T*SOL® basic

Version 5.0

Design and Simulation
of thermal solar systems

User Manual

Disclaimer

Great care has been taken in compiling the texts and images. Nevertheless, the possibility of errors cannot be completely eliminated. The handbook purely provides a product description and is not to be understood as being of warranted quality under law. The publisher and authors can accept neither legal responsibility nor any liability for incorrect information and its consequences. No responsibility is assumed for the information contained in this handbook.

The software described in this handbook is supplied on the basis of the license agreement which you accept on installing the program.

No liability claims may be derived from this.

Copyright und Warenzeichen

T*SOL® is a registered trademark of Dr. Gerhard Valentin.

Windows Vista®, Windows XP®, and Windows 7® are registered trademarks of Microsoft Corp. All program names and designations used in this handbook may also be registered trademarks of their respective manufacturers and may not be used commercially or in any other way.Errors excepted.

Berlin, 31. Aug. 2012

Dr. Valentin EnergieSoftware GmbH
Stralauer Platz 34
10243 Berlin
Germany

Tel.: +49 (0)30 588 439 - 0
Fax: +49 (0)30 588 439 - 11

info@valentin.de
www.valentin.de

Valentin Software, Inc.
31915 Rancho California Rd, #200-285
Temecula, CA 92591
USA

Tel.: +001 951.530.3322
Fax: +001 858.777.5526

info@valentin-software.com
http://valentin-software.com/

Management: Dr. Gerhard Valentin
AG Berlin-Charlottenburg
HRB 84016

Content

1 Program Information

1.1 Why T*SOL?

T*SOL® is a program for designing and simulating solar thermal systems with hot water supply, space heating, swimming pool heating, process heat and large-scale systems.

Users include planners, installers, energy consultants and architects.

T*SOL basic is designed for the simulation of solar systems for detached and semi-detached homes and enables immediate presentation of the respective solar system, including revenue and profitability forecasts. Typical, simple systems are available, which cover approximately 80% of the applications for such facilities in Europe and USA.

T*SOL Pro also offers corporate systems, indoor pools, process heating and large-scale plants in addition to the standard systems. In addition, processing is made easier as a result of:

- Multiple variants within a single project, the project tree
- Object shading, design assistant, result charts
- Editable load profiles and components (collectors, boiler, storage tank)

T*SOL Expert is also suitable for simulating local solar heating networks.

- Using the variant comparison, the program allows investigation of the influence of individual system components on the performance of a solar thermal system.
- The simulation results can be analyzed in graph or table format.

With its comprehensive bases of calculation, T*SOL® is a professional tool for planning a solar thermal system.

1.2 New in T*SOL

a.o.: Roof layout with PhotoPlan

You find all new features on our web site:
-> http://www.valentin.de/en/sales-service/customer-service/release-notes..

1.3 System Features

Overview

- Simulation of solar thermal systems for DHW supply and space heating over any period of time up to one year
- Design (optimization of collector area and storage tank volume) to reach specific targets
- Influence of partial shading by the horizon
- Graphic and tabular entry of shade values
- Extensive component database
- Roof coverage with Photo Plan
- Domestic hot water consumption profiles included in calculations
- Both radiator and underfloor heating possible
- Balancing of energy, pollutant emissions and costs
- Calculation of standard evaluation parameters such as system efficiency, solar fraction etc.
- Detailed presentation of results in reports

- Economic efficiency calculation of a system following simulation over a one-year period
- The program user interface (so-called GUI), a context sensitive program online help (press F1) and the handbook are available in five languages: German, English, French, Spanish, Italian.

System Configuration

You can select from common system configurations.

Swimming pool module: Outdoor pools can be integrated within the solar cycle.

System components, e.g. collectors, boilers, storage tanks, and also consumption profiles are loaded from the databases.

Simulation and Results:

The calculation is based on the balance of energy flows and supplies yield prognoses with the help of meteorological data input hourly.

T*SOL® calculates the energy produced by the solar system for hot water production and heating as well as the corresponding solar fractions.

The results are saved and can be presented as detailed documentation or as a clearly-arranged presentation.

Economic Efficiency Calculation

After running a simulation for a period of one year, an economic efficiency calculation can be run.

Taking into account the system costs and subsidies, the economic efficiency parameters, e.g. capital value, annuities and cost of heating are calculated and presented in a report.

Project Reports, End Customer Output

In addition to the standard languages of German, English, French, Spanish and Italian, project reports are available in seven further languages: Portuguese, Polish, Slovakian, Slovenian, Czech, Hungarian and Romanian.

Supplied Databases

The program includes extensive databases for:

- collectors
- boilers (The various auxiliary heating systems are grouped by type.)
- storage tanks

Demo Version

The demo version includes climate locations from all major world regions.

- Berlin, Moskau, Prague, Rom, Würzburg
- Boston, San Francisco, Washington, Rio de Janeiro
- Beijing, Delhi
- Melbourne
- Cape Town, Kinshasa

2 Software Management

2.1 Hardware and Software Requirements

- **Internet connection**: Internet access is highly recommended. The program and databases
- are updated via the Internet.
- **Processor**: 1 GHz Pentium PC
- **RAM**: 512 MB
- **Free hard disk space**: 400 MB
- **Color monitor**: VGA, min. 1024x768, 16 bit color depth
- **Operating system**: Windows XP ServicePack 3, Windows Vista or Windows 7
- **Graphics:** OpenGL Version 1.1 (for Photo Plan), printer driver
- **Software:** .Net-Framework 3.5 SP1. (The .NET framework is installed automatically, if not present.)
- Mouse
- A printer with graphics capability
- In order to run T*SOL®, you must have full access (administrator rights) to the T*SOL® installation directory.
- T*SOL® adopts the formats for currency, numbers, time and date set in the country settings of Windows' control panel. These formats also appear on print-outs. It is important for the operation of the program that separators for thousands and decimals are different.

Recommended configuration:

- You should set your monitorto display *Small Fonts*via the Windows control panel.

2.2 Installation

To install the program, please click on the installation file tsol_basic.exe. You will be guided through the installation.

In order to install the program, you must be logged on with administrator rights.

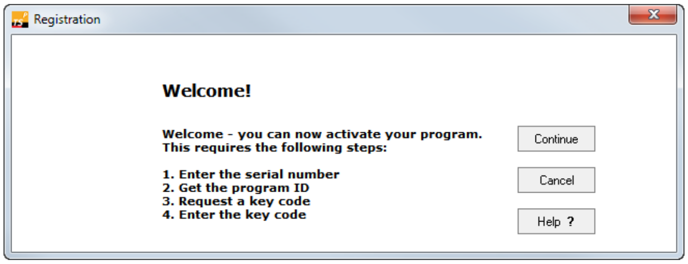
To run the program, you must have read and write rights to the T*SOL program directory. (e.g. C:\Program Files\Valentin EnergieSoftware\TSOL).

All installation paths have English descriptions.

The programe icon appears in the Windows Start Menu and on the desktop after installation.

