TRNSYS 16

Update description

December 2003

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1. Introduction

This document describes features added to version 16 of the TRNSYS simulation environment. One of the reasons for the growing popularity of this tool is its modularity: a wealth of component models is now available in the standard package, as part of add-on libraries or as free component models that live on the Internet. Users can easily develop their component models and add them to the package.

In version 16, this capability of TRNSYS to adapt to new types of simulation problems has been pushed beyond new limits: Using the Dynamic Link Library (***DLL***) technology, it is now possible to easily add a new component, written in any programming language, as a Windows™ DLL. This way, component models created by different teams can be used together without even using a compiler: copying the DLL provided by the model author onto the hard disk is sufficient to run it!

This new dimension in modularity is also supported by TRNSYS' graphical user interface: customized interface components can easily be added as "wizards" by third-party developers. This new architecture, together with a wealth of new functions has been in integrated into a complete simulation environment: The ***TRNSYS Simulation Studio***.

The programs that make the TRNSYS Suite have been renamed to reflect the higher level of integration:

- The ***TRNSYS Simulation Studio*** is the next generation of the IISiBat visual interface
- ***TRNBuild*** (formerly known as Prebid) is the visual interface of the multi-zone building model (***Type 56***)
- ***TRNEdit*** is the successor of TRNSHELL. TRNEdit is used to develop stand-alone distributable TRNSYS applications

This document describes the main new features in TRNSYS 16. It is organized in sections that cover each component of the TRNSYS package.

2. TRNSYS 16 features at a glance

TRNSYS Simulation Studio

- Multiple connection port for better clarity of complex projects
- New user-friendly connection window
- Plug-ins for easy parameter input
- New user-friendly output window (to manage all outputs in one central location)

TRNSYS kernel

- Multi-DLL architecture. Adding new Types is as easy as dropping a file in a folder
- Full backwards compatibility for deck files (no change required) and Types (4 lines to add)
- Performance enhancements (time steps down to 0.01 sec, Enhanced speed for equations)
- Usability enhancements (Equations order, improved error handling, etc.)

Component library

- Combined Data reader and Solar radiation processor for easier configuration
- Full support of current TRNLIB components: HYDROGEMS library developed by IFE, links with external programs (Matlab, Excel)
- Addition of several components currently available in the TESS Libraries

TRNBuild – Type 56

- New 2-band window model
- Chilled ceilings
- Enhancements to the visual interface: improved library management (walls and windows), automatic segmentation of active layers, copy-paste of defined wall & window types, etc.

TRNEdit

- Multiple tabs to organize the input fields
- Clickable areas in pictures with links to external applications or other tabs
- More intuitive syntax, improved documentation and examples

General package enhancements

- Electronic documentation available on the CD and online
- Improved examples and templates
- Easier access to weather data

3. TRNSYS Simulation Studio

This chapter describes new features of the TRNSYS Simulation Studio, TRNSYS' graphical user front end. This simulation environment, based on CSTB's IISiBat™ technology, allows users to define and run simulations. It also includes tools to create new, user defined components in different programming languages.

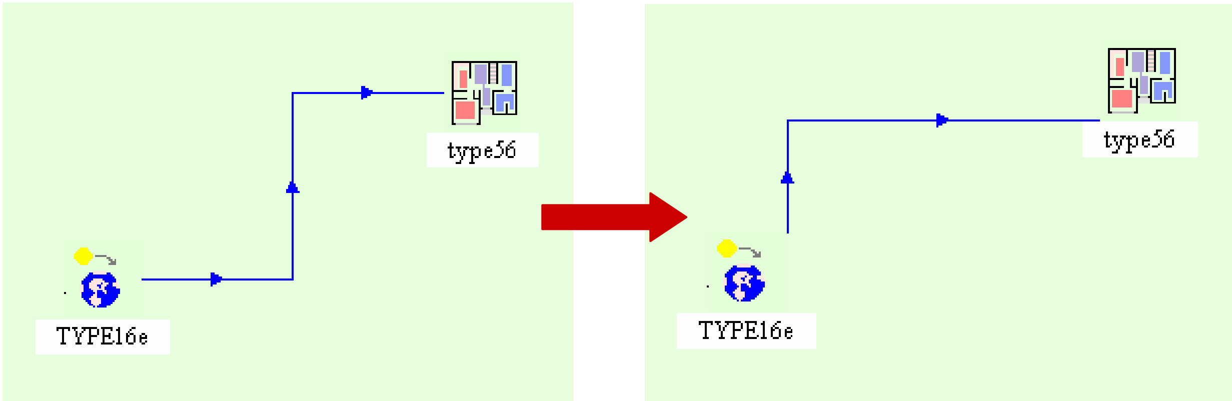
3.1. Multi port links

As TRNSYS includes a growing number of system components (see section 5 for more details), the traditional "Input-Output" style of system representation becomes less efficient. In order to depict systems more clearly and intuitively, the Link concept has been extended.

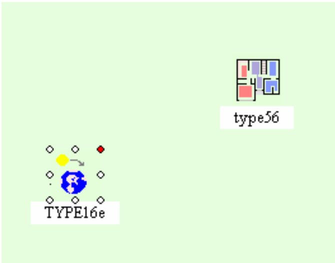
3.1.1. New link concept

A link connecting two components can now have ***8 ports***. Each port can be used as input or output for link connections (this means that the traditional "inputs left / output rights" is no longer enforced; the user can freely define links as he sees fit for a given system).

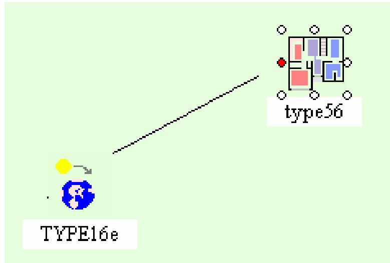
A click on the icon will automatically connect the link to the nearest port from the source type. In link mode, the port that is going to be connected is dynamically displayed as a red circle. Connections can also be moved from one port to another one for existing links.



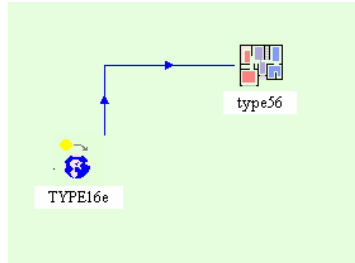
Example by selecting source and target ports :



Step 1
Mouse on the source port



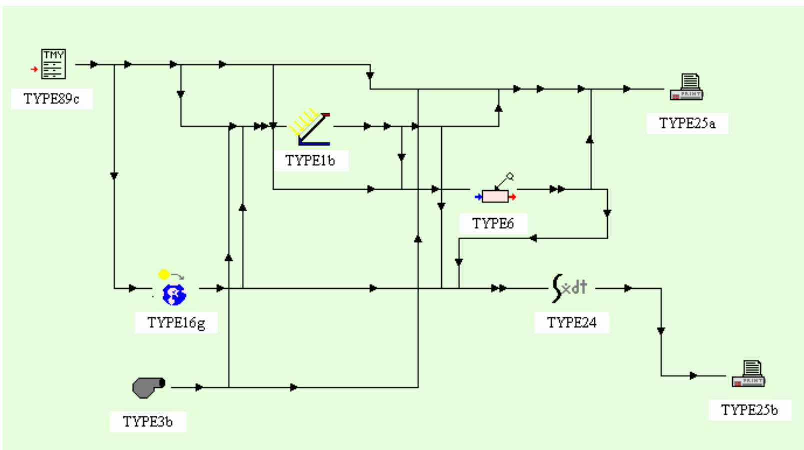
Step 2
Choose a port on the target type



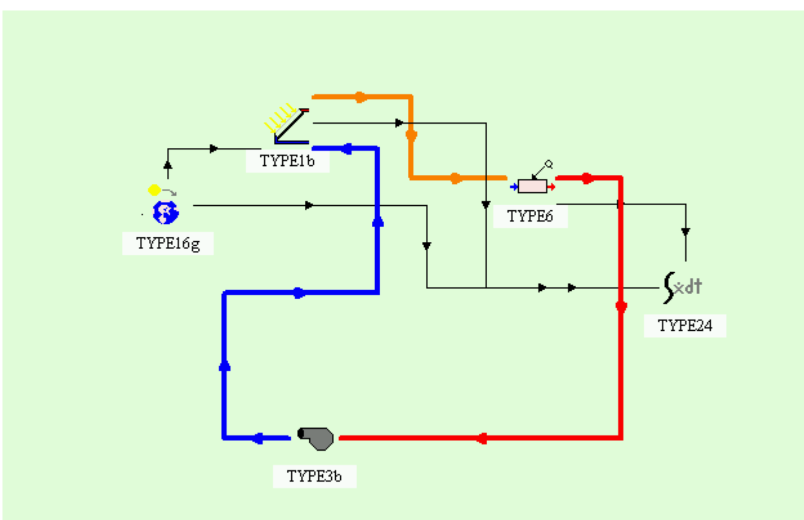
Step 3
Types are linked

3.1.2. Clearer projects

With the multi port connections, the project is easier to design and to understand. For example, the figure here below shows the "begin.tpf" example in IISiBat 3.



