T*SOL®

The Fast and Professional Simulation Programme for the Design and Optimisation of Solar Thermal Heating Systems

Version 4.x Professional

VALENTIN ENERGYSOFTWARE

User Manual

T*SOL®

Version 4.x

A Windows™ Programme for the Design and Simulation of Solar Thermal Systems

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1 Programme Information

1.1 Why T*SOL®?

T*SOL® is a programme for the design and simulation of solar thermal systems including hot water preparation, the support of space heating and swimming pool heating.

The programme allows the planner to investigate the influence of individual system components on the operating behaviour of a solar thermal system. All system parameters can be quickly changed via the user-friendly interface.

Simulation results can be evaluated in graph or table format, making T*SOL® an excellent tool for planning a solar thermal system.

1.2 System Features

1.2.1 Overview

- Simulation of solar thermal systems supporting domestic hot water and space heating over any period of time up to one year
- Design (optimisation of collector array area and storage tank volume) of the system to reach specific targets
- Influence of partial shading by the horizon and other objects (buildings, trees etc)
- Graphic and tabular entry of shade values
- Design Assistant with automatic system optimisation
- Comprehensive component database
- Working on a number of system variants at any one time within a project is possible, making it easy to compare systems
- Domestic hot water consumption profiles included in the calculations
- Both radiator and under-floor heating can be included
- Investigation of energy use, pollutant emissions and costs
- Calculation of standard evaluation values for solar thermal systems such as system efficiency, solar fraction etc
- Detailed presentation of results in reports and graphics
- Economic efficiency calculation following simulation over a period of one year
- Online Help facility

1.2.2 System Configuration

With the standard version you can select a system from the most common system configurations.

With the swimming pool module, which is offered as an extra module to the standard programme, you can add an indoor or outdoor swimming pool to the solar cycle.

SysCat, the other extra module that is available, enables you to select from a number of large-scale solar systems (as tested during the *Solarthermie 2000* programme).

The system components (collectors, boiler, storage tank, and also consumption profiles) are loaded as units from the database.

The Design Assistant helps you to quickly produce a system variant, carrying out automatic optimisation of the system.

With T*SOL® both shade from the horizon and from objects close to the system is calculated. For the objects, you can take account of seasonal variations in shading (eg trees with and without leaves).

1.2.3 Simulation and Results

The calculation is based on the investigation of energy flows and provides yield prognoses according to the hourly meteorological data provided.

T*SOL® calculates the energy produced by the solar system in the production of hot water and space heating and the corresponding solar fraction.

The results are saved and can be presented in graph format or in a results overview (Summary Report). The graph maps the course of energy and other values, over any given period, and can be saved as a table in text format, so that the results can be copied into other programmes for further evaluation.

By varying individual system parameters, the optimal system configuration can be found.

1.2.4 Economic Efficiency Calculation

After running a simulation over a period of one year, you are able to carry out an economic efficiency calculation for that variant.

Taking into account the system costs and any financial support (eg government grant), the economic efficiency parameters, eg capital value, annuities and cost of heating, are calculated and detailed in a report.

1.2.5 Comprehensive Database of Components

The programme comes with a comprehensive database of the following components:

- Collectors
- Boilers
- Storage tanks

If you want to stay up to date, we would recommend a T*SOL® Service Agreement. You will then be sent regular programme updates and revised component database units.

2 Installation

2.1 Hardware and Software Requirements

T*SOL® is a WINDOWS™ application. One of the following operating systems needs to be installed on your computer before you can run the programme: Windows 95, Windows 98, Windows ME, Windows NT or Windows 2000.

T*SOL® requires a minimum of 32 MB RAM. With less memory there is no guarantee that the programme will run.

Recommended system configuration:
- 400 MHz Pentium-PC
- 64 MB RAM
- VGA colour monitor (min. 800x600, 16 bit colour depth)
- Mouse
- Disk drive
- CD drive
- Printer that supports graphics

The fully installed programme uses ca. 40 MB of hard disk space. Each additional weather data file requires 5 MB. You will require approximately 50 MB of free hard disk space in order to run PV*SOL® comfortably. Please ensure that you have enough space free on the hard disk before you install the programme.

In order to run T*SOL® you must have the full licence rights (licence disk) to access the installation folder.

The formats for currency, numbering, time and date that are defined within the country settings of Windows‘ system control on your computer are automatically reproduced within T*SOL®. These formats also appear in any T*SOL® documents that you print out. In order to run the programme, it is important that the symbols separating thousands and decimals are different.

You should set your monitor display to *Small Fonts* via the Windows system control.

2.2 Programme Installation

Please close all programmes before commencing the installation procedure.

To install the full version of the programme you will require the CD and a licence disk, which cannot be copied, or the release code.

The installation programme starts automatically after inserting the CD in the CD drive. However, should a problem occur, you can open the installation programme via Windows Explorer by double-clicking on start.exe in the CD drive folder.

Please then follow the installation programme instructions. You are able to select the installation path of your choice.

If you are starting the programme for the first time, a dialogue window will appear with options for licensing the programme!

To register the full version, please insert the licence disk in the drive when requested to do so. Without this disk you are only able to use the programme as a demo.

You are able to enter your name and/or your company name, in two lines of up to 30 characters. These two lines will then appear in the header of all T*SOL® print-outs.

The logo illustrated here will be used as the programme icon. After installation it will appear in the Windows **Start** menu.

The single licence version of T*SOL® can only be installed onto the hard drive of one computer. However, since the database and project files can be saved to any paths required, and this path can then be set in the programme as the standard path, it is therefore possible to move parts of the programme to other hard drives.

If you wish to install the whole programme onto a network, you will require the network version of T*SOL®.

3 Brief Instructions

The aim of this section is to introduce the user to the scope of the T*SOL® programme, drawing on the most important and most frequent questions raised by users. The planning and design of a solar thermal system using T*SOL® will be illustrated using the menus and following the various steps that need to be carried out, in their recommended order. The corresponding speed button symbols for direct access to the dialogues will be shown.

3.1 General Information on Design

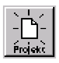
There is no simple method of calculating the exact definition of a solar system's yields. The number of parameters required to determine the operating behaviour of a system is too large. This is not only affected by the changeable, non-linear behaviour of the weather, but also by the dynamic nature of the system itself.

Of course there are rules of thumb such as 1-2 m² collector surface per person and 50 l storage tank capacity per m² of collector surface, but these are only valid, if at all, for small systems serving one or two households. Only calculation-based simulation makes it possible to investigate larger systems in respect of the influence of the surrounding conditions, consumption variations and different components on the operating conditions of the solar system.

Solar systems can be used for heating purposes, above all, in areas where heating is also required in summer. These systems will then, even during the transitional period, make a considerable contribution to heating the building. However, something that should be avoided at all costs is the design of a solar system for heating without the possibility of seasonal storage, even in winter. This would lead to extremely large collector surfaces and at the same time excess energy in summer, ie to systems with very poor efficiency and therefore very high heating costs!

In order to design and optimise a solar system with T*SOL®, the following steps should be followed:

3.2 Set Up a New Project (File menu)



To set up a new project you will need to open the **General Project Data** dialogue and enter at least the name of the project. This will also serve as the name of the project folder, into which the project variants worked on in the course of the project should be saved. All other details can be entered at a later date, as and when required.

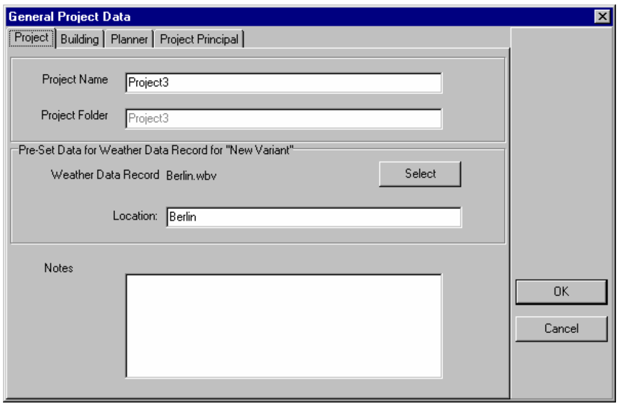


Figure 3.2.1:
Data entry dialogue for setting up a new project

Exit the dialogue with OK to set up the project. You can then define and work on as many project variants as you wish.

