (shaded window surface = number_of_blinds*interdistance). For horizontal blinds, the tool determines each timestep (hourly) which part of the window is shaded by the solar protection.

The model of the solar protection is developed by the KU Leuven, department building physics, based on a PhD thesis of N. Safer. The model takes into account the direct and diffuse solar obstruction of the blinds. To cope with reflection of direct solar radiation on the blinds, a radiation balance model is used. This model simplifies the real life multi-reflections that occur between the blinds themselves and the blinds and window. The reflection coefficient of the blinds

and the window are used in this radiation balance model.

This application contains the following tabs :

- Tab “Project information” : general information about the project : title, address, description
- Tabs “Rectangular Building” and “Trapezoidal Building”: geometry (length, height, volume) for a rectangular/trapezoidal building, wall configuration
- Tabs “Windows” : one tab for each orientation allowing the definition of geometry, composition and solar protection for windows. 3 cases can be defined for the solar protections of a window.
- Tab “Internal gains” : powers and profiles (persons, lighting, equipment)
- Tab “HVAC conditions” : energy used, profile, temperatures, air change
- Tab “Results” : includes all the simulation results (see the paragraph “Results”)

A screenshot of this interface is shown on the figure below.

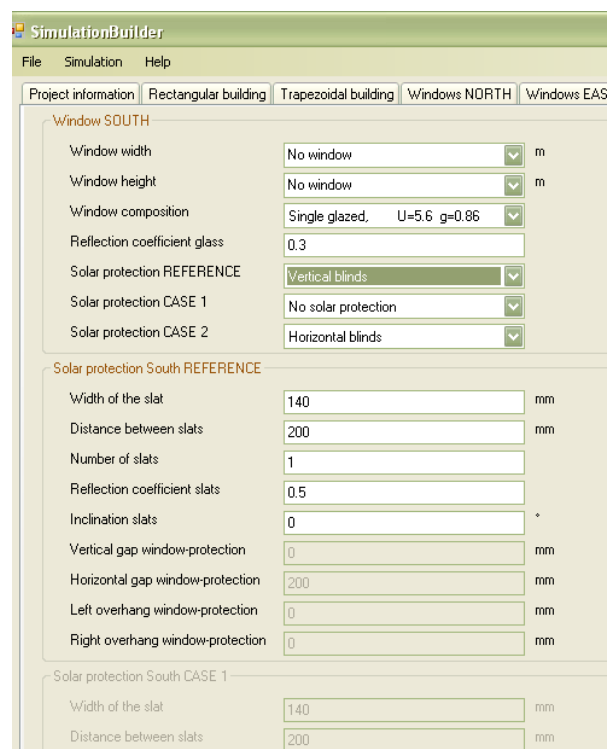


Figure 1: interface example

The interface includes a very detailed help file (see the figure below).

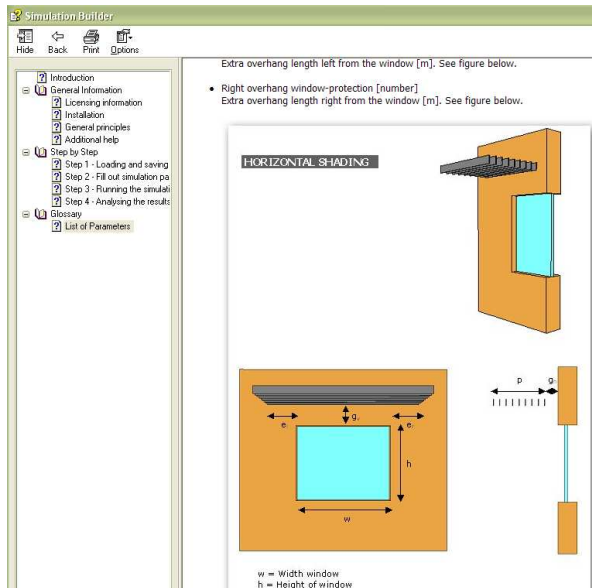


Figure 2: help file visualisation

Effect of white roofing membrane with high reflectivity on the temperatures and loads of a single zone building

An other example of this tool development concerns an application able to simulate the effect of a white roofing membrane with high reflectivity on the temperatures and loads of a single zone building.