Taking advantage of the multi-port capability of the TRNSYS Simulation Studio, using graphic attributes for links and hiding input/output layers, the same project looks as here below:

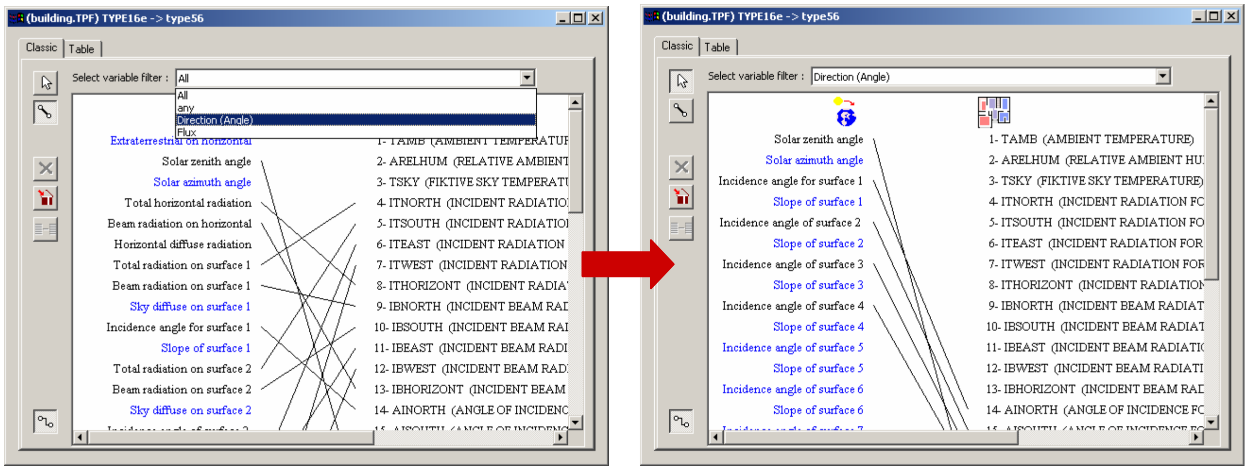


3.2. New connection window

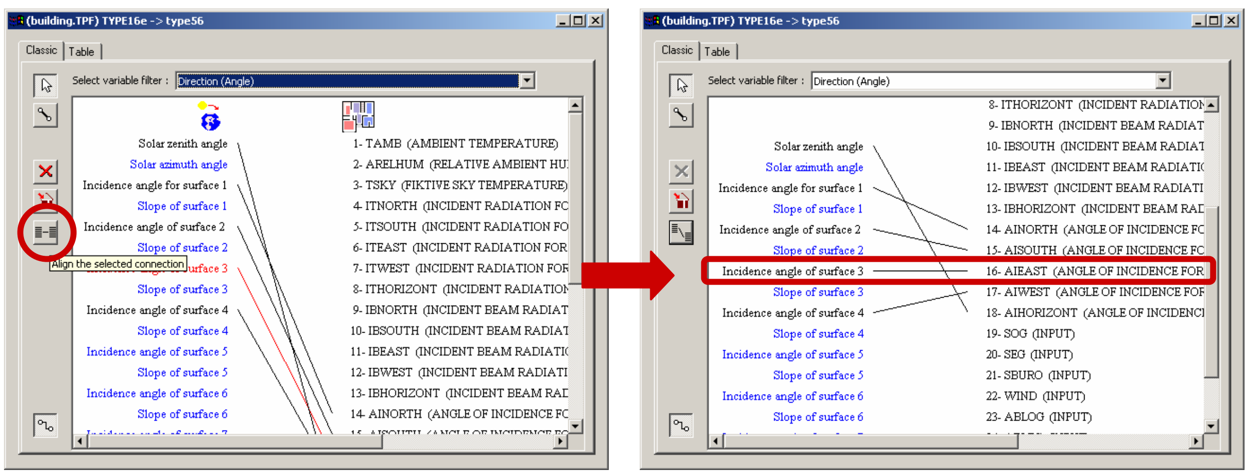
The connections window is now separated into 2 tabs. The first one, called "Classic", displays the same information as users know from TRNSYS 15. The second one, called "Table", displays the list of connections in the form of a table. In addition to this new mode, the "Classic" tab has new features.

3.2.1. The "classic" tab

A filter now allows the user to select which type of variable is to be displayed, using the dimension of each variable as a criterion. Example: Show only variables with the dimension "Direction (Angle)"

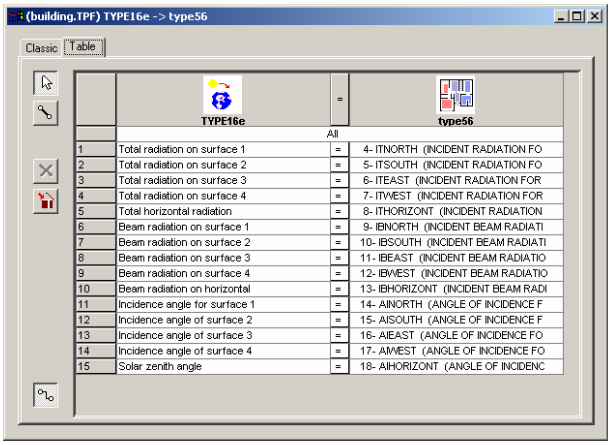


Connections can be horizontally aligned, with respect to a selected connection. Example: Select a connection and click on the new "Align" button



3.2.2. The "table" tab

All connections which involve the 2 linked components are listed in a table.

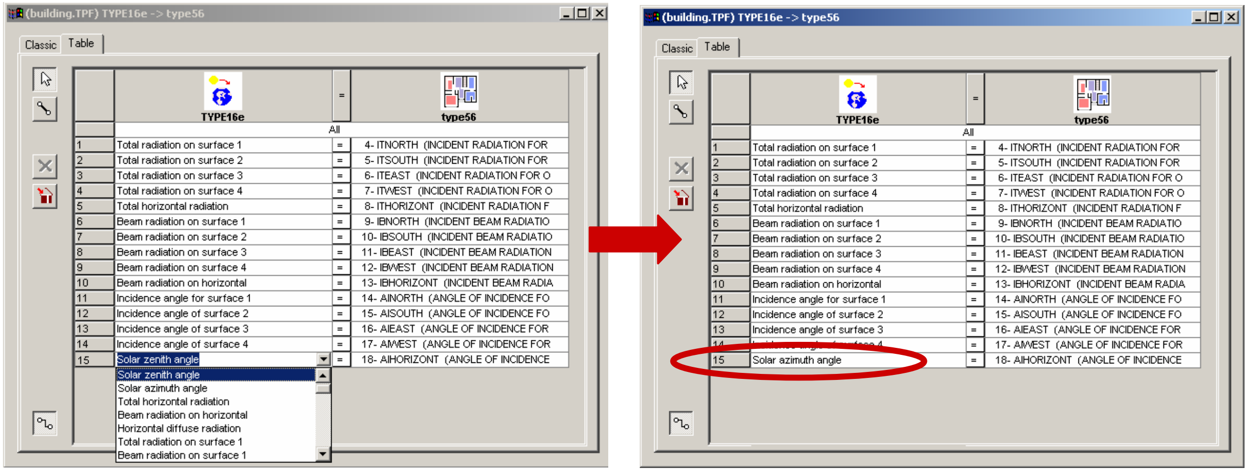


New connections can be added by clicking on the "link" button and deleted by clicking the "delete" button.