3.3 Set Up a New Variant (File menu)

Within each project you have the possibility of setting up as many variants as you wish, each containing different systems and components. You can open and work on up to six variants at any one time.

There are a number of options for setting up a new variant.

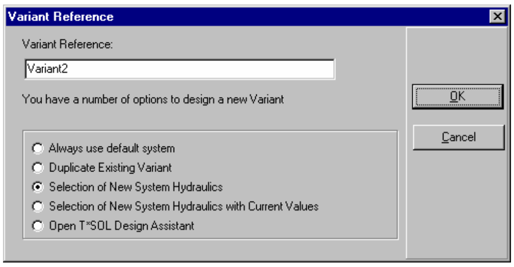


Figure 3.3.1:
Data entry dialogue for setting up a new variant

3.4 Design Assistant (Calculations menu)

If you do not have a firm idea of the design of your solar system, you should use the **Design Assistant** to size your system.

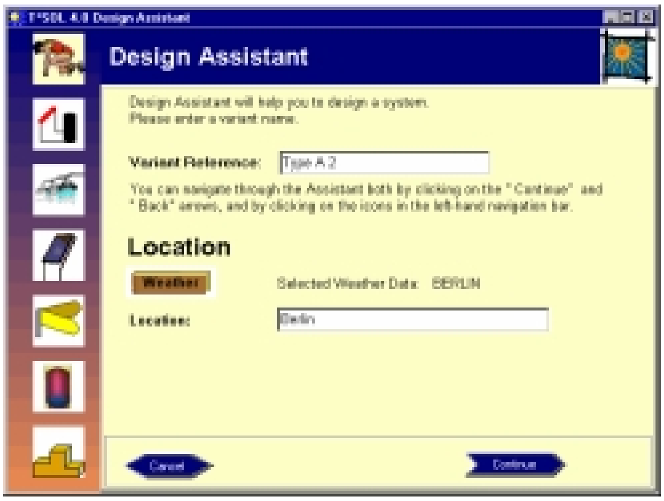


Figure 3.4.1: Design Assistant

The Design Assistant leads you through all the necessary stages, including the selection of a suitable collector and storage tank. These components are determined, after entry of the desired solar fraction, by the calculation results of a mini simulation.

By clicking on the **Accept** button, the parameters entered and determined in the Design Assistant are transferred into the system.

3.5 Select a System (Systems menu)

If you already know which system components you want to use, you can select these directly from the **System | Select** menu. This gives you an overview of all of the component combinations available with your version of the programme.

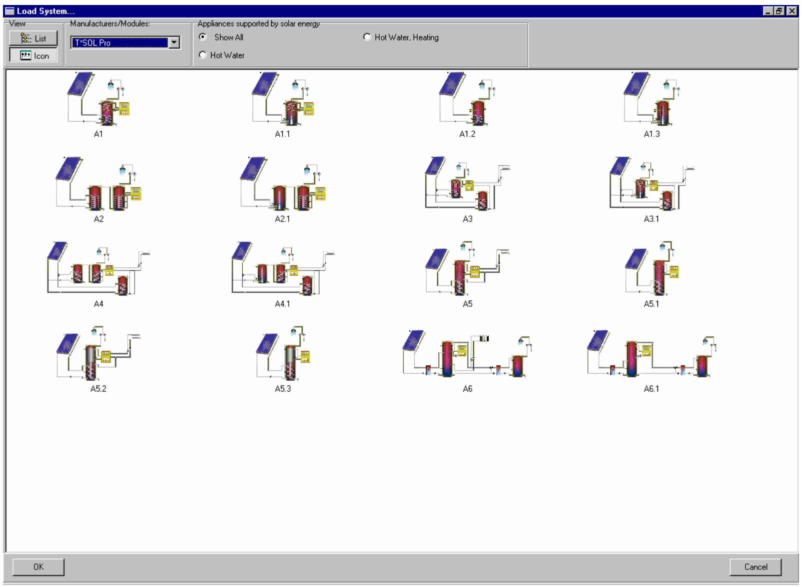


Figure 3.5.1: Standard Systems Selection Dialogue

Select the system you want to use by double clicking on the image or on the list entry. The system will take on the parameters of the currently active project variant.

3.6 Enter System Parameters (Parameters menu)

This menu allows you to enter or change your solar system’s component parameters.

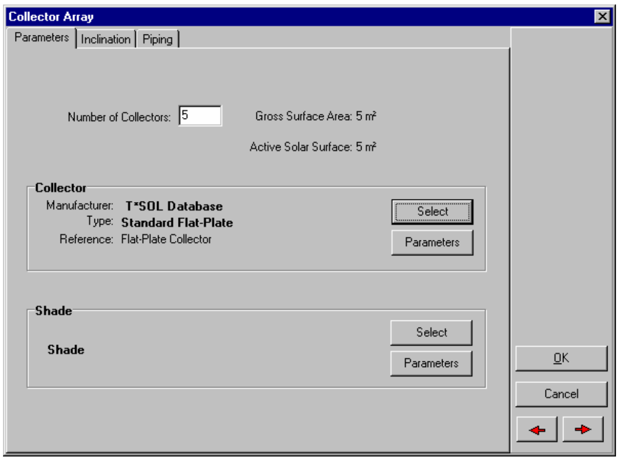
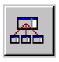


Figure 3.6.1:
Data entry dialogue for system components – eg collector array

A number of parameter dialogues are displayed, onto which all the necessary data is entered. Use the red arrow buttons in the bottom corner to move between the dialogue windows.



Another possibility to enter the parameters is via the **Main Dialogue**. In the Main Dialogue you can also use the red arrow buttons to move between the dialogue windows.

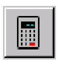
A quick way of reaching the individual parameters for the individual components is via the system diagram. Just position the mouse arrow over one of the components and double click or click with the right mouse key to get to the corresponding dialogue (characteristics).

The Set Data in respect of the climatic conditions and the hot water and heating requirements for the actual variant can be modified via the corresponding buttons allocated.

3.7 Simulation (Calculations menu)

The size of the simulation interval varies between one and six minutes. What is decisive here is the system inertia resulting from the capacities and energy flows.

For the evaluation of the simulation results, it is often enough to work with values resulting from larger simulation intervals (hourly or daily).



Use the speed button to carry out a simulation for the project variant that is currently active.

If you go to the simulation dialogue via the **Calculations** menu, you are able to select the simulation period and the recording interval. Depending on the selected simulation period, a number of different recording intervals are offered.

Figure 3.7.1:
Data entry dialogue for simulation parameters

Clicking on the **View** button allows temperature conditions to be observed during the simulation. The exact time of each simulation step is shown in the status bar of the variant.

At the end of the simulation a selection dialogue opens so that you can view the results (report or graphics) or carry out an economic efficiency calculation.

3.8 Economic Efficiency Calculation (Calculations menu)

In order to carry out an economic efficiency calculation, the results of a simulation carried out over a period of one year must be available.

Click on the button, or access the dialogue via the **Calculations | Economic Efficiency** menu. The parameters required to carry out an economic efficiency calculation are taken on the one hand from the Pre-Set Data (**Options** menu), which can be changed as required for the design of special systems and on the other hand from the simulation results.

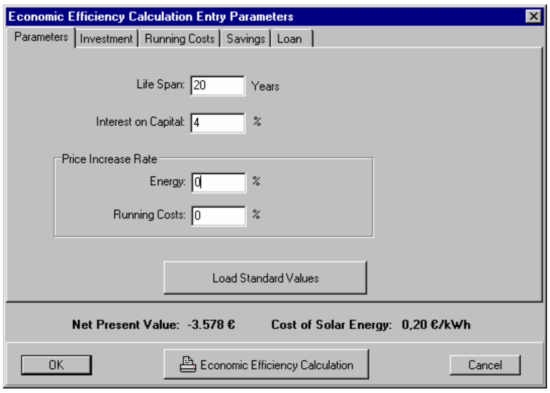


Figure 3.8.1:
Data entry dialogue for economic efficiency calculation

For each respective variant, however, you can enter different values. If the changed values are to be used in the simulation results, a warning will appear before saving.