This application is quite similar to the solar protections models but it presents the following additional features :

- Simulation of detailed roof configurations. It could be a flat roof or a shed roof (number of sheds, geometry, roof surface reflectivity and emissivity)
- Definition of wall composition : choice of material with conductivity, capacity, density and thickness (see example on the figure below)

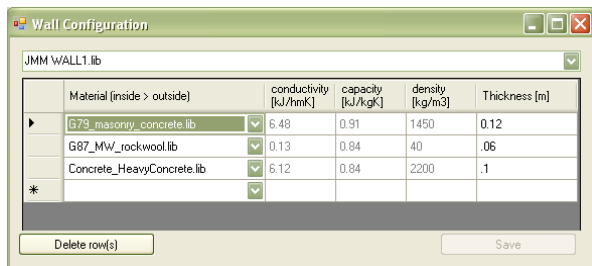


Figure 3: wall configuration interface

The application enables the simulation of 3 identical single zone buildings with different roofing membrane properties (reflectivity and emissivity). Everything except the roofing membrane is identical for the 3 cases.

The results give a comparison on the temperatures and loads of a single zone building.

RESULTS AND VISUALISATIONS

Automatic tables and graphs

A first analysis can be done via the TRNSYS online plotter, during or after the simulation. This online plotter shows different tabbed graphs.

When the online plotter is closed, a summary table and graphs are loaded in the tool interface, tab "Results" (see figure below).

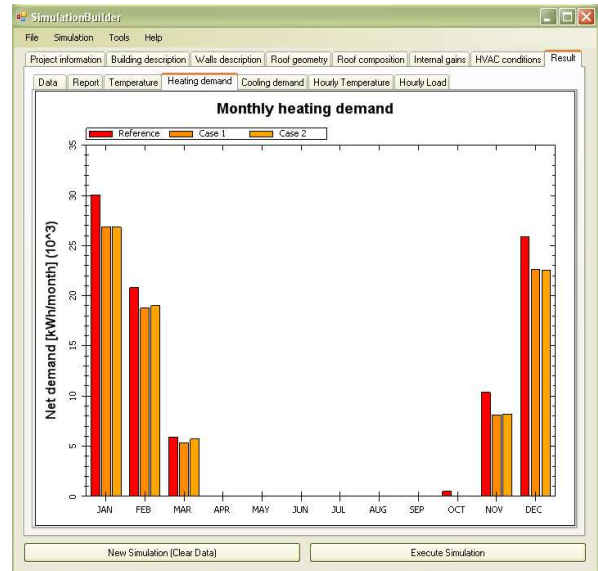


Figure 4: tab Results

This tab is composed of several subtabs that are explained below (example for the solar protections application described above) :

- Subtab "Data": this section gives an overview of the used variables in the simulation, filled in via the controls. All controls are listed, also the disabled ones. The data can be easily copied to external documents.
- Subtab "Report": shows a results summary table with yearly overviews of the reached temperatures, heating and cooling demand and internal and solar gains in the building for the different cases. For temperatures, 'Hours>X°C' means number of hours during which the temperature is between X°C and X+1°C. Only the hours during the occupation period are counted. This table can be easily copied to external programs.
- Subtab "Temperature": contains a histogram graph of the occurred temperatures in the building for the 3 cases. Hours>X°C' means number of hours during which the temperature is above X°C. Only the hours during the occupation period are counted (occupation as defined by the user in tab 'Internal gains' section 'persons'). See below for general commands for graphs.

- Subtabs “Heating demand” and “Cooling demand”: shows a graph of the monthly heating demand for the 3 cases. Net heating/cooling demand is defined as the net quantity of energy or heat/cool that would be needed to maintain the heating temperature setpoint in the zone without taking into account production losses or distribution and emission losses.
- Subtab “Gains”: this graph gives a monthly overview of the solar and internal gains for the 3 cases.
- Subtab “Hourly temperature”: contains a graph of the hourly ambient air temperature and the indoor air temperature for the 3 cases for the complete year.
- Subtab “Hourly load”: the last graphs shows the hourly net heating and cooling loads as defined above.

For all the graphs; a multiple zoom is available without any command by clicking and dragging a rectangular in the graph or by scrolling after having clicked in the graph. This also works for monthly graphs. Panning is also possible with the scroll wheel of the mouse.