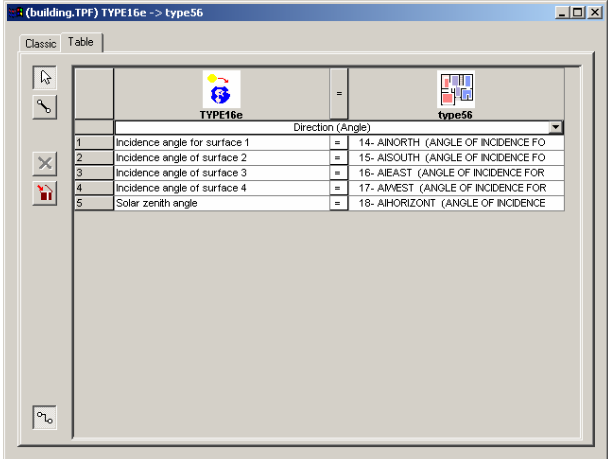
When adding, deleting or modifying connections in the "table" tab, the "classic" tab is updated, and vice versa. Selections made in one tab remain active in the other.

In the "table" representation, a connection can be easily modified: either the source (output) or the target (input) of the connection can be changed by selecting a different variable from a popup menu. The popup menus only contain variables which are allowed to connect to the given variable.

In the following example, the last connection is modified; the input variable "Solar Zenith Angle" is replaced by "Solar Azimuth Angle".



As in the classic tab, a filter can be applied: by selecting "Direction (Angle)", only connections involving variables of dimension "Direction (Angle)" or "dimensionless" are displayed, as shown below.



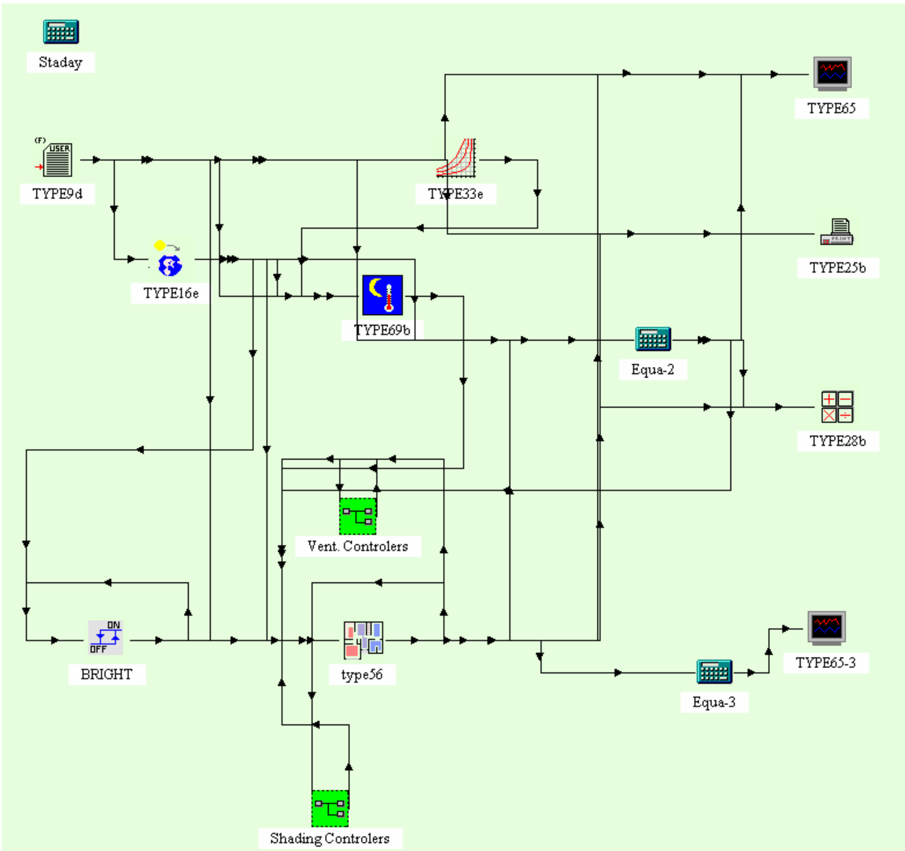
3.2.3. Connection wizard

For complex models, such as the multi-zone building model, defining a link to or from the model can be quite complex, time-consuming and error prone. The new "connection wizard" was designed to overcome these problems: As soon as a link is created, the wizard will propose a set of typical connections. For example, the wizard "knows" which outputs of the solar radiation processor / weather reader must be connected to which variables of the building model, and will ask the user for complementary information if necessary.

3.3. Improved navigation in projects

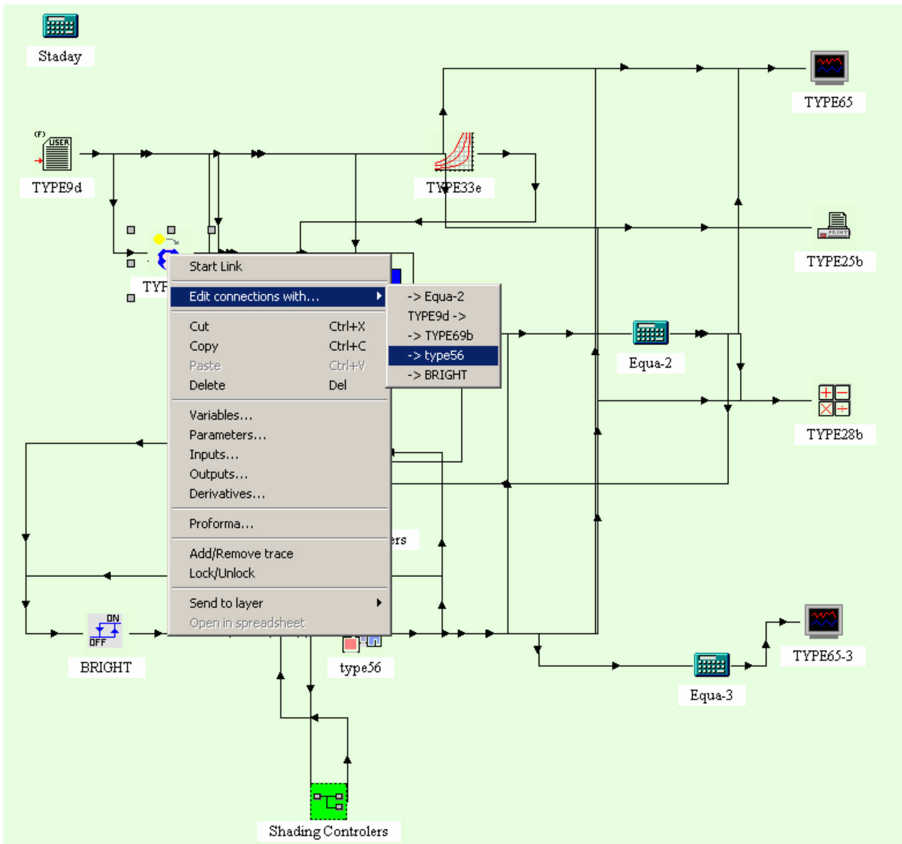
In very complex projects, it may become quite difficult to find a particular link to open the connection dialog. A new menu now lists all source components and target components, so the corresponding connections windows can be accessed easily.