The following values are entered onto the **Parameters** worksheet :

The *Lifespan* is the period given by the manufacturer as being the estimated operating life of a system. For the majority of solar systems this is between 10 to 20 years.

The *Interest on Capital* is the interest rate at which the capital for the investment is borrowed from a bank, or the interest that might be charged on the capital used.

The *Price Increase Rates* of the Running Costs and Energy (fuel costs) are important in calculating the Net Present Value.

Changes can be made to the **Investment** worksheet as follows:

The *Investment* can be entered as an absolute amount and as a specific cost in €/m² of collector surface area.

The *Subsidy* can be entered as an absolute amount, as a percentage of the investment and as a specific subsidy in €/m² of collector surface area.

The **Running Costs** worksheet includes the following parameters:

The *Fixed Running Costs* of the system can be entered as an annual amount or as a percentage of the investment in percent per annum.

The *Pump Running Costs* are the product of the running time produced by the simulation, the pump performance and the specific electricity costs.

From the **Savings** worksheet it is possible to change the *Specific Fuel Price* adopted from the **Options | Pre-Set Data** menu, if you want to design a special system.

By changing the values produced by the simulation for the *Solar Yield* and the *Fuel Savings* (the programme will warn you before the changes are saved), you can for example determine at which values the system would be economically viable.

On the **Loan** worksheet up to three loans can be defined:

The *Loan Capital* is the amount of credit that is taken out.

The *Term* is the amount of years in which the loan has to be repaid.

In addition, either the *Annual Installment* or the *Loan Interest Rate* has to be entered. In each case the other field is blocked and calculated by the programme.

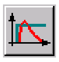
The annual installment is the fixed annual amount with which the loan and interest are repaid over the agreed term.

The loan interest rate is the percentage of interest that has to be paid on the loan. If the loan interest rate if less than the capital interest rate, the loan takes on the function of a subsidy; if it is more, the total costs increase. With identical interest rates they remain the same.

The economic efficiency calculation provides figures for the Net Present Value of the system and the Cost of Solar Energy.

3.9 Evaluate Results (Results menu)

T*SOL® offers you a two ways of evaluating the simulation results: graphical display and the Summary Report.



The graphical display allows you to select up to eight curves. A graphics window appears with its own menu, so that you can format the graphs as you wish. You can change the break-down of the values, the display interval (from 1 day up to 1 year), font type and style, colour and presentation (line graph or bar chart) of the curves and the guide lines.

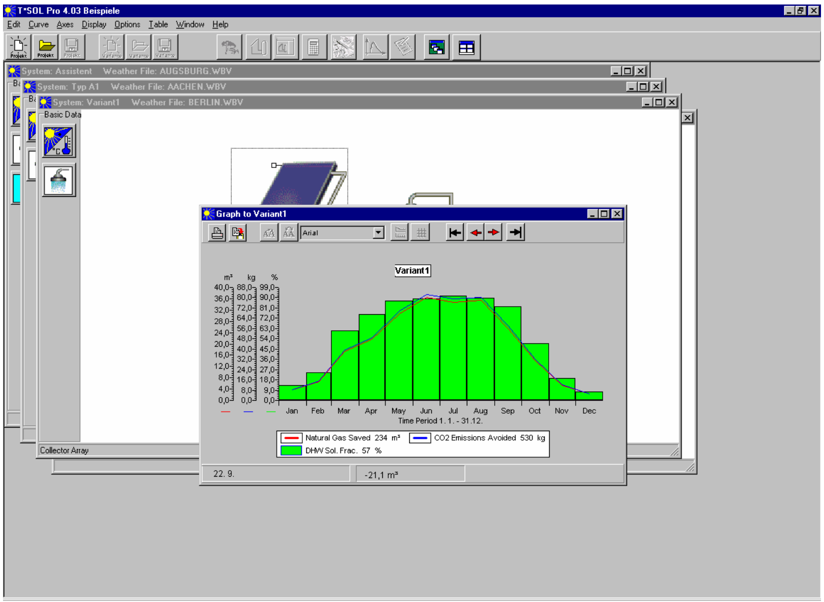


Figure 3.9.1: Simulation results graph

The axes can be redefined and the graphic can be given a title. The values can be copied and pasted into other programmes for further evaluation.

The **Summary Report** consists of a three-page overview including the system diagram, the entry data and the simulation results. The summary report can be printed via the page preview.

4 Calculation Examples

Read the following two project examples and at the same time carry out the individual steps in the T*SOL® programme.


You will find further project examples in the project folder, which is reached via the menu **File | Open Project** or by clicking on the button.

4.1 Use of the Design Assistant

The Design Assistant is there to help you establish the dimensions of a solar system. It should therefore be used if you are not sure of the size of the collector array and/or the size of the storage tank to be installed. The Design Assistant is an independent part of T*SOL® Professional and the results it produces can be accepted into the main part of T*SOL® - the system screen.

Project Example:

A renovated block of 6 flats in Augsburg requires a solar system for hot water supply and the support of space heating. The building has a pitched roof with a 35 degree inclination facing south east and an area of 40 m².

Is this area large enough to provide the target 20% solar fraction of the total energy consumption?

This question is most easily answered by using the Design Assistant.


You are able to use the Design Assistant at any time when working on an existing project – either use the **Calculations | Assistant** menu, or (the faster option) click on the button in the upper button bar. You can then select to replace the dimensions of the currently active project variant with one of the sets of values calculated by the Design Assistant. If you want to design a new variant, use the **File | New variant** menu and click on the command *Open T*SOL Design Assistant*.

For our calculation example, however, we want to design a new project, as the questions regarding collector area and size of storage tank need to be answered right at the beginning of a project.

4.1.1 Set up a New Project

When you start T*SOL®, the first dialogue window will prompt you to select the project you want to start with.

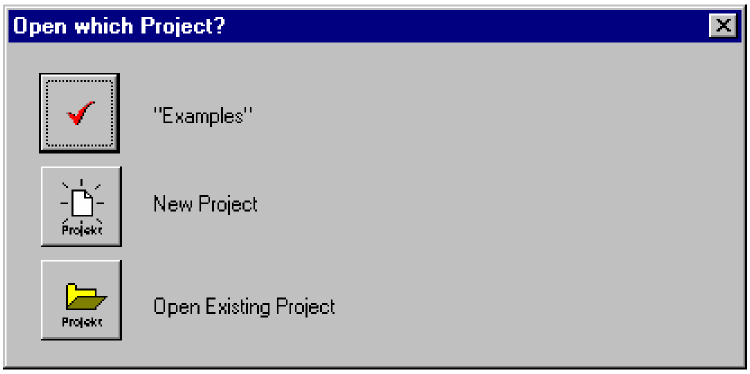


Figure 4.1.1:
Project selection dialogue.

Click on the *New Project* button in the dialogue. If, however, you have already started T*SOL®, you can reach the same stage via the **File | New Project** menu or by clicking on the button in the upper button bar:

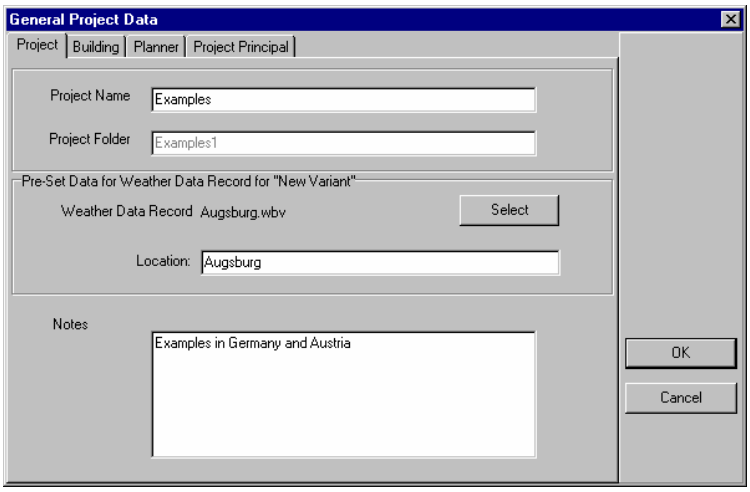


Figure 4.1.2:
General Project Data entry dialogue.