By right-clicking in a graph, a menu pops up with different options : copy the graph to the clipboard for use in external programs, save image, save the current graph with current zoom, print., show point values (display the value of the variable while moving the mouse pointer over it).

A last way to analyse the simulation results is by directly using the output files that are created during the simulation. These files are found back in the folder “Results”. They can be opened with a text reader or imported in a spreadsheet.

Automatic report generation

The software can automatically generate a report including all of the hypothesis and results of the project. All data entered to the interface are included in the report. All graphs are also automatically copied in this report.

Therefore, the client has a final report ready for distribution without any additional effort.

Several examples of graphs and results are given on the following figures.

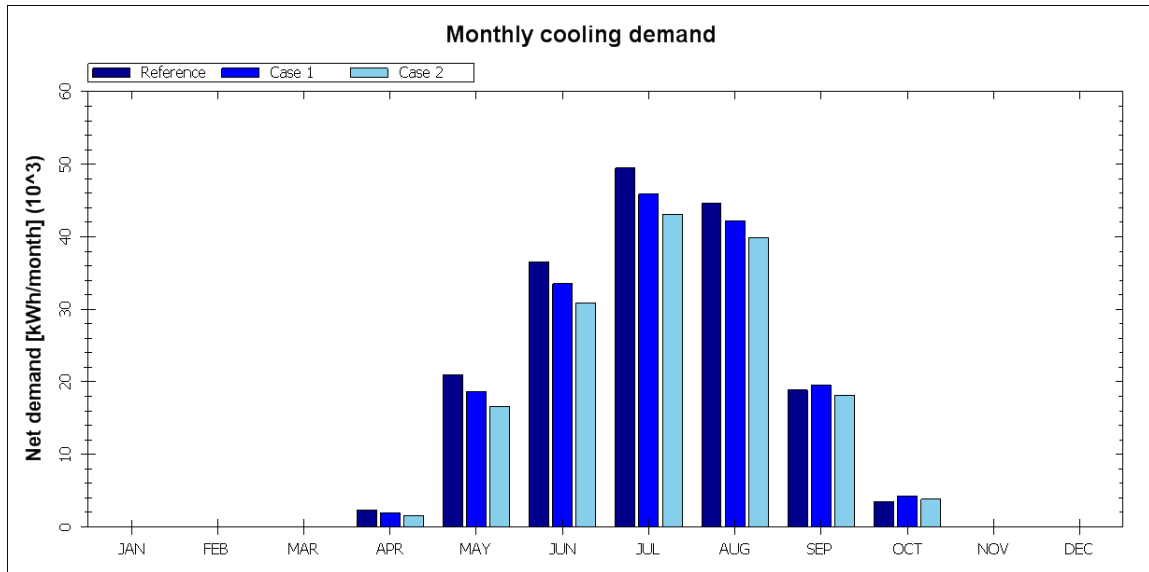


Figure 5: monthly cooling demand

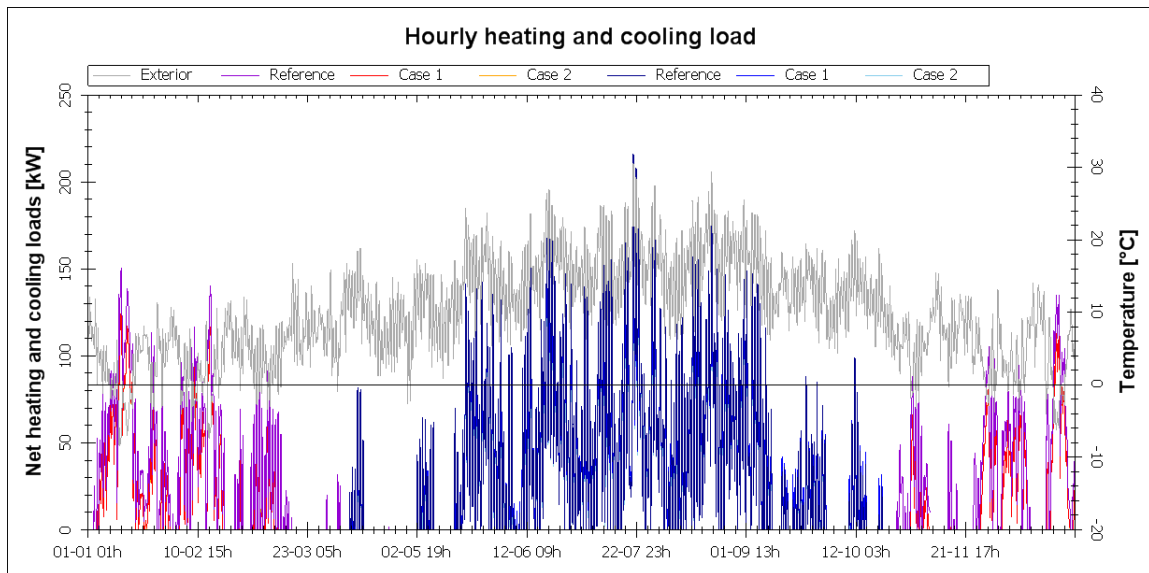


Figure 6: hourly heating and cooling load

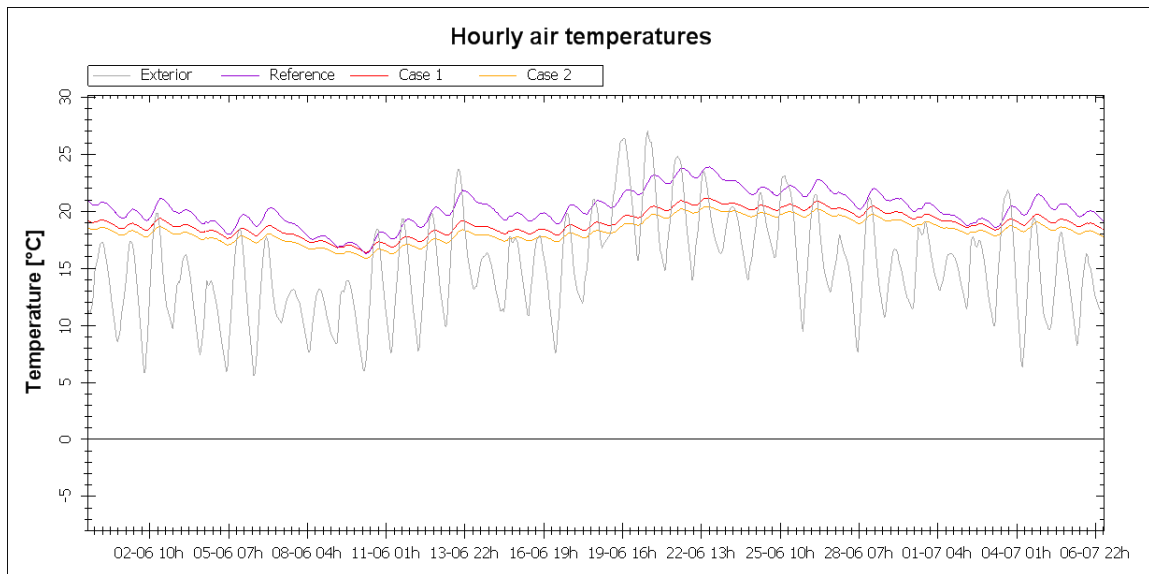


Figure 7: zoom on hourly air temperatures

CONCLUSION

This tool shows there is an important potential in the development of stand-alone applications. Companies are highly interested to have software allowing them to quickly show the impact of their energy products. It is therefore a real added value for them.

They can include the results in their business proposition by showing the energy savings realised with their product. An additional argument is that the tool is based on a validated software and the consultancy is realised by an independant expert.

The development of a fully customizable interface allows us to simulate any application. The interface is very easy to use and we can get instantaneous results. These results are shown in graphs wich can be directly inserted into reports.

Building simulation knowledge is not required to use this tool. thanks to the TRNSED interface which is very accessible and attractive. The selection of parameters and variables that can be modified by the user is made in close collaboration with the client and determines the scope of the tool and it's userfriendliness.

The two applications given in example in this paper are developed as a stand alone software wich can be installed on the computer of the client.

In future development we will make web based application wich can bring additional advantages:

- The client doesn't require the investment (time and money) of a software
- The developper provides only a web bases interface. No problem of licence.

In a completely web based software, a pay-per-run business model can lower the set up cost for the client.

ACKNOWLEDGEMENT

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