Example: Modify the link between Type16 and Type56



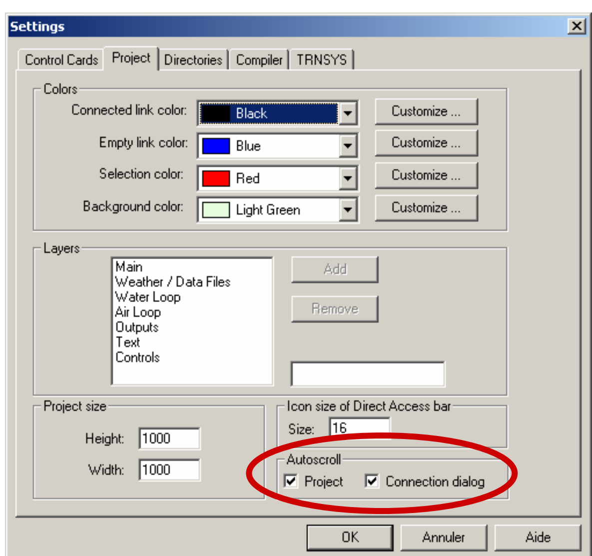
With the help context menu, the right connection window can be easily found. Just right click on the Type16 (or Type56) and choose "Edit connections with…".

Then, select "→ type56" (or "Type16 →") to open the connections window.



3.4. Auto scroll management

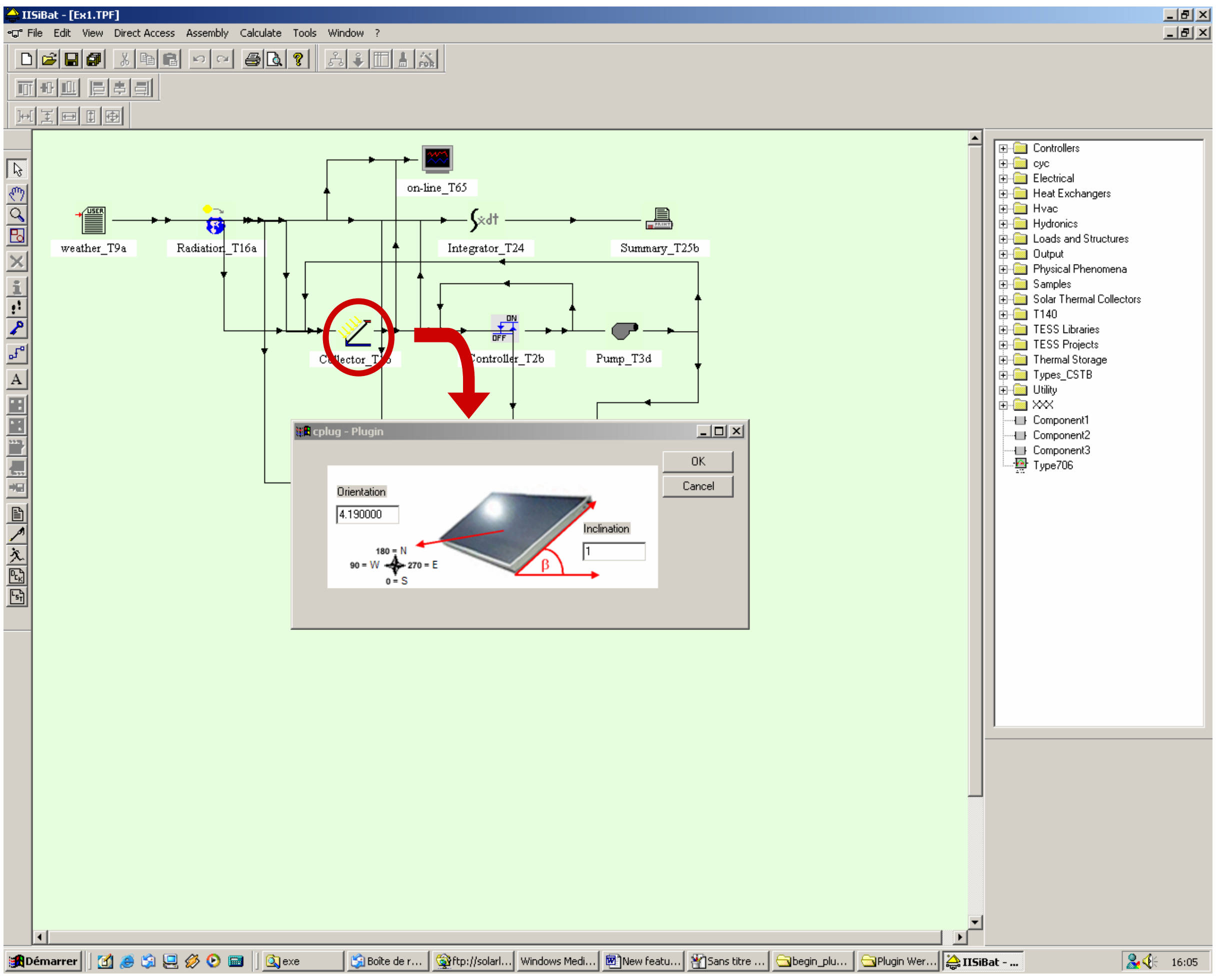
While many users appreciated IISiBat's Auto scroll is a feature, others tended to be confused by it. Auto scroll can now be enabled or disabled – separately for project and connections windows. This functionality is accessible from the file/settings menu, and by choosing the "Project" tab.



3.5. The GUI plug in technology

The TRNSYS kernel has evolved to allow users to add new components by simply copying a DLL, containing the component, to the set of predefined TRNSYS components (TYPES). Just as this new software architecture allows using any programming language to easily add new models (equations and algorithms) to the simulation, TRNSYS Simulation Studio's revolutionary new GUI plug-in technology allows to modify the graphical front end of the simulation environment, as well for existing (standard) components as for user-defined components.

Plug-ins can be dynamically added to the TRNSYS Simulation Studio, in the form of .EXE files. They can be written in any programming language. You can then tell the Simulation Studio to launch the plug-in instead of the usual variable definition window to modify the type. Plug-ins can even be applied to equations defined inside the Simulation Studio: a simple list of equations can this way have its own, specific GUI.

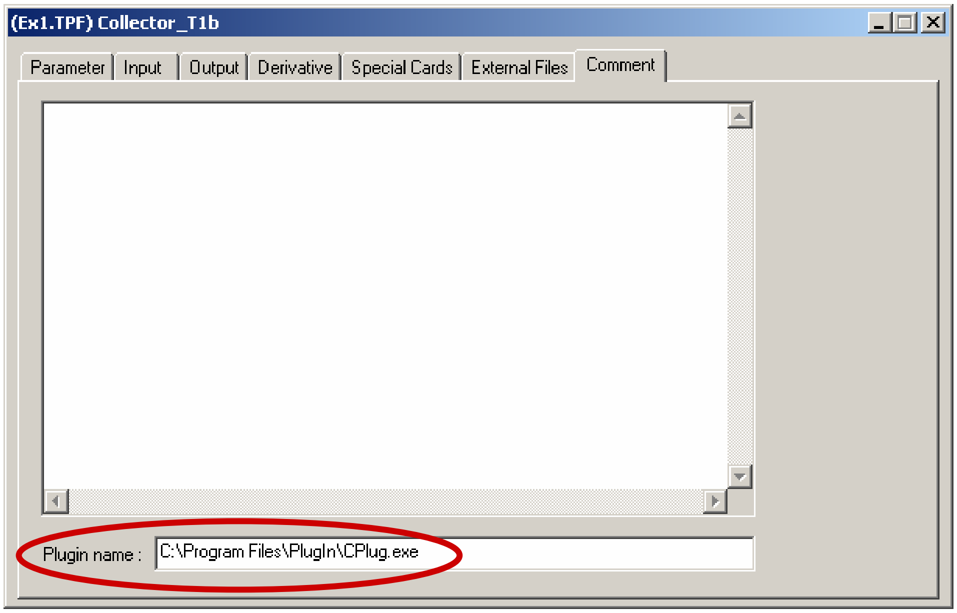


This new technology has been and will be used by the TRNSYS developer team to continuously improve the Simulation Studio's user interface, by adding customized functions for a growing number of components.