The single-user version of T*SOL® can only be installed locally. However, because it is possible to save the database and project files under any path, and these can be set as standard paths in the program, parts of the program can be moved to different hard drives.

2.3 Registering the Program



Welcome!

**Welcome - you can now activate your program.
This requires the following steps:**

**1. Enter the serial number
2. Get the program ID
3. Request a key code
4. Enter the key code**

After installing and opening the program, you will be asked whether you wish to start the program as a demo version or register the full product. This prompt appears every time you start until the program has been activated.

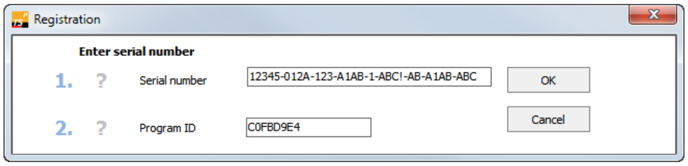
Activation of the program is carried out by entering an activation code. This code is provided during the activation process.

To activate the program, you must

- have a serial number,
- have already installed the program and
- click the button "*Licence Full Version*".

è How to activate the program:

1. Install the program.
2. Start the program.
3. Navigate to the menu *Help › Info › Registration*, and click on *Change Registration*
4. Click *Continue*
5. Enter the serial number.



Enter serial number

1. ? Serial number 12345-012A-123-A1AB-1-ABC!-AB-A1AB-ABC

2. ? Program ID C0FBD9E4

If you have purchased the program, you already have a serial number. It can either be found on your invoice or was sent to you by e-mail. The serial number has the following format: 12345-012A-123-ABCD-1-ABCD-AB-ABCD-ABC

Enter the serial number without spaces. The program will then allocate a program ID, consisting of the serial number and a code for your PC.

You don't have a serial number?

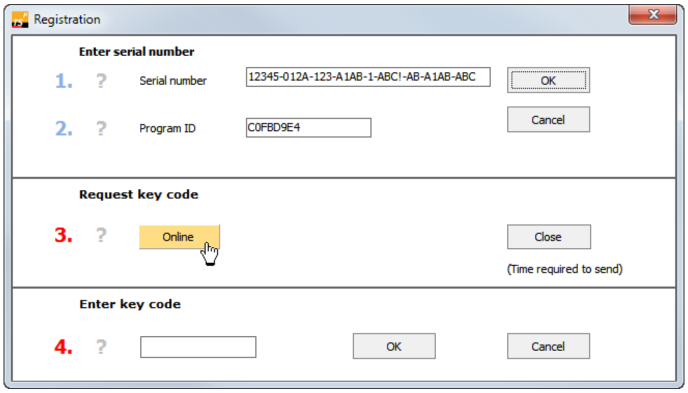
This could the case if, for example, you have installed the program from a demo CD or downloaded it from the internet. You will need to purchase a full version of the program to obtain a serial number.

Send us the order form, which can be printed within the program under *Info › Registration* or purchase the program direct from our website.

You've purchased the program and can't find your serial number?

No problem. Just send us a copy of your invoice for the program with your contact details and we will resend you your serial number.

6. The program ID will be created automatically.
7. Request activation code online or by telephone:



Serial number 12345-012A-123-A1AB-1-ABC!-AB-A1AB-ABC

Program ID C0FBD9E4

You must now send us the serial number and program ID so we can provide you with an activation code. The activation code can be obtained in a range of ways:

Request activation code online

This method requires an internet connection.

Click the Online button. A form is displayed in your web browser. Enter the required data for activation. The fields marked * must be filled out.

Complete the form and send it straight off, our e-mail address is already filled in. After sending, your activation code will be sent to the e-mail address given in around 20 minutes.

Request activation code by telephone

You can request the activation code by telephone. In this case, you will need to provide us with your customer number, the serial number and the program ID.

8. Enter activation code

The program ID is automatically provided as soon as you enter the serial number. You will need to let us know the program ID when registering, so that we can send you your key code.

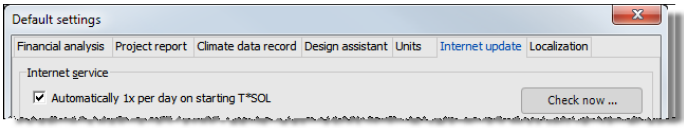
You now need to enter the activation code in the relevant field in the registration window manually or by copying and confirm with *OK*.

Registration and activation are now complete. You will receive a message that registration has been completed and the program is now fully functional.

2.4 Software Updates via Internet

Menu *Options › Site Data › Check for Updates*

On the *Internet updates* page, you can set the times at which T*SOL should check whether a new update is available on the server. If you are using a proxy server, you can enter the required settings here.



☑ Automatically 1x per day on starting T*SOL

Image: window: Internet update preferences

Prerequisites:

1. Formal prerequisite: Software maintenance agreement, refer to:
   in the EU and others: http://www.valentin.de/en/sales-service/customer-service/software-maintenance-agreement
   in the U.S.: http://valentin-software.com › Solar Thermal
2. Technical prerequisite: Active internet connection

è How to update via the internet:

3. If there is an active internet connection, the program checks whether a new update is available on the server according to the settings on the page Internet update:
    - daily at first program start
    - or on clicking *Check now ...* .

   If you are using a proxy server, you can enter the required settings here.
4. If a new release or new databases are available, the program will close and the installation program will be downloaded to the Desktop and run from there.

Proxy settings

T*SOL is using your computer's system proxy settings to connect to the network.

2.5 Maintenance agreement

To make sure that you always work with the latest version of our programs and have the latest component data available, we recommend that you take advantage of our Software Maintenance Agreement (http://www.valentin.de/en/sales-service/customer-service/software-maintenance-agreement (This link will open in your browser.))

The software maintenance covers:

- Download of software updates, i.e. new program releases,
- Download of new component databases e.g. collector or tank database.
- Responding to general questions regarding delivery, serial numbers and activation of the software program/s and updates, as well as the ability to access component data.

2.6 Licensing Terms and Provisions

How many times can the program be installed?

The number of permissible installations corresponds to the number of licenses you have purchased. If, for example, you have purchased a single-user license, you may install the program on one workstation.

In addition, you can activate the program on a second computer, e.g. a laptop. However, this is only possible on the condition that the two installations are not used simultaneously.

Licensing Provisions

Menu *Help › Info ... › Program Info › View License*

The license is displayed as .pdf file.