The project name that you enter in the first field is saved as the file name for the project, so you won't have any trouble finding it later on. On this Project Data dialogue worksheet, you are already able to define a weather data record by clicking on *Select*. The selected weather data record will then be automatically loaded within this project for each new variant selected.

The other worksheets, **Building**, **Planner** and **Project Principal** do not have to be filled in at this stage. They provide useful information about the project, but can also be left blank.

After confirming the project data with *OK*, a standard system is loaded and the system screen for Variant 1 appears with a diagram of the system.

From here you can start the Design Assistant by clicking on the button in the upper button bar. The system diagram is now of secondary importance.

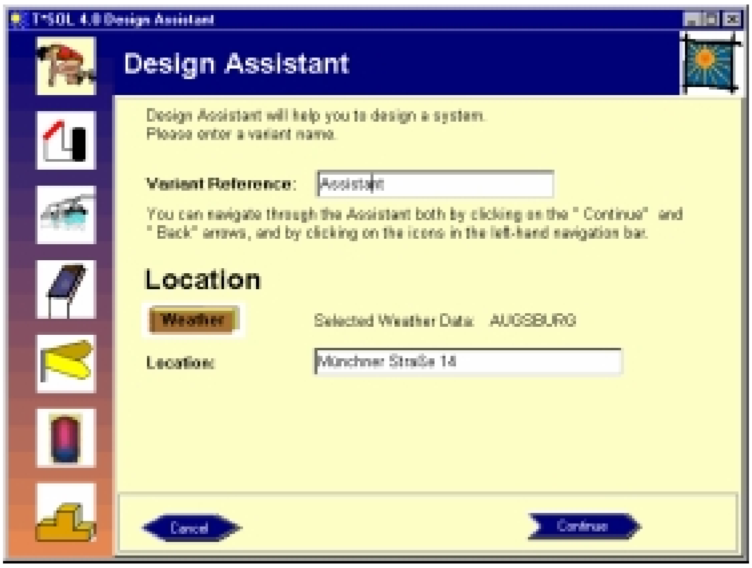


Figure 4.1.3:
Design Assistant first sheet.

On the first sheet of the Design Assistant, you start by giving the planned solar system a name. The word *Variant* is used, as it is possible to calculate a number of different system variants within a project.

The weather data record for Augsburg has already been entered, as this was selected in the General Project Data dialogue. However, this can be changed by clicking on the button *Weather*. Independent of the weather data record, the location of the building can also be entered, eg the street address where the solar system will be installed.

In order to reach a result, we now have to go through the individual worksheets of the Design Assistant, entering the information required. Use the buttons *Continue*, *Back* and *Cancel* at the bottom of the dialogue to do this. You can also click on the icons on the left of the dialogue to access the individual sheets direct.

4.1.2 System Selection

The next two sheets contain details on system selection. This depends on the planned use of the system. You will have to select whether the system is to be used to supply hot water and/or space heating. For the Project Example above, therefore, you should click on the circle to select *Space Heating*. Depending on the selections made on this worksheet, the following sheet offers a selection of system configurations and types. The selection of the various systems is divided into small-scale, combination tank and buffer tank systems. Click on the tabs to view the systems available under each category.

To define the amount of collector area required, the Design Assistant makes use of a shortened simulation procedure on an hourly basis. This procedure is restricted to the use of simple system configurations. Design Assistant does not therefore contain all of the system configurations that you can access from the system screen via the **System | Select** menu.

Back to our Project Example: the requirement is for a solar system to provide hot water and support of space heating for a block of flats. We decide on the DHW System (2 tanks) with Space Heating Buffer Tank (Small-Scale Systems – A4, three tank system) and click on the corresponding diagram. This highlights the system and we click on *Continue*.

4.1.3 Define Consumption

Two worksheets need to be completed here: hot water and heating consumption.

You have a choice of two ways of entering the hot water consumption. If you know what the average daily consumption will be, you can click on the circle and then enter the amount direct. If you do not know, then you can enter the estimated or actual number of people that will be using the system. A figure for the absolute consumption will then be calculated based on the number of people via a pre-set specific consumption figure. The specific consumption per person can be entered and changed from the system screen via the menu **Options | Pre-Set Data| Design Assistant**.

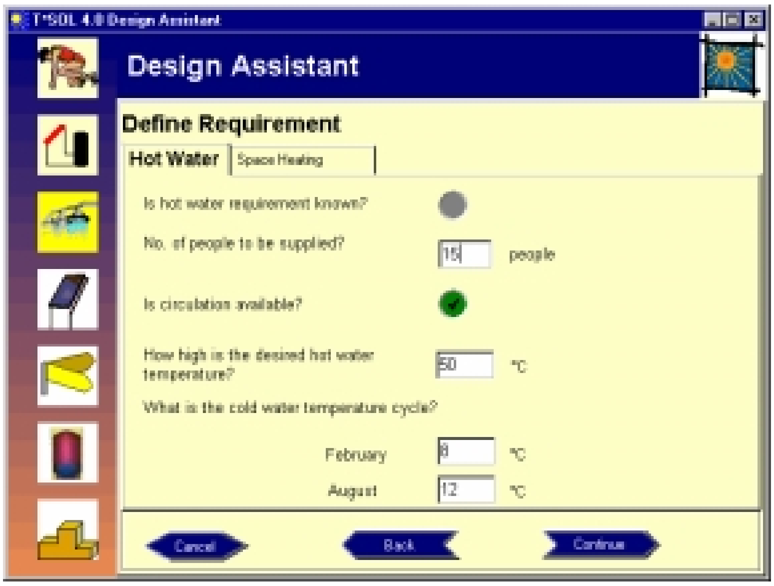


Figure 4.1.4: Definition of hot water requirement in the Design Assistant.

Our building contains 6 flats. If the calculation is based on 2.5 occupants per flat, this gives a total figure of 15 occupants for the block (enter 15 in answer to the question *No. of people to be supplied*?). As hot water circulation is usual in many blocks of flats we should click on the corresponding circle, so that circulation losses depending on total consumption will be included in the calculation. The desired hot water temperature and the cold water temperature should be entered here and can also be pre-set under **Options**.

Click on the tab labelled **Space Heating** to get to the worksheet for the space heating requirements.

Our building has a floor space of 480 m², which we enter as the area to be heated in the first entry field. We also have the possibility here to enter the heating energy requirement (eg according to DIN 4701) or, as this value is often not known, to let the programme calculate it via internal codes, after entering the building heating standard (this calculated value can then be seen from the system screen). In our case we need to remove the tick (by clicking on it) for *Is heat demand known?* and then make the selections illustrated below.

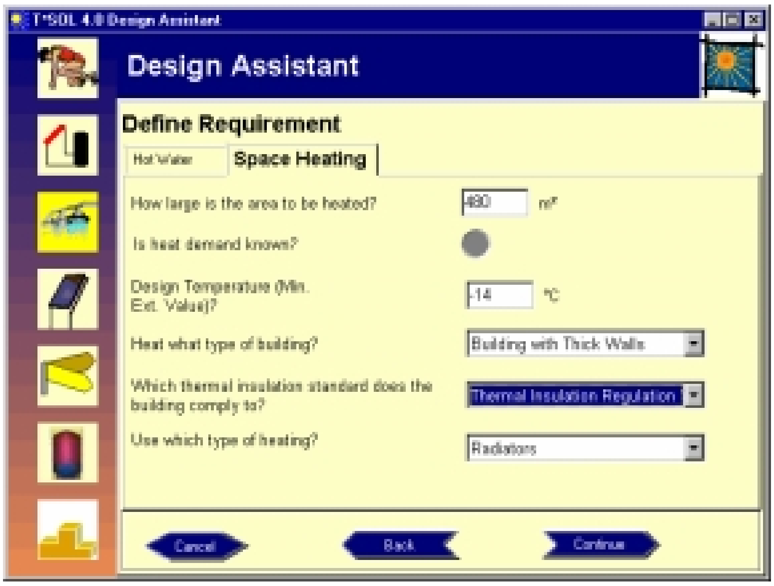


Figure 4.1.5: Definition of the space heating requirement in the Design Assistant.