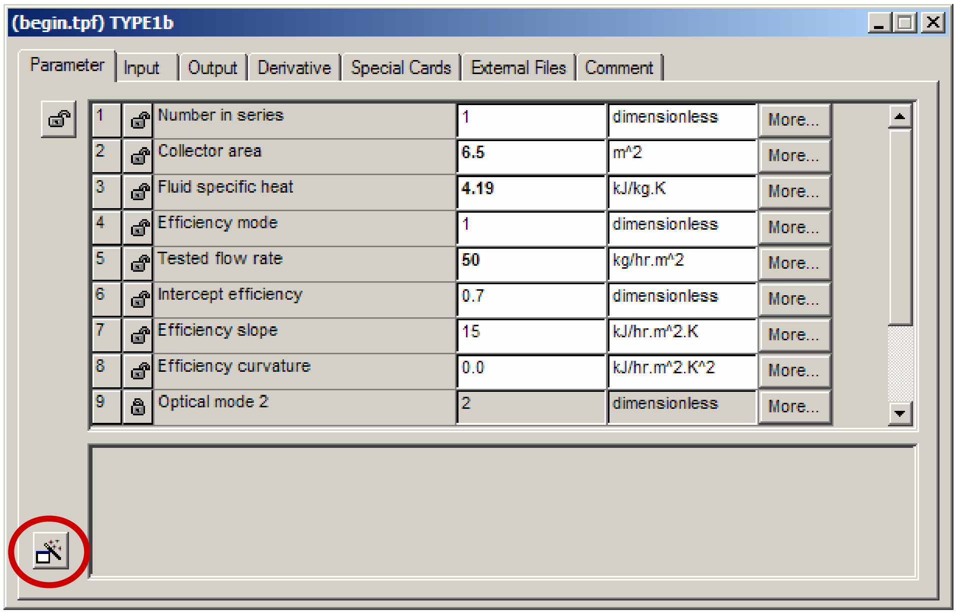
At the same time, the plug-in specifications are open, so that third-party developers or even users can easily add GUI functionality to either standard or user-defined types.

3.5.1. Implementing plug-ins

The interface is implemented in an EXE program (called Cplug.exe in this example). The plug-in name is simply specified in the comment tab of the PROFORMA.



When a type using a plug-in is used in a project, a new button appears:

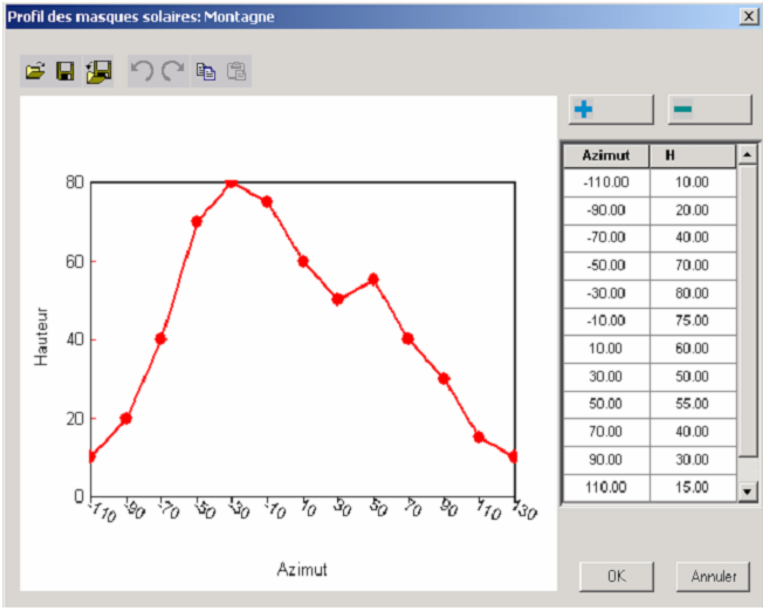


Clicking this button will launch the plug in. Instead of launching the plug-in each time by clicking on the "wizard" icon, a global option allows to automatically launch the plug in instead of the "classic" window. This is done through a global setting in the control cards, similarly to the "Write TRNSED commands" setting. If the "automatically launch plug-ins" radio button is selected, the plug-in will be launched every time a user double-clicks on a component.

3.5.2. Plug-in examples

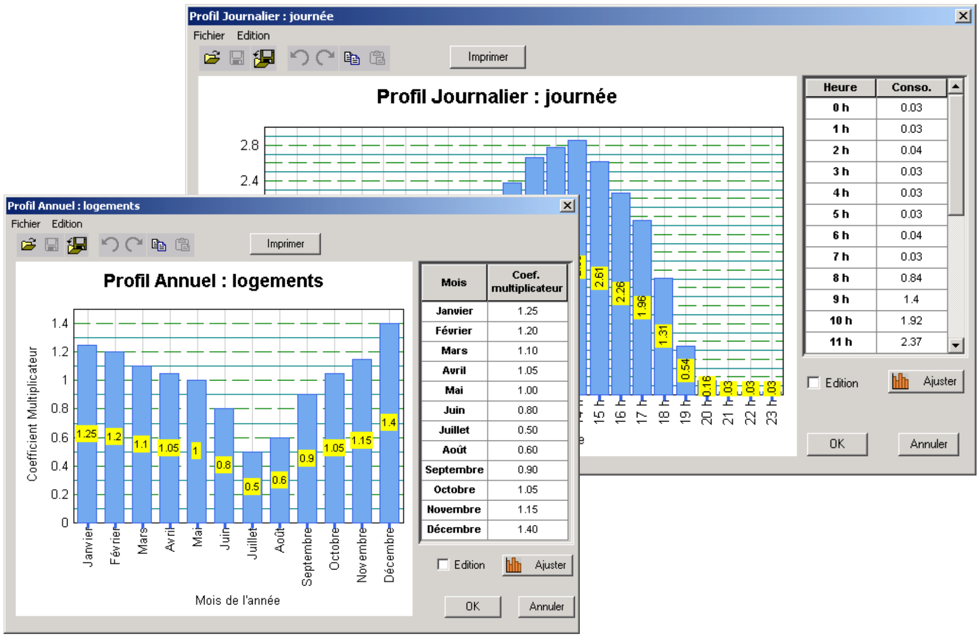
Interactive mask editor for type 68

This example of a plug-in allows to interactively edit shading masks.



Profile editor for type 14

This example of a plug-in allows to interactively edit forcing functions interactively such as water draw, etc.

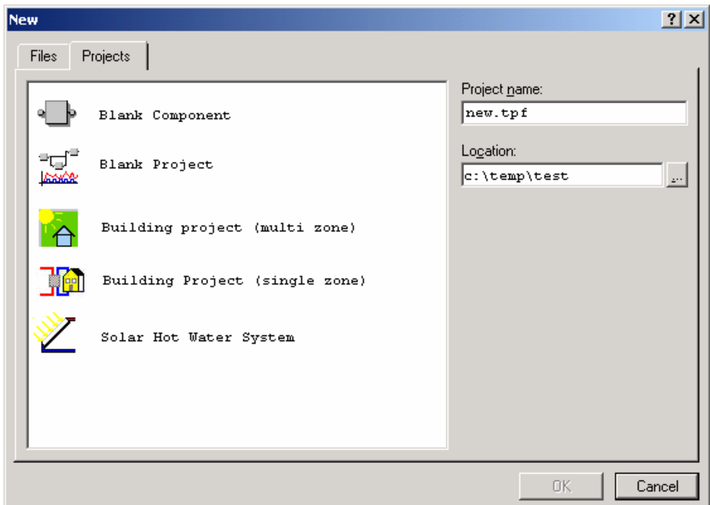


3.6. Project templates

Creating a completely new project from scratch involves a lot of repetitive tasks to set up the "infrastructure" needed for the simulation. For example, most simulations will require solar radiation data to be computed for different orientations, the solar radiation processor must be connected with the models using this data, etc.

In practice, most users will do this only once, in order to create project templates, adapted to the types of simulations they usually run. A new project is then started from one of these templates.

The developers of the TRNSYS Simulation Studio have turned this commonly used working method into a feature of the simulation environment: When creating a new project, the user can still decide to create an empty project or open an existing project. In addition to that, a choice of typical project types is proposed: solar hot water system, multi-zone building, etc. A new project wizard will determine a number of important parameters for the project selected (number of orientations to be used, number of zones in the building model, etc.) in a dialog with the user, and then create a running template project.



3.7. Export to C and to Visual Studio Workspace

To better support TRNSYS' new DLL-based architecture and multi-language programming, the C and C++ languages are now explicitly supported by the Simulation Studio. Just as IISiBat 3 allowed to create FORTRAN source code templates from a PROFORMA description, it is now possible to generate C/C++ source files.