3 Using the Program

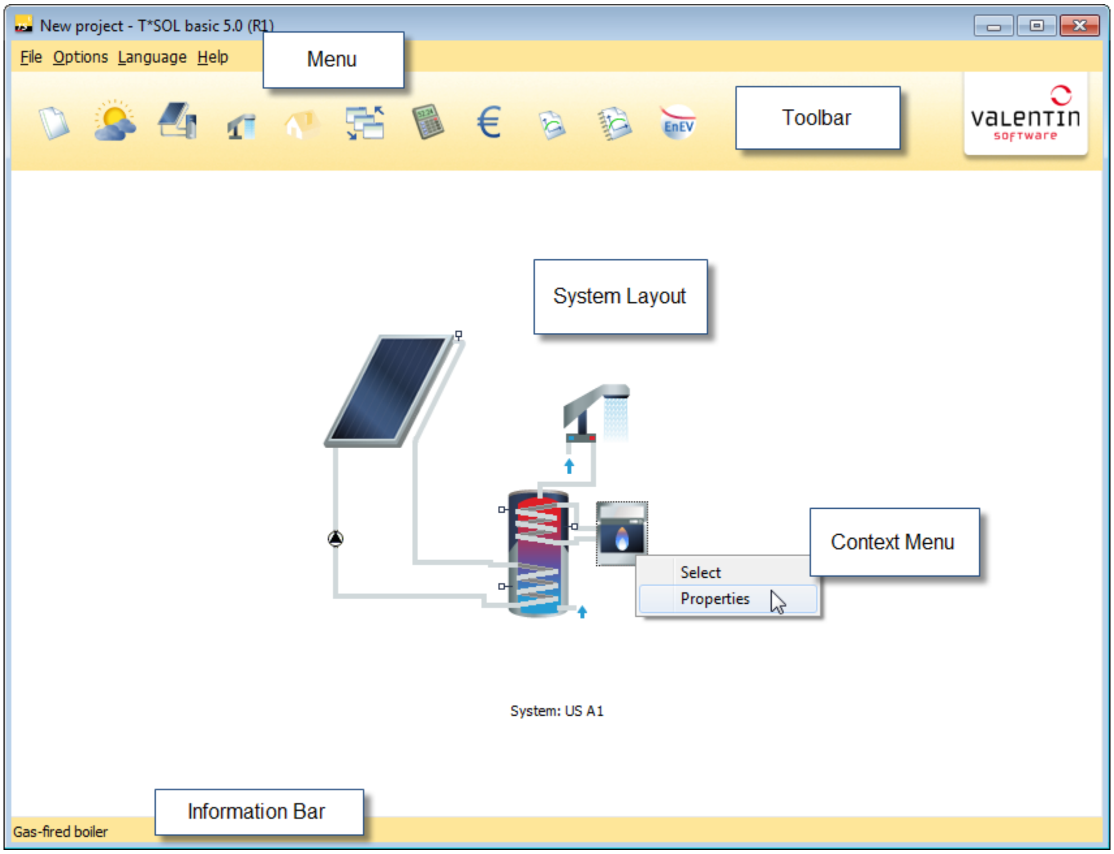


Image: T*SOL® user interface

The T*SOL® program is operated via menus and symbols.

The program window contains

- a menu bar and
- a toolbar containing icons providing easy access to the menus. If you hold the cursor over the symbol, a descriptive text against a yellow background appears.
- Other windows, dependening on which menu is open.

3.1 Launching the Program

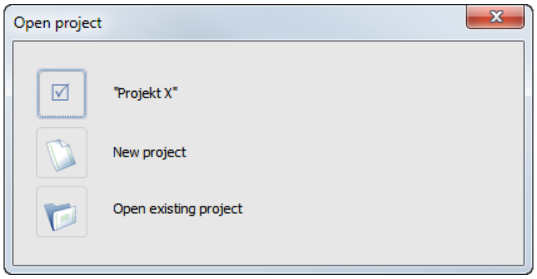


Image: Select project dialog

When you launch T*SOL®, you are asked first, which project you would like to start with.

The corresponding system or a default system is then displayed as a system layout in discrete windows.

3.2 Menu and Tool bar

General functions are accessed via the menu, project-related functions are accessed via the toolbar symbols.

The symbol functions can be displayed by holding the cursor over the symbol and a descriptive text against a yellow background promptly appears.

Create new project

Open project

Save project

System selection

Simulation

MeteoSyn climate data

Define hot water consumption

Define heating requirements

System definition

Financial Analysis

3.3 System layout

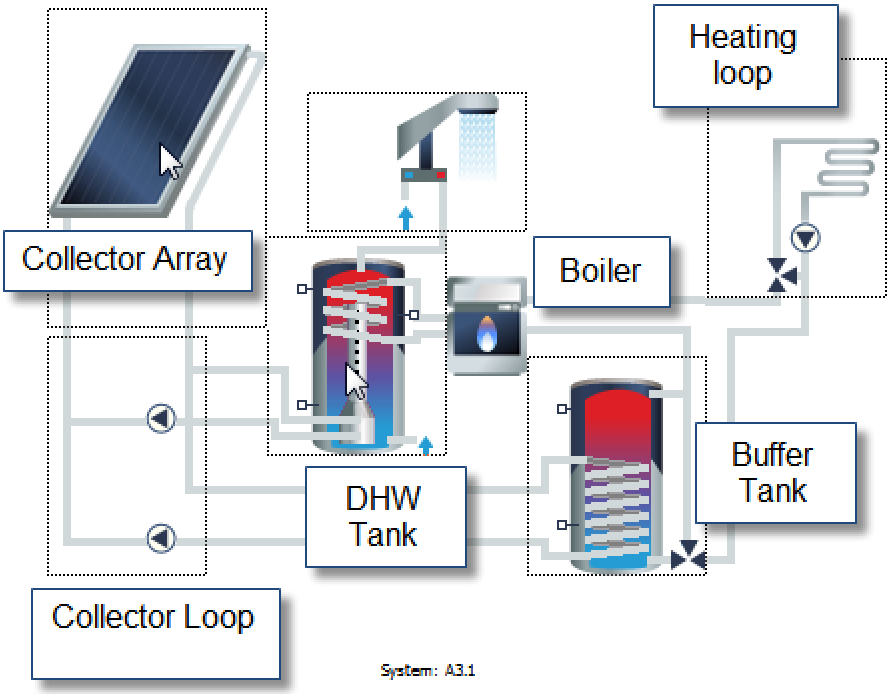


Image: System layout: component selection boundaries

The project is represented by a system layout.

When you move the cursor over the system layout, the information bar at the bottom of the window displays the component name. Click on a component and a dotted frame will appear around it.

Selecting *Properties* from the context menu (=right mouse key) or double clicking on the component takes you to the system definition, either directly to the set paramaters dialog for the component or the definition of the system, depending on the position of the cursor.

Clicking *Select* in the context menu opens a list box for this component.

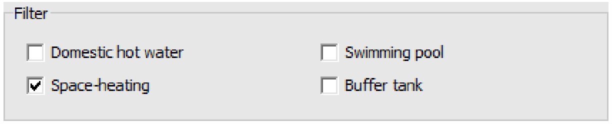
Exit the parameter settings by clicking *OK*. Changes to the component types or, for example, the position of the temperature sensor are updated in the system layout.

3.4 Selection Dialog for Systems and Components

The database selections offer some features facilitating the selection:

- Filter

  Filter the table by using the checkboxes on top of the table.