To provide a figure for the annual space heating requirement, which T*SOL® calculates for every hour of the year, you will need to enter the standard external temperature.

4.1.4 Define Collector Array

To start with, the Design Assistant uses the standard flat-plate collector from the T*SOL® database. This corresponds to a simple collector with an area of 1 m². You can, however, select any collector of your choice from the database by clicking on the collector button or, from the system screen, select your preferred standard collector under **Options | Pre-Set Data**.

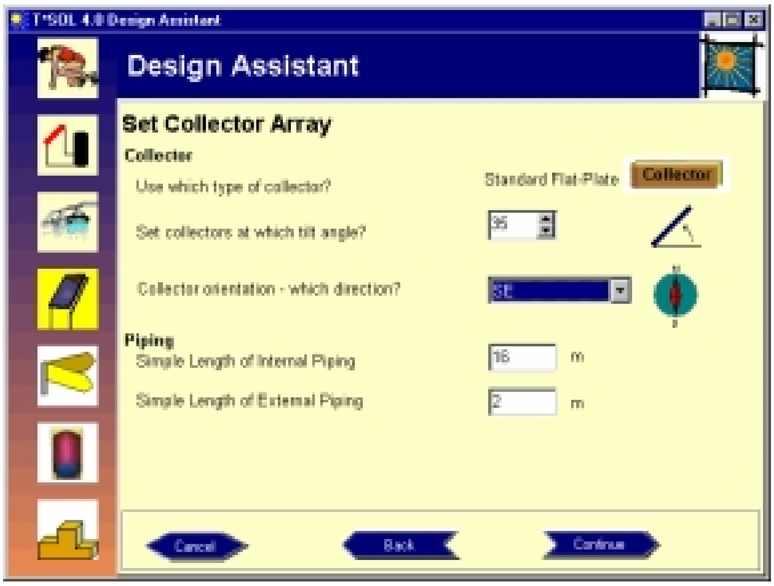


Figure 4.1.6: Definition of the collector array in the Design Assistant.

The tilt angle and orientation of the collector array need to be entered next. The values for the piping are based exclusively on the collector loop. The single length of piping should be entered. The heating losses and hydraulic resistance of the piping are calculated from these values.

After clicking on the *Continue* button, the Design Target needs to be entered. In our Project Example a solar fraction of 20% of the total energy consumption (hot water and space heating) is required. We have selected natural gas as our fuel for auxiliary heating.

By clicking on *Continue*, we are provided with a selection of storage tanks that the Design Assistant recommends for our system. Each of the recommended tanks can be changed by opening the database and making a new selection. For each of the three buffer tanks recommended, we can carry out a variation calculation by clicking on *Variation*.

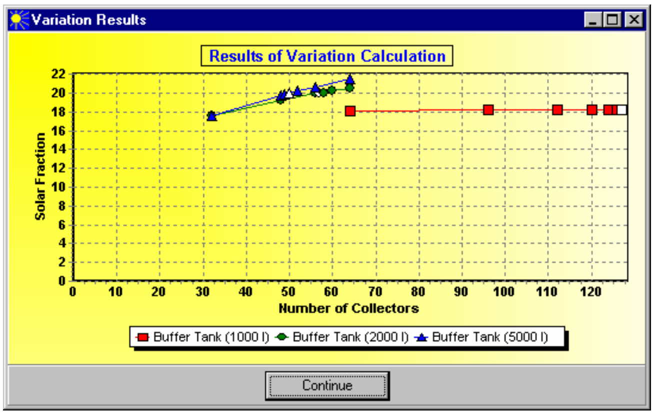


Figure 4.1.7: Graph of simulation results in the Design Assistant.

This takes you to a graph of the simulation results, showing the number of collectors required for the three different buffer tank sizes. The collector number with which the target of a 20% solar fraction is reached is shown by a white symbol.

It can clearly be seen that with a 1000 litre tank the target of a 20% total solar fraction will not be reached. On the other hand, the difference between a 2000 litre and a 5000 litre tank is minimal.

The result is clearer still after clicking on *Continue* and the results are then shown in three bar charts.

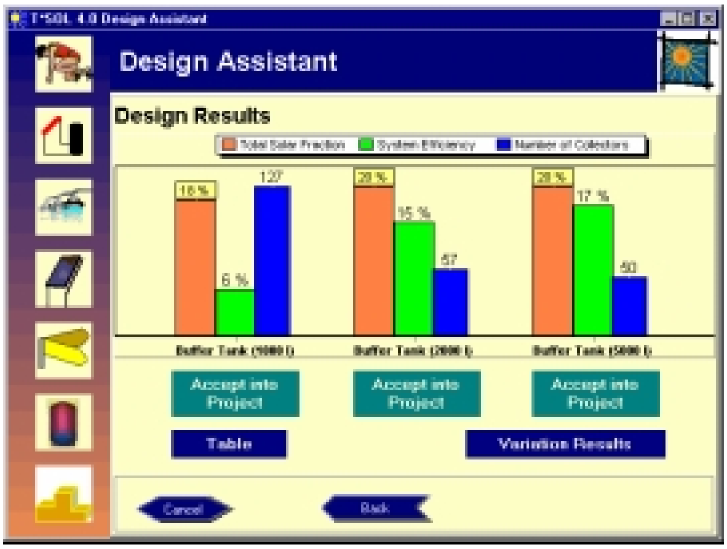


Figure 4.1.8: Graphical display of simulation results in the Design Assistant.

Included in these charts, in addition to the solar fraction, is a further important evaluation figure, the system efficiency. With an increase in the tank volume, the system efficiency increases and the collector area reduces, with the solar fraction remaining constant.

Since in our Project Example a maximum roof area of 40 m² is available, the collector area even with a large tank volume is too large to fit onto the roof. What can be done?

Let us try again with better quality collectors – evacuated tube collectors.

We therefore click on the collector icon on the left hand side of the Design Assistant screen and this takes us back to the collector selection sheet (Set Collector Array). There we click on *Collector* and select the Standard Evacuated Tube collector from the T*SOL database, and otherwise change nothing, and then click on the icon with the steps on the bottom left of the screen. The results are now completely different.

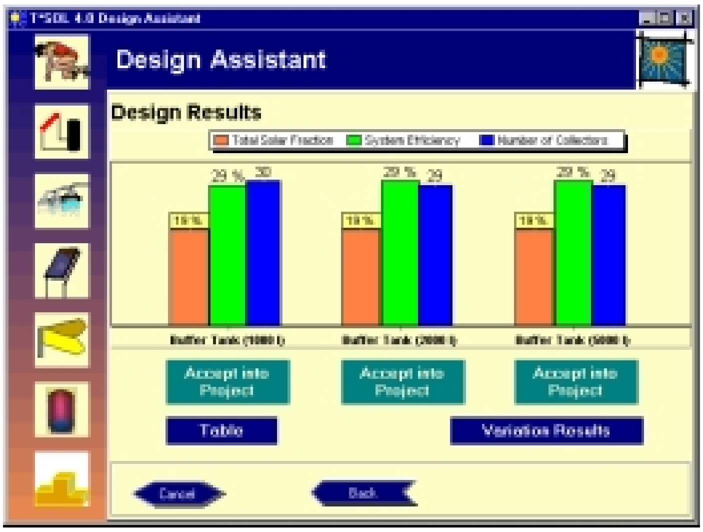


Figure 4.1.9: Graphical display of simulation results in the Design Assistant after selecting a different type of collector.

With a much improved figure of 29% system efficiency, less than 30 collectors are required. We decide on the variant with the 2000 litre tank and click on *Accept into Project* to return to the system screen. The data that has been entered in the Design Assistant has been transferred into the system on the system screen.