In addition to that, workspaces are automatically created for the Microsoft Visual Studio™ compiler environment. If this recommended environment is used for development (either for Fortran or C/C++), the generated source can be directly opened in a complete workspace, which will directly create a DLL for the new component (Type) in the right TRNSYS directory. After exporting, the Developer Studio is started automatically, with the new template open. The user only has to paste his source code into the template, choose "build" from the Visual Studio's menu, and the new model can be run with the existing TRNSYS, without loosing any previously added Types.

3.8. Additional TRNSYS Simulation Studio enhancements

Many more features and enhancements are included in the new TRNSYS Simulation Studio. This update description cannot explain all of them in detail – we invite you to discover them soon in the new TRNSYS documentation, which will be available in electronic form. Other improvements to the graphical user interface include:

- Possibility to customize deck style
- Improved PROFORMA editor
- Create outputs to file or Online by simply checking a checkbox in the variable window
- Possibility to define UNIT numbers, automatic assignment of Logical Units
- Improved error handling
- Possibility to move "Global cards in the component list (better connection to TRNSYS*Lite*)

4. TRNSYS kernel enhancements

The TRNSYS kernel has been substantially modified for TRNSYS 16. The enhancements have three main objectives:

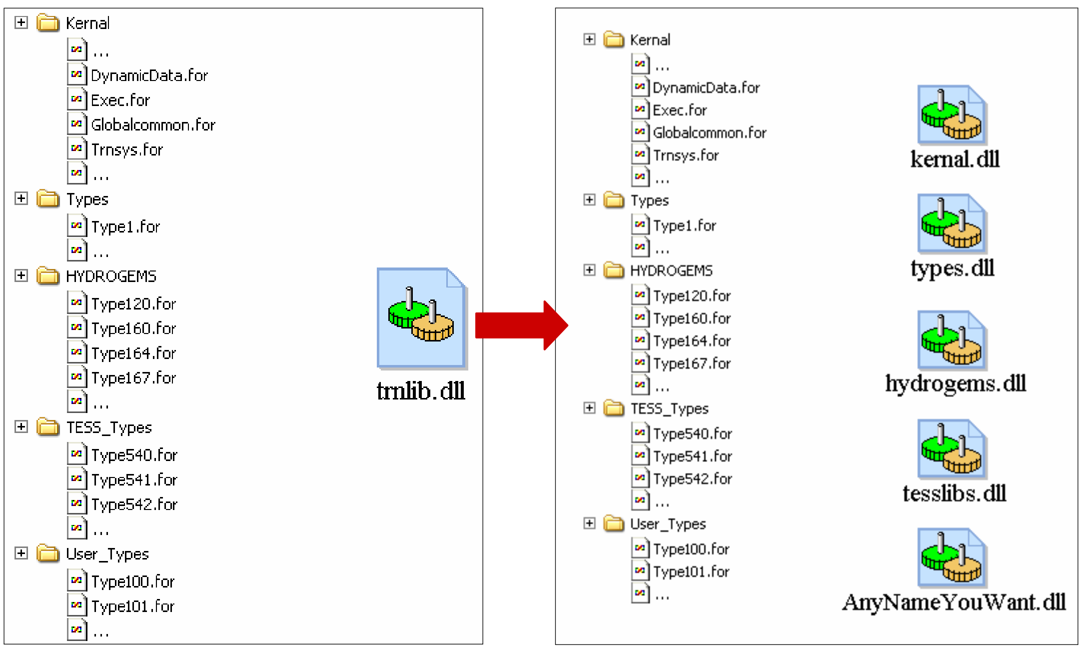
- Improved usability
- Improved performance (accuracy / speed)
- Improved maintainability
- Backwards compatibility (existing deck files and existing Types)

This document only lists the most significant enhancements.

4.1. New multi-DLL architecture

In TRNSYS 15, adding a new component (Type) required to rebuild the Fortran DLL that included all the TRNSYS Types and the kernel. TRNSYS 16 is split in several DLL's that are loaded when TRNSYS is launched. TRNSYS then searches through all the DLL's for the components that are used in the simulation. This process allows to easily add a new component to TRNSYS by dropping a pre-compiled DLL into the right directory.

The principle of the multi-DLL project is illustrated in the Figure here below.



The TRNSYS kernel only loads the components that are used in a simulation and manages conflicts between DLL's (e.g. Types defined in more than one DLL). This makes the DLL much smaller in most cases.

It is still possible to recompile TRNSYS 16 as a single DLL for advanced users who give more importance to easy debugging.

4.2. Improved numerical precision and "time definition"

All variables in TRNSYS are now double precision numbers. This leads to an improved numerical accuracy, which is measurable for example by the very small time steps achievable in TRNSYS 16 (down to $1/100^{th}$ of a second). Programming new Types is also easier thanks to the consistent use of double precision.

TRNSYS 16 uses a more intuitive definition of the simulation start time. The TRNSYS time still refers to the time at the end of a time step, but the initial time is now really the starting time of the simulation. In TRNSYS 15, a usual yearly simulation with an hourly time step was using a start time of 1. TRNSYS 16 simply uses 0.

4.3. Enhancements to the TRNSYS solver

A new numerical solver has been added to TRNSYS. The new solver is intended to replace the default solver (successive substitution) in special cases with a strong feedback without a sufficient capacity in the system. A typical case is natural ventilation simulation, where a strong coupling exists between temperature and airflows. The new TRNSYS solver is hence similar to the solver implemented by EMPA in TRNFLOW, the extended Type 56 with integrated airflow modeling.

4.4. Easier programming of new components

Several kernel modifications will simplify the process of creating new components, besides the use of a multi-DLL architecture and the consistent use of double precision numbers:

- All components are called an extra time at the end of each time step with a flag indicating that convergence has been reached. This is especially useful for components that need to store values or print information and warnings at the end of a time step.
- Several checks have been added to detect buggy components (e.g. error flagging if a component modifies output variables outside of the allotted bounds, error flagging if an output is set to infinity (NaN))
- Simplified management of storage variables through intuitive access functions (e.g. Get_Storage_Vars)
- Improved error checking and error handling (e.g. unified message processing)
- New data structures have been added, allowing Type programmers to check whether a logical unit number has already been assigned and to automatically assign logical unit numbers to data files.

4.5. Other usability enhancements

- The equations can now be declared in any order in a TRNSYS input file. New functions have also been added to TRNSYS equation processor
- The TRACE command can be used for equations
- Equation solving can now be done to within a TOLERANCE instead of being absolute, aiding significantly in convergence.
- A timer routine is available to identify the routines where TRNSYS spends most of the simulation time
- List file reporting of logical unit number, type numbers and unit numbers used within the input file.

4.6. Backwards compatibility

- Existing TRNSYS 15 input files (IISiBat projects or deck files) can be run without any modifications
- Existing TRNSYS 15 Types can be used after adding 4 lines of code to the Types. Adding those lines is a systematic operation that does not require any programming knowledge

5. Enhancements to the standard component library

5.1. Combined Data reader and Solar Radiation Processor

Transsolar's Type 109, which combines the capabilities of Type 9 / 89 and Type 16, has been added to the standard library. This component suppresses the need to connect all the meteorological variables before processing them and it also simplifies the solar radiation processor configuration.

5.2. Integration of the HYDROGEMS library into the standard library

The HYDROGEMS library, developed by IFE (Norway), has been added to the standard TRNSYS library and fuel cell components are now fully supported by your TRNSYS distributor.

5.3. New links with external programs: Excel, Matlab

New Types that link TRNSYS with Excel and Matlab were contributed to TRNLIB, the library of freely downloadable components on the SEL website. Those Types have been improved and converted to TRNSYS 16 and are now fully supported by TRNSYS distributors.

5.4. New HVAC components from the TESS libraries

Several components from the TESS libraries have been added to the standard TRNSYS library for TRNSYS 16. Among others, models have been added for absorption cooling machines, improved pump models, simple ground temperature models, etc.