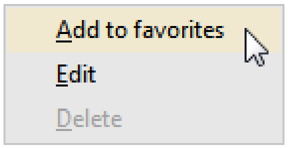
  Filter

  ☐ Domestic hot water ☐ Swimming pool

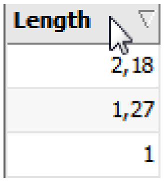
  ☑ Space-heating ☐ Buffer tank

- List of your own favorites:

  right-click the component, context menu *Add to favorites*

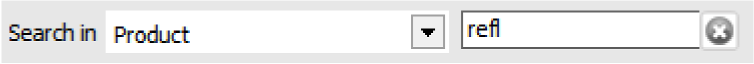
  

- Sort table: by clicking into the table header



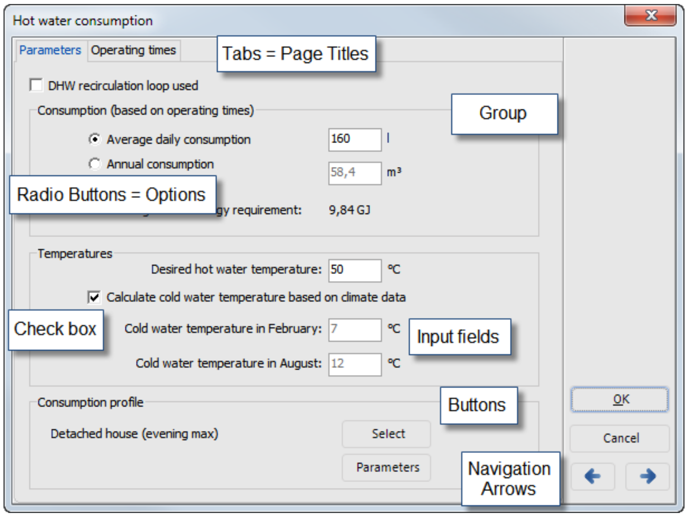
Length
2,18
1,27
1

- Search function: search by character string in the selected column



Search in Product refl

3.5 Open Dialogs, Enter Data



Hot water consumption

Parameters | Operating times

☐ DHW recirculation loop used

Consumption (based on operating times)

● Average daily consumption 160 l

○ Annual consumption 58,4 m³

gy requirement: 9,84 GJ

Temperatures

Desired hot water temperature: 50 °C

☑ Calculate cold water temperature based on climate data

Cold water temperature in February: 7 °C

Cold water temperature in August: 12 °C

Consumption profile

Detached house (evening max)

Image: Dialog window:entry and control elements

The dialog window for entering simulation parameters is activated either via the respective menu, the keyboard combination *CTRL+underlined letter* or by clicking the button in the toolbar. The symbols of dialogs which can be accessed directly via buttons are reproduced in this handbook.

Dialog windows contain edit fields, checkboxes, radio buttons and list boxes.

Values in edit fields which can be changed are shown in black type. Gray type means that only the current value can be shown. However, depending on other entries (in checkboxes or via radio buttons), it may become editable again.

! Data from the components database cannot be altered if they represent "real" components from manufacturing companies. Only data on "virtual" T*SOL database components can be modified!

ý Click a *checkbox* to activate the property it represents. If the box is empty, the property is not activated.

¤ *Radio buttons* always relate to at least two options. Click to select an option.

Switch between dialog fields with the mouse or by pressing the *TAB* button on your keyboard. Pressing *TAB* moves you to the next field, *SHIFT+TAB* to the previous one.

Clicking a *button* opens a new dialog.

Some options can be enlarged with the magnifier.

Browse the menus by using the arrows.

Close dialogs by clicking the button *OK*, *Cancel* or *Close*, via the small WINDOWS button x at the top-right of the window or with the key combination *ALT+F4*.

Click on the *OK* button to save entered data and close the dialog. The program then checks the value entered - whether they are in a valid format or physically possible. If you leave a dialog by clicking Cancel, all changes are discarded.

The program also adopts the following typical WINDOWS™ conventions:

- Grayed-out menus and symbols cannot be executed.
- The format of figures, dates and currencies is governed by the formats set in WINDOWS control panel. If you change the settings in *Control Panel › Time, Language and Region*, you must restart T*SOL for these changes to take effect.
- All graphics can be sent to a printer. Printer settings can be changed within the program.
- The tabular presentation of graphs, the appliance load profile and tabular presentation of shading can be copied via the clipboard to and from spreadsheet programs (e.g. Excel).

3.6 Help

Context-sensitive online help on all T*SOL (R) dialogs and menus is available by pressing function key *F1* or via the help menu. In addition to the table of contents, you can also search in the index or by keyword. Click on an underlined link to move to the corresponding text. You can browse between the separate help texts.

3.7 Typical Operational Sequence = QUICK START

Here a simplified operational sequence for the simulation of a thermal solar system with T*SOL:

1. Create new project
2. Set site data
3. Select sytem
4. Define component parameters
5. Run simulation
6. Print project report

4 File Menu

Here, you will find all the options required to handle your projects.

In T*SOL, systems to be calculated are managed as projects.

After starting T*SOL, you can choose to create a new project, open the last project edited or select another project (if it already exists).

Create a New Project

Menu *File › New*

Using the menu *File › New*, you can create a new project.

If a project is open and you have not yet saved your changes, you will be prompted to save before the new project is created.

Open

Menu *File* › Open

In the *File › Open* menu, you can open an existing project.

A list of projects saved in the Projects folder appears.

If a project is open and you have not yet saved your changes, you will be prompted to save all modified projects before another project is opened.

Open last project

Menu *File › Open Last Project*

In the *FIle › i (1,2,3, ...)* menu, you can conveniently call up the most recently edited projects.

Save

Menu *File › Save*

In the *File › Save* menu, you can save the currently open project.

The projectdata.prj project file as well as all project variants are saved in the folder with the project name you have entered under *File › Project Data*. The project name is displayed in the headline of the T*SOL window.

If you have not entered a project name, the name 'project+consecutive number' is automatically created for the folder and project name.

Exit

Menu *File › Exit*

This command closes the program.

If the current project has been changed, the changes are saved automatically.

5 Site Data

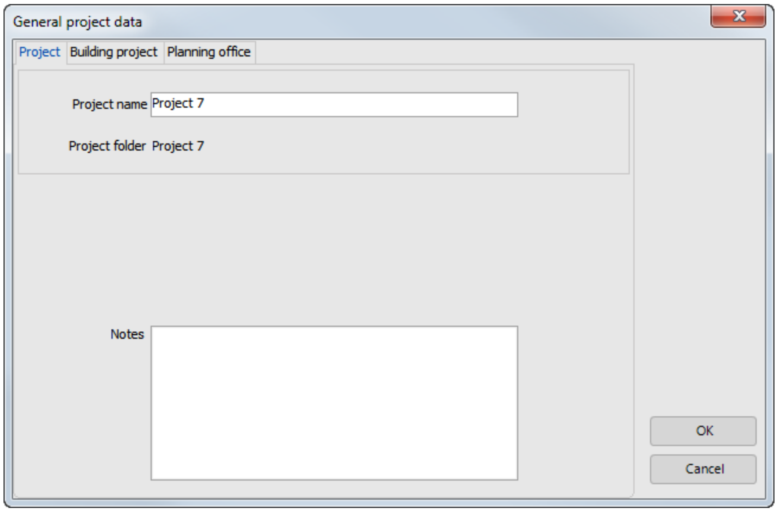
Symbols *Site Data*

In order to design a useful solar system and be able to carry out financial analyses, the climatic conditions in which it operates and its site data must be known.