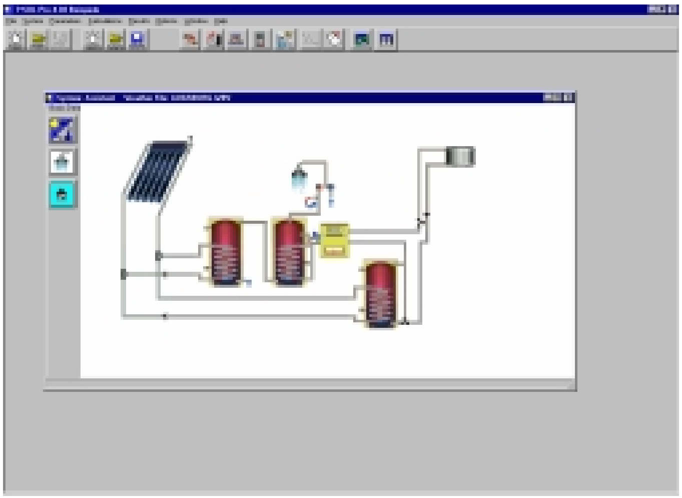
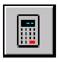


Figure 4.1.10: Diagram of the system configuration designed with the help of the Design Assistant.



Back in the system screen it is now possible to carry out an immediate simulation (click on the Start Simulation button), or to enter new or change existing parameters.

4.2 Type A: One tank system for solar hot water supply

This type of solar system is frequently used for one and two family houses. As a rule, pre-configured systems are used here, as offered by many collector manufacturers. The configuration of number of collectors, storage tank and other components should then be entered into T*SOL®. For frequently used systems, you can save these as a standard project and then copy into a new project as required and simply change the pre-set data, such as location, collector tilt angle and orientation.

In this case, the calculations using T*SOL® mainly serve to determine the expected primary energy savings, as well as the system's solar fraction. An important result is also the proof that the system is not oversized. When a system is oversized this is shown by the maximum tank temperature frequently being reached, thus leading to high collector temperatures.

Project Example:

A solar system for the supply of hot water is required for a newly built bungalow in Aachen. The bungalow is to be home to a family of five.

- What size should the collector area be?
- At which tilt angle should the collectors be installed on the flat roof?
- How often does the temperature drop below 35 degrees centigrade?
- How much heating oil can we expect to save?
- Which other measures should be taken into account when building the house?

The following additional details are provided with the house plans:

- The bungalow's longitudinal axis is oriented from the south east to the north west.

- 240 m² floor space.

4.2.1 Design a New Variant

We have already set up a project via the **File | New Project** menu (in this case it is the project named "Examples"). For the above Project Example you will need to set up a new variant of "Examples" via the **File | New Variant** menu. A dialogue appears into which you can enter a *Variant Reference* and in which you can select the method for design. We name our variant TYPE A1 and select …*New System Hydraulics*.

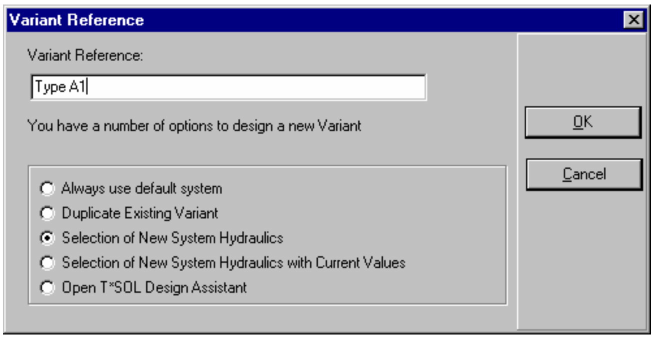
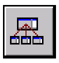


Figure 4.2.1:
Dialogue for setting up a new variant.

After confirming with *OK*, the **Load System** screen opens. The amount and types of systems available for selection and simulation depends upon which of the T*SOL modules you have installed on your computer (Standard, Swimming Pool, SysCat). You can change between icons of the systems and a listing, in order to get an overview. We select the system labelled A1 and load it into our variant with a double-click, or a single click and a click on OK, and we are then back in the system screen.

We now need to enter the specific parameters for the location, consumption and system components into the system we have selected. There are a number of ways of doing this:

- individual components can be accessed via the menu commands of the **Parameters** menu;
- click on one of the components in the system diagram, to select the system component, and then double click with the left mouse key to get to the component dialogue (or click just above or below the system to select the whole system, and then double click to get to the system dialogue) or click to select the component/system and then click with the right mouse key and select **Characteristics** from the mini-menu;



- or click on the main dialogue button to access the main dialogue direct.

4.2.2 Define Parameters

For the complete definition of a system, as required in our example, it is best to go direct to the **Main System Dialogue**, as this will automatically take you through all the necessary dialogues. In the main dialogue you can use the red arrow buttons in the bottom right hand corner to move between the various component dialogues.

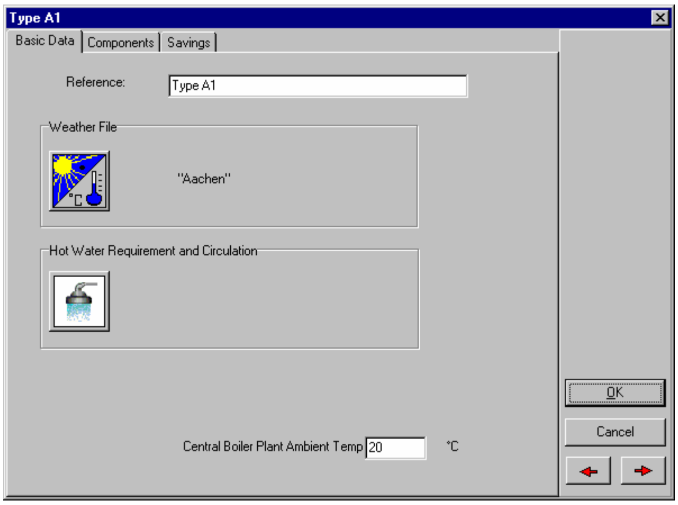


Figure 4.2.2: Main Dialogue

In the *Reference* entry field of the first worksheet in the main dialogue, you can enter a new variant name, or amend an existing name. This reference, in this case Type A1, is the name that is shown in T*SOL's® blue title bar and is the reference under which you will be able to find the variant again, eg in the Load Variant dialogue. The weather data is also loaded here, the hot water requirement is entered and the ambient temperature for the central boiler plant is defined. This temperature is the reference temperature for the calculation of storage tank losses and circulation losses.

After loading the weather file for *Aachen* from the weather database for Germany (additional weather data for other countries can be installed from the CD), we click on the red arrow to go to the next dialogue: **Hot Water Consumption**.

On the **Parameters** worksheet you enter the average daily consumption for the operating period given on the **Operating Times** worksheet - usually the average daily consumption over a year. At the same time, the total consumption for the operating period and the resulting energy consumption are shown. The total consumption figure is dependent on the values entered under Temperatures on the **Parameters** worksheet.

For our example of a bungalow in Aachen, we know that hot water is required for a family of 5. If we assume a high standard, say 35 litres per person per day, we get to a total of 175 litres per day at a temperature of 50 degrees centigrade. This daily consumption will not be spread out equally over the day, but will be required at certain periods in differing volumes. This pattern of use is illustrated in the Load Profiles. A number of different Load Profiles are available for selection from the database and these can be loaded via the *Select* button.

Click on the *Parameters* button to check and make changes to the load profile.

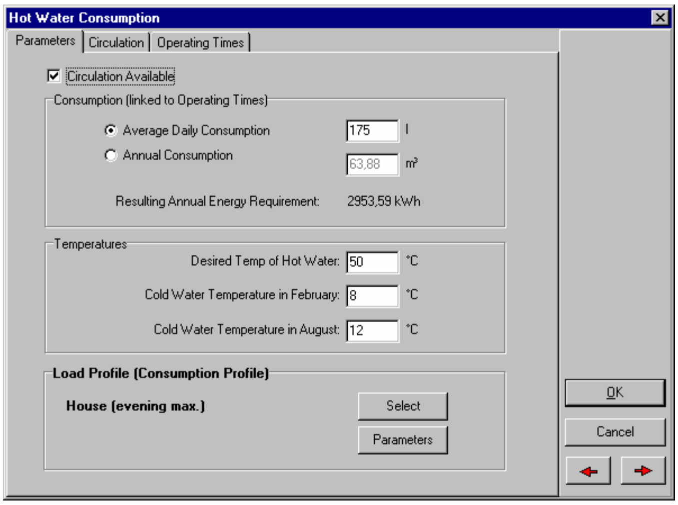


Figure 4.2.3:
Hot Water Consumption dialogue

Our bungalow will have a hot water circulation system. You can take account of this by selecting *Circulation Available* at the top of the **Parameters** worksheet (Hot Water Consumption dialogue). Once selected, a new worksheet will appear, labelled **Circulation**.