5.5. Other new components

- New controllers (real-time PID and generic feedback controller) have been added
- A radiator model has been added

5.6. Enhancements to existing standard Types

The existing standard Types have been extensively modified for TRNSYS 16. Some samples of those enhancements are:

- Type 11 (tee piece or flow diverter) now has a cooling mode
- Type 16 (solar radiation processor) now allows up to 20 surfaces (or more after recompiling the DLL)
- Printers and integrators can use relative or absolute time
- Type 34 (overhang and wingwalls) has been modified to simplify connections with Type 56 (multi-zone building)
- Type 89 (data reader for standard weather files) is able to read CWEC and standard TMY files
- Etc.

5.7. Enhancements to existing standard Utility Routines

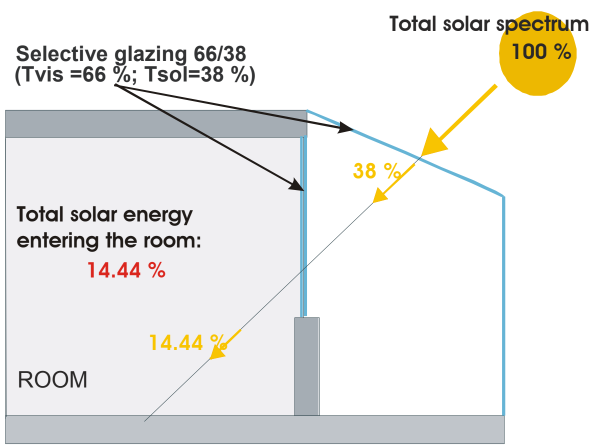
- All utility subroutines now exist in single and double precision versions.
- PSYCH now has new modes of operation
- STEAM has been modified to return more accurate results outside the vapor dome region.
- DynamicData now allows for up to 4 independent variables (previously limited to 3) and up to 10 dependent variables (previously limited to 5).

6. TRNBuild and Type 56

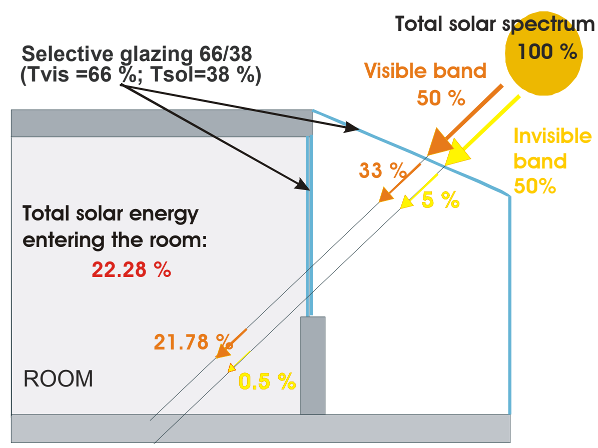
The multi-zone building model in TRNSYS is known as Type 56. Building input data is defined using a visual interface, TRNBuild. TRNBuild is the next generation of the well-known Prebid interface.

6.1. Integration of a 2-band model for solar radiation

Many modern glazing systems have properties depending on the wave-length of the solar radiation. For example, a sun protection glazing might have a transmittance for the entire solar spectrum of Tsol = 38 % whereas the transmittance in the visible band of the spectrum is Tvis = 66 %. Because of those selective properties, a 1-band model can give incorrect results if two or more selective glazing systems are in series, as shown in the following example:



1-Band model (TRNSYS 15)

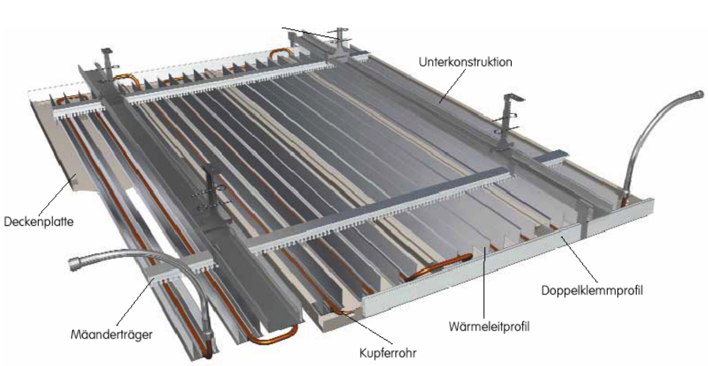


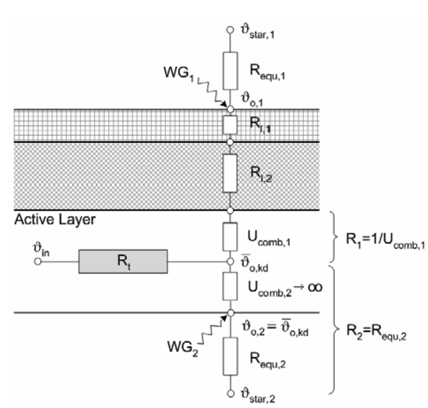
2-Band model (TRNSYS 16)

The amount of energy entering the sunspace is 38 % for both models, but differences occur for the room adjacent to the sunspace. The amount of energy entering the room is 14.4 % for the 1-band model. The correct value of 22.3 % is only derived by the 2-band model with a visible and invisible band. The new 2-band model assumes that the solar energy in the undisturbed spectrum is split equally between the visible and invisible. The required glazing properties can be read from the existing window library.

6.2. New integrated model for chilled ceilings

A chilled ceiling model has been integrated in the multi-zone building model (Type 56). The integrated model allows adding a chilled ceiling to a room quickly and easily. This model is similar to the existing model of thermally-active building elements (so-called "active layers" in Type 56).





The model is based on a new resistance model developed by EMPA, Switzerland. Unlike a concrete core heating or cooling system, a chilled ceiling is practically thermally decoupled from the wall. The characteristic constant resistance associated with a particular model of chilled ceiling is determined by data measured under given test conditions (e.g. DIN4715-1). This data is typically supplied by the manufacturer. All other resistances are time-varying and are calculated during the simulation.

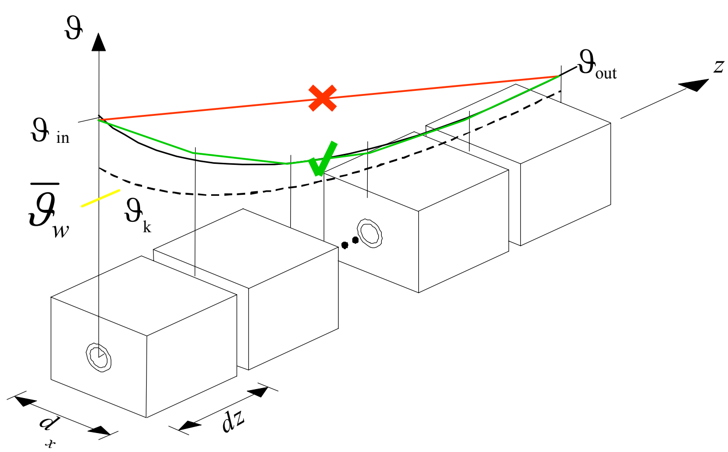
The main advantages of the new model are:

- Easy definition as an active layer within the TRNBuild interface (→ no additional external links, etc.)
- Measured data supplied by the manufacturer is used to initialize the model
- Ability to handle different types of chilled ceilings
- Variable flow rates
- Fast simulation

6.3. New features of the TRNBuild Interface

TRNBuild is better integrated in the TRNSYS Simulation Studio, which is the centerpiece of TRNSYS 16. In addition to the better integration, new features have been introduced in TRNBuild to improve the usability of Type 56:

- Input masks for the new chilled ceiling model
- Improved library handling especially for windows
- Defined walls, windows and layers can now be copied, renamed and deleted
- Automatic segmentation of walls with active layers
  The thermally-active layer model assumes a linear temperature profile over the pipe length. In general, this requires the use of 3 segments to obtain a good approximation of the real temperature profile and the segments must be coupled to each other. In TRNSYS 15, this had to be done manually. The subdivision and the coupling of wall segments is now done automatically. The figure here below illustrates the approximation of a temperature profile (black line) with one segment (red line, ***x***) and with three segments (green line, ***V***).