The corresponding dialogs are opened via these buttons:

5.1 Project Data

Symbol *Project data*



Project name: Project 7

Project folder: Project 7

Image: Input dialog for general project data

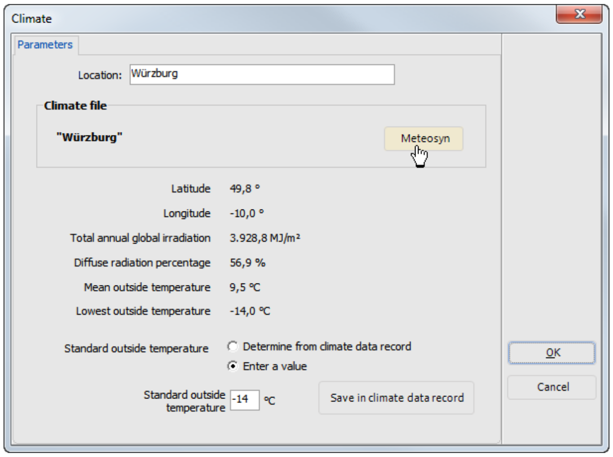
The *Project Data* dialog opens at the first page, *Project*.

è Proceed as follows:

1. Enter at least the project name.
   The other pages *Project*, *Building Project* and *Planning Office* are optional. You can also load an image of the building.
   If this information is completed, it appears on the cover of the project report.
2. Exit the dialog by clicking *OK*.

5.2 Climate

Symbol *Climate*



Location: Würzburg

Climate file

"Würzburg"

Latitude 49,8 °

Longitude -10,0 °

Total annual global irradiation 3.928,8 MJ/m²

Diffuse radiation percentage 56,9 %

Mean outside temperature 9,5 °C

Lowest outside temperature -14,0 °C

Standard outside temperature ○ Determine from climate data record ● Enter a value

Standard outside temperature -14 °C

Image: Dialog for climate defaults

è How to proceed:

1. Navigate to the menu *Site Data › Climate* and first enter the intended location of your solar system
2. Click on the *MeteoSyn* button. The climate data administration *MeteoSyn* is opened.

Standard outside temperature

The standard outside temperature is the design temperature for the space heating energy requirement and must be calculated for every location from local standard values.

If the climate data file does not contain a standard outside temperature, the lowest outside temperature is calculated and used as the design temperature.

è How to proceed:

1. Select *Enter Temperature* in the *Standard Outside Temperature* box.
2. You can then enter the standard outside temperature.
3. If you are using a *.wbv climate data record, you can then save the entered standard outside temperature in the climate file by clicking on the *Save in Climate File* button.

Overview of standard outside temperature of 15 illustrative reference locations (following the 15 climate zones in DIN 4108-6).

Climate zone	City	Standard outside temp.	Strong wind
1	Norderney	-10	W
2	Hamburg	-12	W
3	Rostock	-10	W
4	Potsdam	-14	
5	Braunschweig	-14	W
6	Erfurt	-14	
7	Essen	-10	
8	Kassel	-12	
9	Chemnitz	-14	

10	Hof/Saale	-18	W
11	Würzburg	-12	
12	Mannheim	-12	
13	Freiburg i.Br.	-12	
14	Munich	-16	
15	Garmisch Partenkirchen	-18	

5.2.1 MeteoSyn

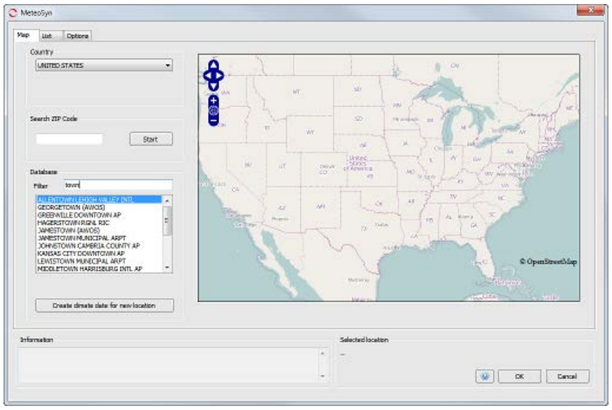
Symbol *Climate › Meteosyn*

The MeteoSyn module provides location-dependent climate data used in the simulation programs from Dr. Valentin EnergieSoftware GmbH.

Climate data for the U.S. are provided by TMY3.

5.2.1.1 MeteoSyn, Select Location Climate Data by Map

Symbol *Climate › MeteoSyn*



Country: UNITED STATES

Filter: town

ALLENTOWN LEHIGH VALLEY INTL
GEORGETOWN (AWOS)
GREENVILLE DOWNTOWN AP
HAGERSTOWN RGNL RIC
JAMESTOWN (AWOS)
JAMESTOWN MUNICIPAL ARPT
JOHNSTOWN CAMBRIA COUNTY AP
KANSAS CITY DOWNTOWN AP
LEWISTOWN MUNICIPAL ARPT
MIDDLETOWN HARRISBURG INTL AP

Image 4: Menu *MeteoSyn › Map*
For loading climate data records

è How to select climate data:

1. Select a country. The map shows the selected country if you have a connection to the internet. Otherwise see below.

   The country list contains those countries for which climate files are available. The location list contains the locations in these countries for which climate files are available.

   If federal states have been entered in the climate data, you will see a dropdown box for them.

è There are various ways of shortening the location list:

2. Select a federal state.
3. Enter part of the location name in the filter below the location list. Example: filter = "town"
   -> The list shows locations including the string "town" somewhere in their name.
4. Enter a ZIP code. Click *Start*.
   The location found is marked in red ▼, available climate data locations in the geographical vicinity are marked green ▼. The location list is reduced to these nearby locations and the town, if available. If the ZIP code search returns no results, this is displayed in the information field.

è Working with the selected location

5. Click on a green mark ⯆ to view the location name and further information. Click on the location name in the pop-up to select this location. It is then listed under *Selected Location*.
6. Or click on a location in the location list. This location is then listed under *Selected Location*, moved to the center of the map, and highlighted on the map with a mark ⯆.
7. Click it to view further information such as average temperature and global radiation.

 Right-click on a location in the list to open the corresponding folder in the file explorer.

8. Click on *OK* to continue working with this location. The selected climate record is imported into the program.
9. Click the *Cancel* button to cancel your changes.

The interactive map requires a connection to the internet.

If you do not have an internet connection, MeteoSyn opens with the *List* page

On the *Map* page, the map is grayed out and a button to test the internet connection is shown.

Reestablish the internet connection, click on *Test Internet Connection* and update the website to regain access to the map.