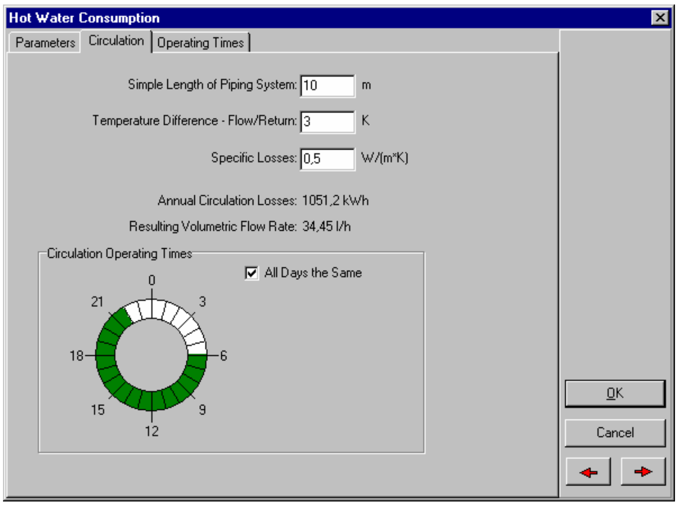


Figure 4.2.4:
Circulation worksheet from the Hot Water Consumption dialogue

On this worksheet, the circulation heat losses are calculated, based on the single length of piping and the specific losses. By changing the temperature difference you can adjust the volumetric flow rate resulting from the circulation pump. Click on the individual hours of the switching timer to adjust the daily running times for the pump. Deselect *All Days the Same* to individually adjust the daily running times for each day of the week.

On the final worksheet of this dialogue, **Operating Times**, you can enter (independently from the Load Profile settings) breaks in the hot water supply, eg during holiday periods. During the operating times that are deselected here, the consumption and circulation will be set at zero.

This completes the entries for hot water consumption and we click on the red arrow again to take us forward to the **Collector Loop Connection** dialogue. From here you can change the *Volumetric Flow Rate* in the collector loop, as well as the mix of the heat conducting medium, eg in order to simulate a low flow system. In the case, the volumetric flow rate in the collector loop would be between 10 and 20 l/m²/h. From the **Control** worksheet you can define the parameters for the collector loop pump control, which is set according to specified temperature differences.

By clicking again on the red arrow, or on the *Parameters* button, you come to the **Collector Array** dialogue. In the *Collector* section of the **Parameters** worksheet, click on the *Select* button to go to the collector database, from which you can make a selection from the list of manufacturers and collector types. In the header bar, there are drop-down lists of manufacturers and collector types, which assist you in finding the product of your choice quickly and easily.

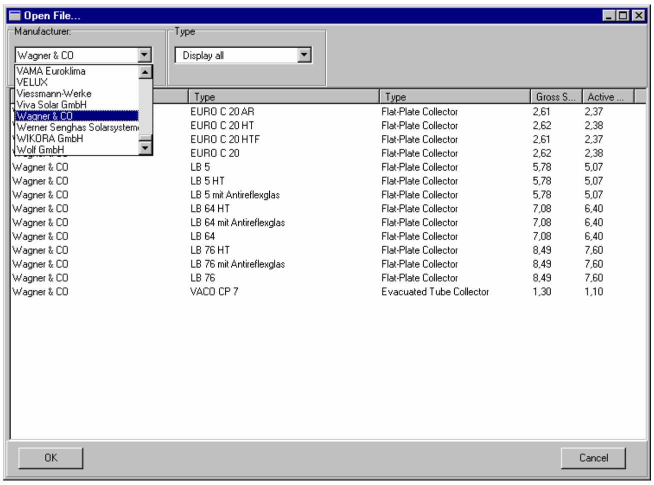


Figure 4.2.5:
Collector selection dialogue

Click on the preferred collector, or select and click on OK, to incorporate the collector into your project design. Entering the number of collectors automatically gives the collector area. We decide to start with 7 collectors with a total active solar surface of 7 m². This is the active area that is available to convert the sun's radiation and which forms the basis of test institute calculations to determine the collector coefficient.

On the **Inclination** worksheet you will find the parameters for the orientation and tilt angle of the collector array. The *Azimuth Angle* is the horizontal deviation between the collector surface vertical and the geographical south in the northern hemisphere (or the north in the southern hemisphere). It is 0° when the surface is facing toward the sun's highest point (zenith). In our case the building is in the northern hemisphere and the building's longitudinal axis runs from south east towards the north west. If the collectors are also installed parallel to this axis, the collector vertical (perpendicular to the active surface) points towards the south west. The azimuth is, therefore, in our case the angle between the south and south west, that is +45 degrees.

As our example deals purely with hot water supply, we can install the collectors at a tilt angle to gain the maximum possible irradiation. The absolute values for irradiation are given at the bottom of the dialogue. For a south west orientation, a tilt angle of 30 to 35 degrees results in maximum irradiation values. For the time being, it is however more effective to select the steeper angle. Thus you can answer the architects question regarding the tilt angle – 35 degrees from the horizontal. At a later stage, we will be able to optimise this angle by carrying out a number of simulations with different angles and then comparing the results.

In the case that you already have information regarding the length of piping from the water heating system to the roof, the single length should be entered on the **Piping** worksheet. If this value is not known, the pre-set values can be adopted.

Click on the red arrow to go to the next dialogue, the **Bivalent Domestic Hot Water Tank**. As our calculation will be based on hot water consumption of 175 litres, we select a storage tank of double size, ie 350 litres, which you can load from the database by clicking on the *Select* button. If you want to use a storage tank that is not included in the database, you are able to change the tank volume after loading. The tank will then be saved in the project with the data as amended.

We do not need to make any further entries for the storage tank, and the Control settings also remain unchanged. The pre-set value for the *Desired Temperature of Tank* of *0 K* (Kelvin) on the **Control** worksheet, means that the upper-tank temperature corresponds to the desired temperature of hot water, which, in this case, we set at 50 °C.

A further click on the red arrow brings us to the **Boiler** dialogue. The architect's plans show a floor space of 240 m². As we need to define a heating boiler, but a calculation of the heating requirement is not available, we can estimate the required power at 240 m² * 50 W/m² = 12 kW and load a correspondingly sized heating oil boiler from the database (via the *Select* button). We leave the pre-set value for the boiler's *Nominal Output* unchanged.

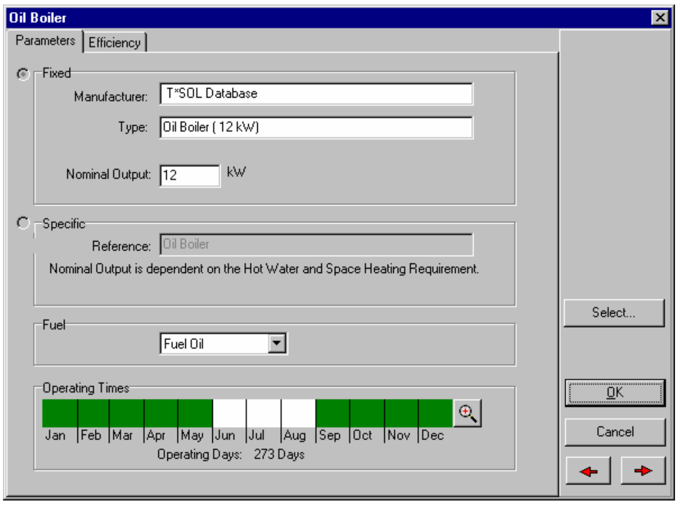


Figure 4.2.6:
Dialogue for the definition of the boiler.

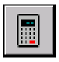
As we want the solar system to provide hot water in summer without the use of a boiler, we click on the months of June, July and August under *Operating Times*, (they change from green to white), so that boiler operation is halted during these months.