7. TRNEdit

TRNEdit is the successor of TRNSHELL. The role of that program in the TRNSYS suite has evolved dramatically since it was introduced: TRNSHELL was once the central program, where the user would edit his/her deck files, launch a simulation and study results, and also launch a recompilation/rebuild of the TRNSYS application. This role is now played by the TRNSYS Simulation Studio, and TRNEdit is mainly used to design stand-alone applications based on TRNSYS (known as TRNSED applications).

TRNSED applications provide a very powerful tool to TRNSYS users who want to share their work with other persons involved in a project without requiring that everyone understands the modeling concepts and without requiring that all project participants purchase a TRNSYS license. Several enhancements to TRNEdit will make that tool even more powerful and improve its usability.

7.1. Improved usability

- The TRNEdit manual is available online, as it is the case for all TRNSYS 16 manuals. This ensures the availability of an updated manual at all times.
- The TRNSYS 16 package includes an advanced example of a TRNSED-based stand-alone application. The example includes step-by-step instructions and all tips and tricks required to build a professional-looking demo. The example also includes re-usable post-processing routines.
- The TRNSYS Simulation Studio fully supports TRNSED
- A more intuitive and more systematic syntax has been introduced. When possible, the new syntax is similar to the equivalent HTML syntax. The old syntax is of course still understood by TRNEdit for backwards compatibility. To illustrate the new syntax, the table here below compares the instructions to add a picture with and without link.

Left-aligned image (no link)

TRNSYS 15	*|<Picture> Img\image.bmp left
TRNSYS 16	*|<img src="Img\image.bmp" align="left">

Left-aligned image that links to a PDF

TRNSYS 15	*|<applink> Img\image.bmp Doc\help.pdf left
TRNSYS 16	*|<img src="Img\image.bmp" href="Doc\help.pdf" align="left">

7.2. Multiple tabs

In TRNSYS 15, a usual TRNSED-based application resulted in a very tall window with all the simulation parameters. The user was required to scroll down that window to access those parameters and it was not always easy to find the right spot to set one particular parameter in a complex simulation.

In TRNSYS 16, it is now possible to distribute the parameters among different tabs, which act as multiple sub-windows for the application. The example here below shows the same application in TRNSYS 15 (left) and TRNSYS 16 (right). In TRNSYS 15, the user needs to scroll down and up to set all the parameters (the whole window is shown in the picture but only one third of it would be visible on a real screen). In TRNSYS 16, parameters are organized in tabs and the user can see a general scheme of the simulation on the main tab.

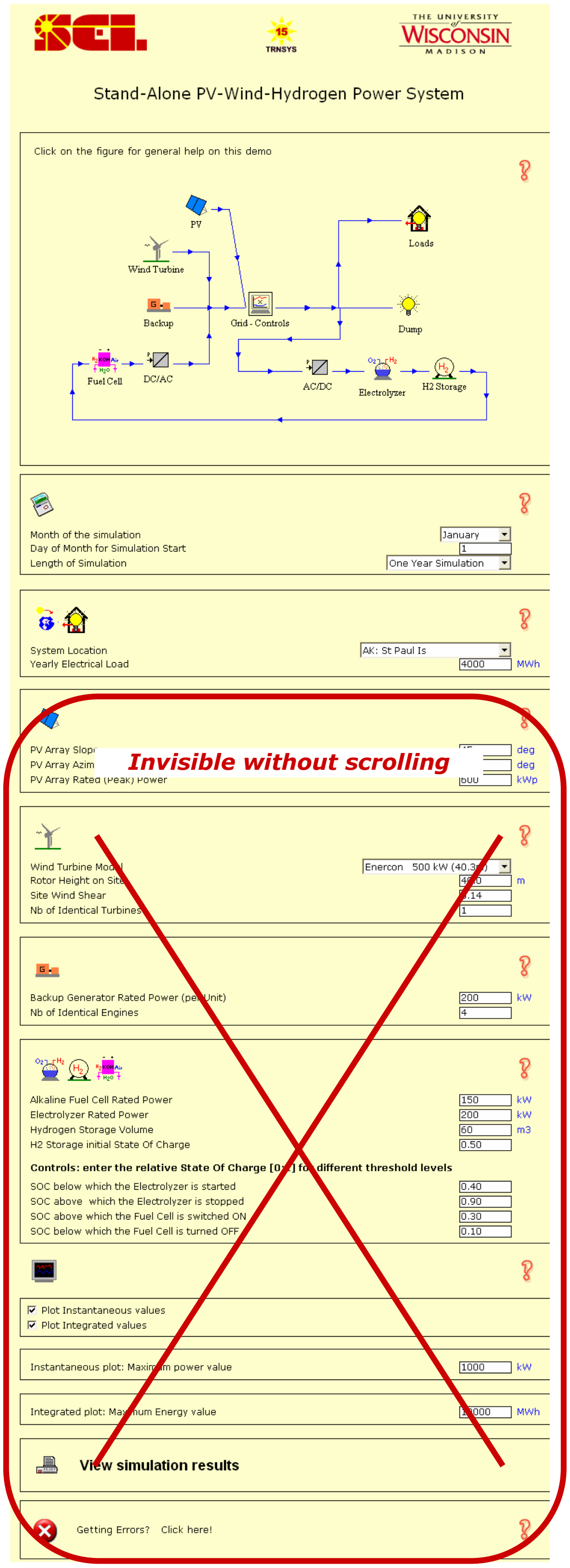
7.3. Clickable areas in pictures and links between tabs

In TRNSYS 15, one picture was associated with one action (e.g. launch a PDF document). In TRNSYS 16, the HTML concept of "picture map" is used to define different areas in one image. Each area is associated to a different action (e.g. launch different external files).

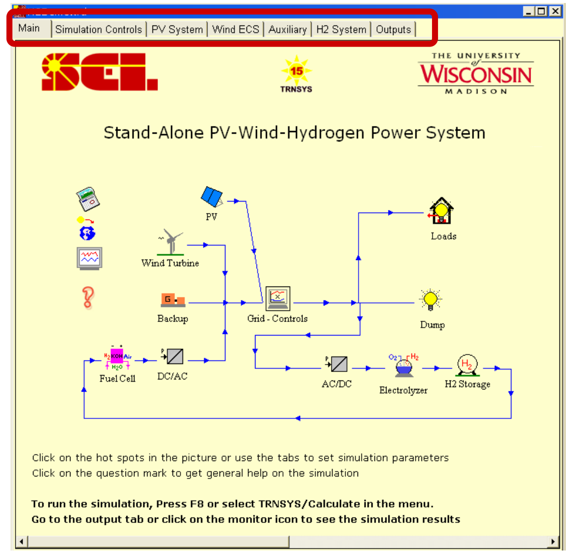
In order to simplify the navigation between tabs, one of the possible actions for a clickable area is to switch to another tab. This concept is also illustrated in the example here below.

7.4. Example

TRNSYS 15

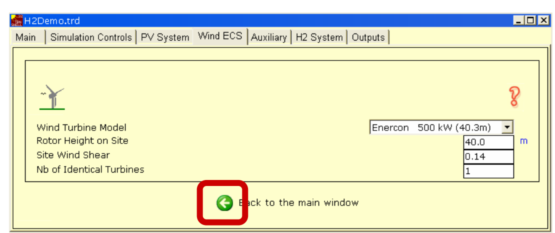


TRNSYS 16



Parameters are accessed by switching to different tabs. For example, all the parameters that define the output options are grouped in the last tab ("Outputs")

Clickable areas in the main image will launch different actions. For example, the question mark will launch the default browser and open the help file. On the other hand, clicking on the wind turbine icon will switch to the third tab and display the wind turbine parameters. From this tab, a "back" button is available to come back to the main tab.



8. *Miscellaneous enhancements*

- The TRNSYS 16 documentation is available in electronic format on the installation CD and on the TRNSYS website
- Hundreds of weather files have been added to the TRNSYS CD. Additional weather files can be downloaded from the internet and used directly thanks to TRNSYS' ability to read all the well-known standard formats
- All TRNSYS 16 programs accept any Windows path- and filename with or without spaces
- The TRNSYS Simulation Studio and all programs in the TRNSYS suite provide better support for Asian localized Windows versions