5.2.1.2 MeteoSyn, Location Climate Data by List

Symbol *Climate › MeteoSyn › Location Data*

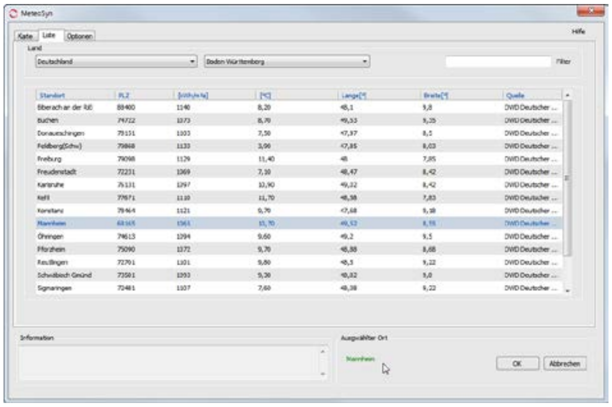


Image 5: Menu *MeteoSyn › List*

Select a country and a state or enter a filter for the location. Click on the location to select it.

5.2.1.3 MeteoSyn, File Import and Database Update

Symbol *Climate › MeteoSyn › Options*

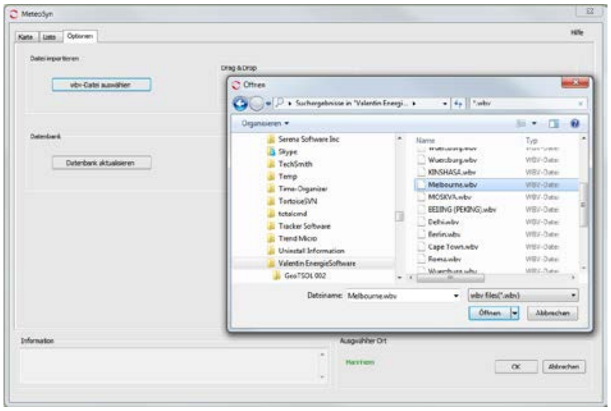


Image 6: Menu *MeteoSyn › Options*

è How to add a climate data file to a location:

1. Click on the *select .wbv file* button and navigate to the desired file.
2. Select one or several files and confirm by clicking *Open*. These files are imported to the database and copied for all users to a specific folder , e.g. C:\Users\All Users\Valentin EnergieSoftware\Meteo2_UserFiles\USA\.
3. Exit the dialog by clicking *OK*.

*) .wbv files is a native Valentin Software climate data file format.

Update MeteoSyn Database

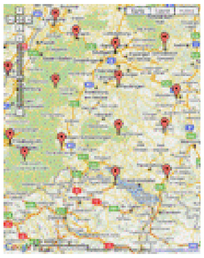
If the content of that folder has been changed outside of MeteoSyn (e.g. in the file explorer) while you have been working with MeteoSyn, you can rebuild the MeteoSyn database by clicking the *Update Database* button.

The database is automatically rebuilt following a reinstallation of the MeteoSyn module. Depending on the number of climate data records and your computer's processing power, this may take some minutes.

5.2.2 Acquire Climate Data

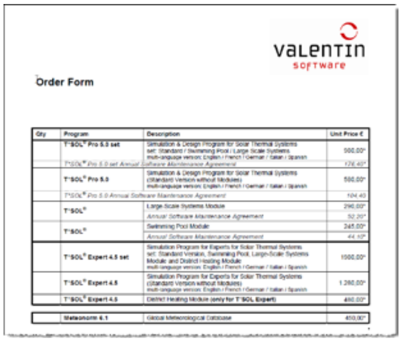
On our website at http://www.valentin.de/index_de_page=weather, you can

view the list of all climate data contained in the program,



generate further climate data for Europe, or

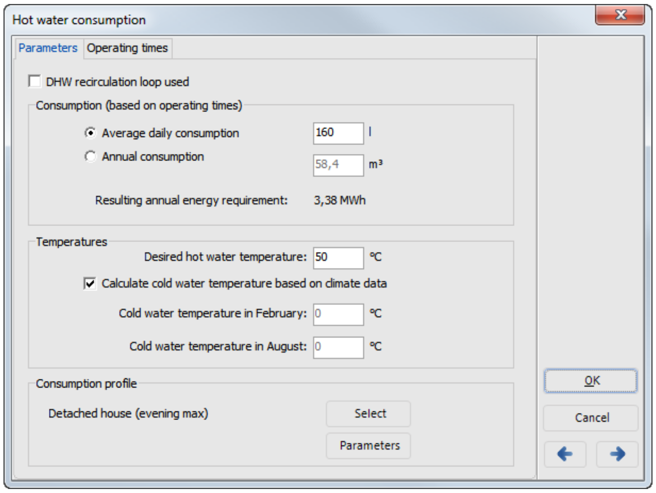
order global climate data.



5.3 DHW Consumption

Symbol *Hot water consumption*

The DHW requirement and its distribution over the year are key values for simulating a solar system.



Hot water consumption

☐ DHW recirculation loop used

Consumption (based on operating times)

● Average daily consumption 160 l

○ Annual consumption 58,4 m³

Resulting annual energy requirement: 3,38 MWh

Temperatures

Desired hot water temperature: 50 °C

☑ Calculate cold water temperature based on climate data

Cold water temperature in February: 0 °C

Cold water temperature in August: 0 °C

Consumption profile

Detached house (evening max)

Image: Dialog for defining DHW requirement

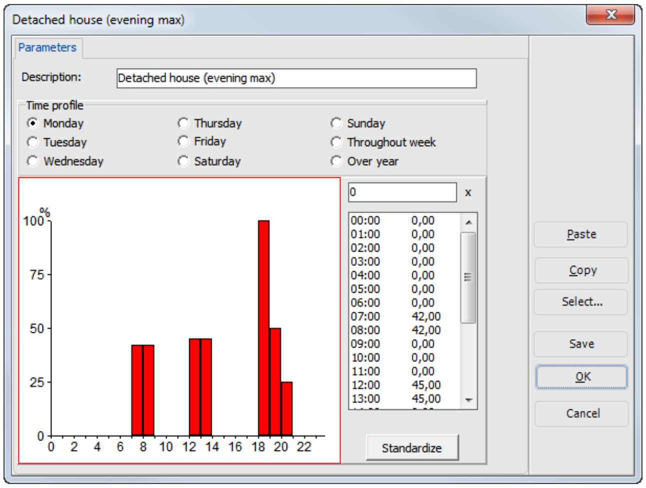
On the *Parameters*page, the average daily consumptionor the annual consumption are recorded.
Calculate a daily consumption of 35–45 l per resident.
The T*SOL default is 4 persons at 40 l = 160 l.

At the same time, the total consumption for the operating time and the resulting energy requirement are displayed. The latter depends on the temperatures you enter in the *Temperatures* section. Enter the cold water temperaturesin February and August and the desired hot water temperature.

Click on the *Select* button to choose a suitable load profile with the most favorable consumption profile for you.