We have now reached the end of the dialogue chain and can exit the main dialogue by clicking on *OK*.

4.2.3 Simulation

After entering the parameters for your solar system, you are now in a position to calculate the system operating conditions over a period of a year by running a simulation. The simulation can be started in two ways: either click on the *Start Simulation* button in the button bar (calculator symbol) or via the main menu **Calculations | Simulation** (which will open the **Simulation Period** dialogue prior to simulation).

On the **Simulation Period** dialogue, the *Simulation Period* is pre-set at 1 whole year, and the results *Recording Interval* at 1 day. Both settings will suffice for our first simulation. *The Pre-run* of 3 days means that the simulation runs for 3 days before the first data is recorded (on 1 January).



Simulation, with the pre-set values, can be started direct by clicking on the *Start Simulation* button in the button bar.

From the **Simulation Period** dialogue, the simulation is started by clicking on *OK*. Once the simulation has started you are able to click on the *View* button and observe the system's temperature fluctuations. Click on the button again to return to fast mode and once the simulation has been successfully completed, the following dialogue will appear:

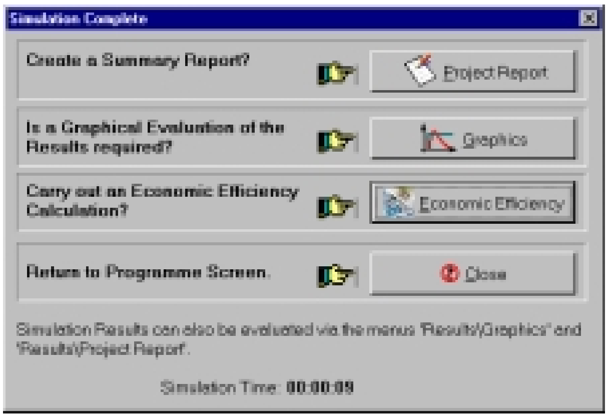


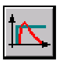
Figure 4.2.7:
Selection dialogue at end of simulation.

4.2.4 Evaluation

An initial evaluation of the system is always possible via the *Project Report*. If you create this report, the first page will show a summary of the most important dimensions, the solar fraction and the system efficiency. On this page we are also given the answer to the question of heating oil savings: the solar system makes annual savings of ca. 400 litres of heating oil.

On the second page, the values for the basic parameters are given and on the third page there are two graphics to assist in evaluation of the system.

The first graphic shows the course of the solar contribution over a period of 1 year in weekly intervals. The second graphic shows the maximum temperatures that the collectors reach on every day of the year. If you experience difficulties in printing these graphics with your printer, you can produce the report in PDF format using Acrobat Reader® via the **Options | Pre-Set Data | Project Report** menu. Once a report has been created it can be accessed via the **Results | Project Report** menu.



In order to answer the question regarding daily storage tank temperature, click on the *Create Graph* button or go to the **Results | Graphics** menu.

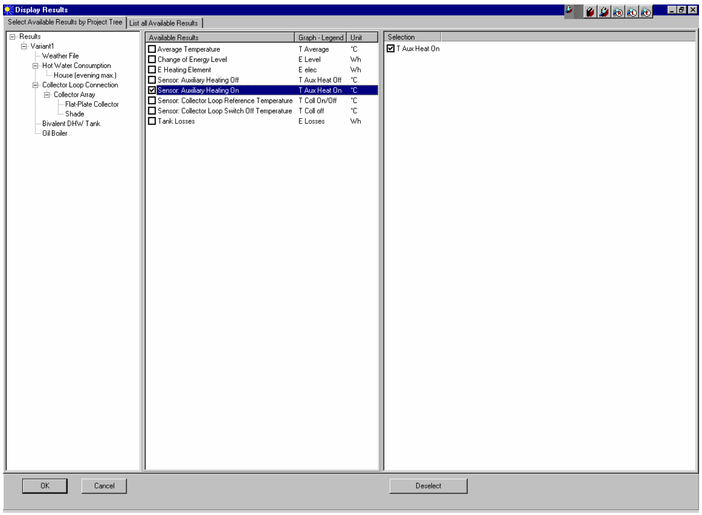


Figure 4.2.8:
Selection dialogue to produce a results graph

First of all, you are able to make a selection from the results that are available for each component listed in the project tree in the left-hand section. With the Bivalent DHW Tank, information on the upper-tank temperature is given if *Sensor: Auxiliary Heating On* is selected. On clicking OK, a graph is produced plotting the mean monthly temperatures. Daily temperature values can be set by double-clicking on the x-axis or, via the **Axes | X-Axis** menu.

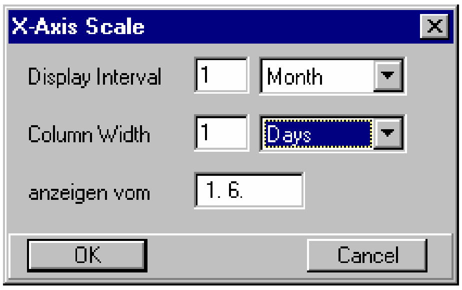


Figure 4.2.9:
Sizing the x-axis for a daily temperatures graph

You can select the *Display Interval* and the value for the *Column Width* here. With a setting of Month, Days and *Display from:* 1.6, as illustrated above, the daily tank temperature is shown from 1st June. You can change the display interval with the red arrow button and jump to the next month.

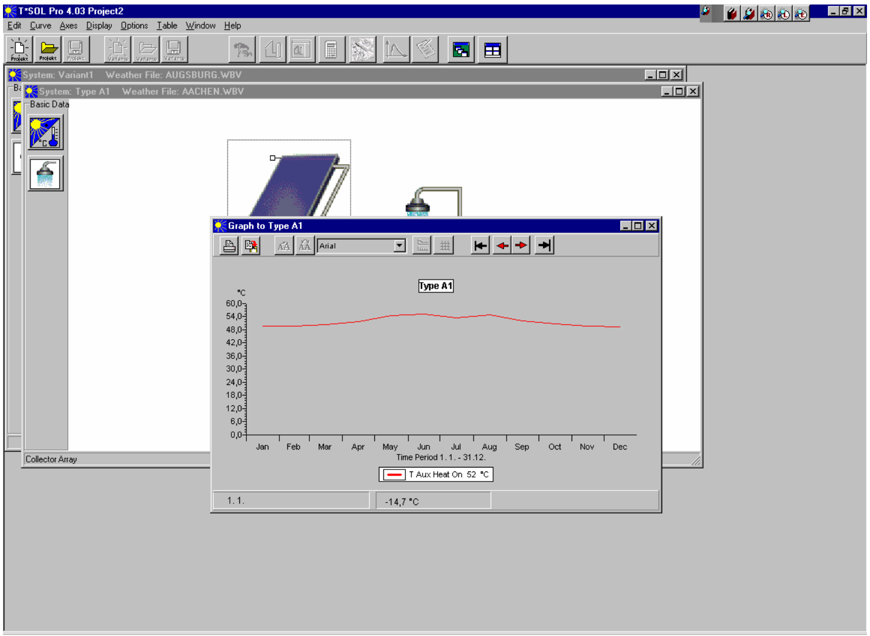


Figure 4.2.10: Daily temperature graph

The graph therefore gives the answer to the question of the number of days that the tank reaches a temperature of 35 degrees. The evaluation is even simpler if you convert the graph into a table via the **Table** menu.

A more precise measure of the temperature course can be gained if the temperature break-down is shown in hourly intervals. However, in order to do this it is necessary to record the values in hourly intervals during simulation. Go back to the **Calculations | Simulation** menu and set the *Recording Interval* at 1 hour. Carry out a new simulation and then you will be able to study temperature changes by the hour! To do this select a *Display Interval* of 1 day for the x-axis.

Continue with this example and consider how the number of days can be reduced in which the temperature falls below 35°C. Change individual parameters, such as storage tank size, tilt angle and collector area! Run another simulation and evaluate the results.

Finally, the architect is asking you about additional building requirements. Recommend that hot water connections for a washing machine and dishwasher be built into the system. With these machines the hot water consumption is increased by 20-40 litres daily, which can be supplied by the solar system, and therefore save valuable energy.