5.3.1 Consumption Profile

Symbol *Hot water consumption › Parameters › Load Profile (Consumption Profile) › Select*



Detached house (evening max)

Description: Detached house (evening max)

Time profile

● Monday
○ Tuesday
○ Wednesday
○ Thursday
○ Friday
○ Saturday
○ Sunday
○ Throughout week
○ Over year

0

00:00	0,00
01:00	0,00
02:00	0,00
03:00	0,00
04:00	0,00
05:00	0,00
06:00	0,00
07:00	42,00
08:00	42,00
09:00	0,00
10:00	0,00
11:00	0,00
12:00	45,00
13:00	45,00

Image: Dialog for defining consumption profiles

If none of the included consumption profiles meet your requirements, you can define new ones. On the *Site Data › DHW Consumption* page, click the *Parameters* to define a new consumption profile. This takes you to a graphic and tabular display. Change your profile file as required.

The weighted consumption profile is displayed as a graph and a table for every day of the week, the entire week, and the year. You can modify it via the table:

è How to define hourly, daily, and monthly consumption.

1. First, enter a new name and click the *Save* button. This creates a new profile file and prevents the originally selected one from being overwritten.
2. Click on the tabular value you wish to change.
3. The value is applied in the textbox above the table.
4. Enter the desired value in the textbox. Either enter percentage values of the respective maximum value (always 100%) or
5. absolute values and then click on *Standardize* to convert the values into percentages.
6. Click on another value in the table. The new value is now applied and the graph updates accordingly.
7. *Save* or exit the dialog by clicking *OK*.

The *Copy* and *Paste* buttons can be used both to transfer daily profiles from one weekday to another and to input the values into a word processor or spreadsheet, edit them there, and then write them back to T*SOL®. You can also apply values from another program if they are available there in the correct format (one value per line; 24 values for daily profiles, 7 for weekly profiles, and 12 for annual profiles).

Save the consumption profile so that it can also be used in other projects.

5.3.2 Circulation

Symbol *Hot water consumption › Circulation*

If a tick is placed in the *DHW recirculation loop used* checkbox, the *Circulation* page appears. Enter the single length of the piping system. Entry of the temperature range is required to calculate the return temperature in the tank when the DHW target temperature is reached. Also enter the specific losses.

Example: circulation loss = 2 * [single length of piping system] m * [spec. losses] W/m * ([DHW target temperature] °C- 20 °C)*[operating hours] h. Circulation losses may change following the simulation, as they are then calculated with the temperature at the tank outlet.

The circulation operating times are set by clicking the fields in the clock (green area = in operation). They can be set the same for all days of the week or defined separately for each day. The annual circulation losses are displayed.

5.3.3 Operating Times

Symbol *Hot water consumption › Operating Times*

On the *Operating Times*page, you can define the days of the year on which domestic hot water is consumed. Entire months can be switched on or off by clicking on the monthly bars, separate days by clicking the magnifier (green area = in operation).

At the same time, the total consumption for the operating time and the resulting energy requirement are displayed. The latter depends on the temperatures you enter in the box below.

5.3.4 Deactivate Hot Water Consumption

Symbol *Hot water consumption*

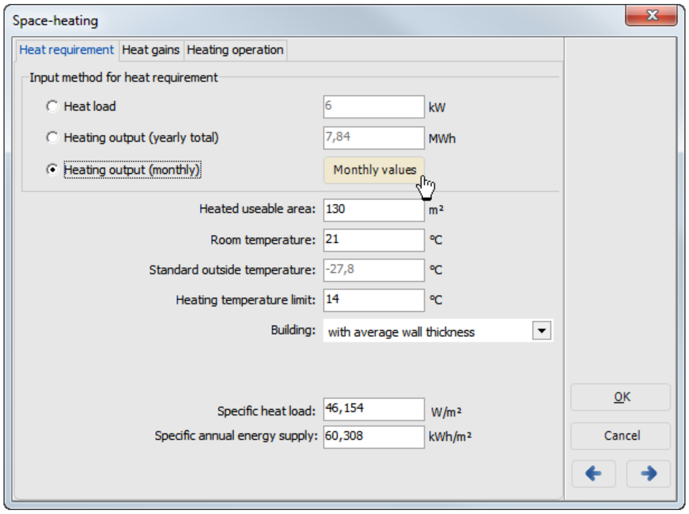
If you want to *deactivate hot water consumption* , adopt the following settings:

- Dialog *Hot Water Consumption › Parameter*:
  switch off circulation
  desired temperature = 20 °C
  cold water temperature = 20 °C
- Dialog *Hot Water Consumption › Control*:
  maximum temperature limit for collector loop = 20 °C
  set target tank tamperature *relative to DHW target temperature*

Entering a consumption of 0 liters is not permitted and would in any case not prevent loading by the collector array and the boiler.

5.4 Space Heating Requirement

Space Heating

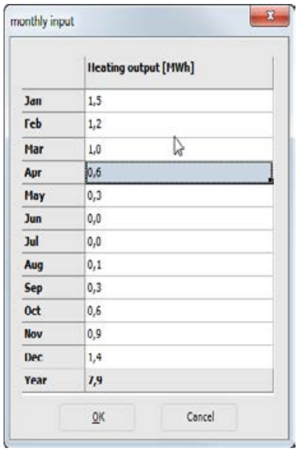


Input method for heat requirement
○ Heat load: 6 kW
○ Heating output (yearly total): 7,84 MWh
● Heating output (monthly)

Heated useable area: 130 m²
Room temperature: 21 °C
Standard outside temperature: -27,8 °C
Heating temperature limit: 14 °C
Building: with average wall thickness

Specific heat load: 46,154 W/m²
Specific annual energy supply: 60,308 kWh/m²

Image: Dialog *Space Heating* Requirement



	Heating output [MWh]
Jan	1,5
Feb	1,2
Mar	1,0
Apr	0,6
May	0,3
Jun	0,0
Jul	0,0
Aug	0,1
Sep	0,3
Oct	0,6
Nov	0,9
Dec	1,4
Year	7,9

Image: Dialog *Space Heating Requirement › Heating Output* - Monthly Values

The current space heating requirement is calculated from the design data, the respective outside temperature, and irradiation.

Heat requirement

Space Heating › Heat Requirement

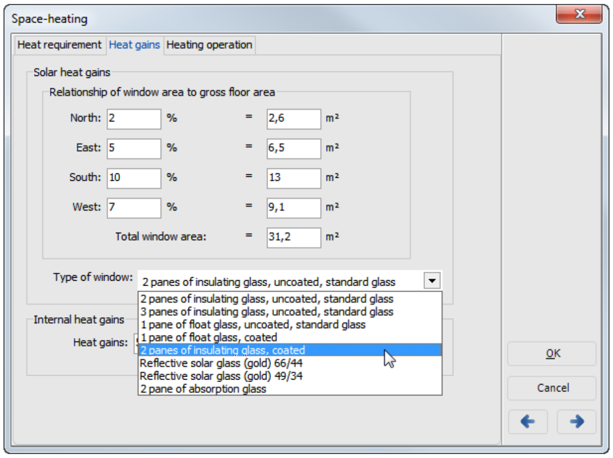
On the *Heat Requirement* page, enter the heat requirement either as heat load or as annual or monthly heating output.

Define the heated useable area as well as the room and standard outside temperature and the heating temperature limit. Enter the type of building.

The total resulting values of specific heat load and specific annual space heating output are displayed below.

Heat gains

Space Heating › Heat Gains



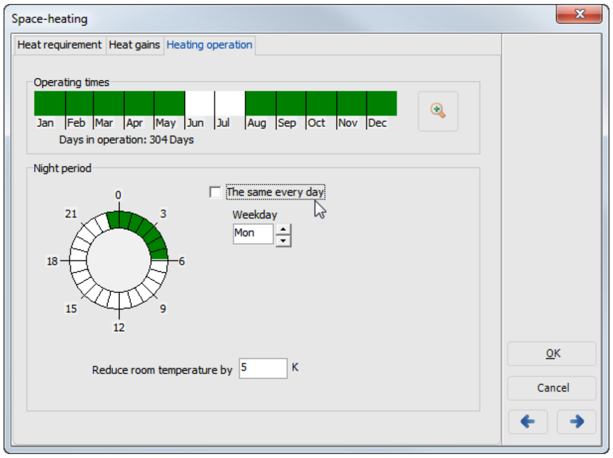
North: 2 % = 2,6 m²
East: 5 % = 6,5 m²
South: 10 % = 13 m²
West: 7 % = 9,1 m²
Total window area: = 31,2 m²
Type of window: 2 panes of insulating glass, uncoated, standard glass

Image: Dialog *Space Heating › Heat Gains*

On the *Heat Gains* page, enter the window area, the window type, and the internal heat gains, e.g. generated from electrical equipment in relation to the gross floor area.

Heating operation

Space Heating › Heating Operation



Days in operation: 304 Days
☐ The same every day
Weekday: Mon
Reduce room temperature by 5 K

Image: Dialog *Space Heating › Heating Operation*

On the *Heating Operation* page, specify the operating times at which the heating is to be used. (green field = in operation)

Click on full months in the month bar to activate or deactivate them.

Click on the magnifier to activate or deactivate individual days.

Define the night period by using the clock (green field = night period). Remove the check þ for *all days equally* to specify individual night periods for each day of the week.

Enter a room temperature reduction. This relates to the internal temperature you entered on the *Space Heating Requirement* page.

5.5 Swimming Pool

System Definition › Swimming pool

This chapter describes the components which only occur in swimming pool systems or otherwise differ from those in standard systems, for example, the collector loop connection for a swimming pool is no different to the usual connection, even if it appears in a separate tab.

For swimming pools, you define the loading sequence of the individual connections in the Collector Loop Connection dialog.

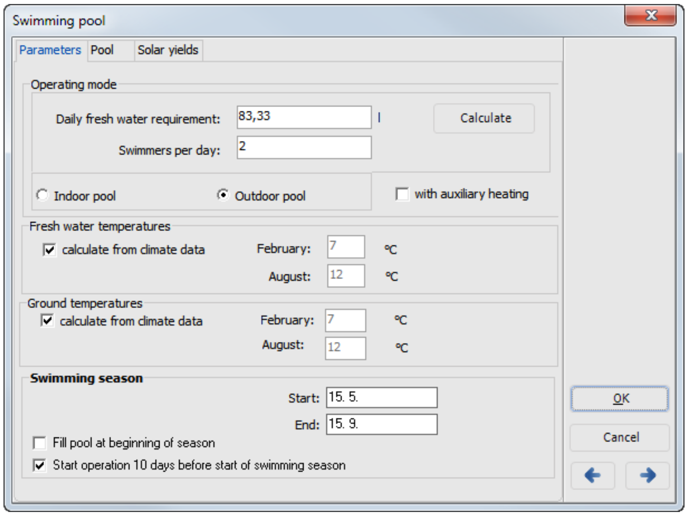
è See also:

6.2 Swimming Pool Systems

7.2.3 Swimming Pool in Collector Loop

5.5.1 Swimming Pool Parameter

System Definition › Swimming pool › Parameters



Operating mode

Daily fresh water requirement: 83,33 l

Swimmers per day: 2

○ Indoor pool ● Outdoor pool ☐ with auxiliary heating

Fresh water temperatures

☑ calculate from climate data February: 7 °C August: 12 °C

Ground temperatures

☑ calculate from climate data February: 7 °C August: 12 °C

Swimming season

Start: 15. 5.

End: 15. 9.

☐ Fill pool at beginning of season

☑ Start operation 10 days before start of swimming season

Image: Input dialog for swimming pool parameters

On the *Parameters* page, you can define the *daily fresh water requirement* and the number of *swimmers per day* under *Operating Mode*.

If you click on *Calculate*, the fresh water requirements is calculated in accordance with VDI guidelines, dependent on the number of persons and the size of the pool.

! T*SOL basic calculates outdoor pools only.

The *auxiliary heating* ensures that the target temperature of the bathing water is always attained.

Define for the *fresh water temperatures* and the *ground temperatures*, whether they shall be calculated from the climate data of your location or whether you define them manually.

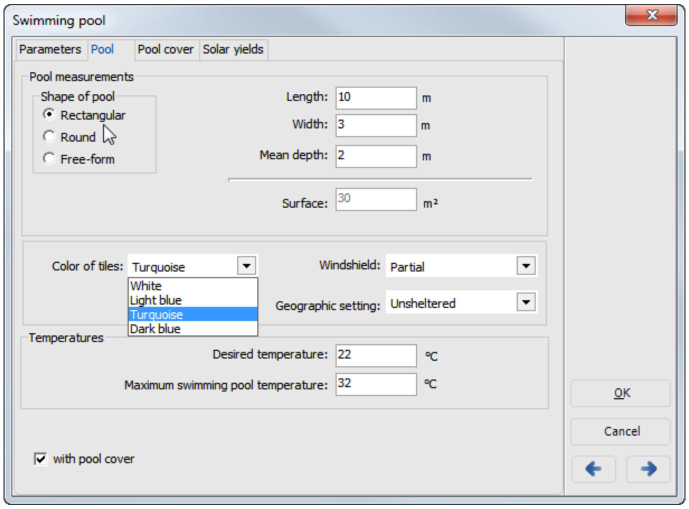
The *swimming season* can be defined for any period of time.

For pools which are only used seasonally, the start of operation can be set 10 days before the swimming season starts, to give the solar system a preheating period.

It is assumed that pools operated all year round were preheated to the target temperature from the beginning.

5.5.2 Swimming Pool: the Pool

System Definition › Swimming pool › Pool



Pool measurements

Shape of pool

● Rectangular

○ Round

○ Free-form

Length: 10 m

Width: 3 m

Mean depth: 2 m

Surface: 30 m²

Color of tiles: Turquoise (White, Light blue, Turquoise, Dark blue)

Windshield: Partial

Geographic setting: Unsheltered

Temperatures

Desired temperature: 22 °C

Maximum swimming pool temperature: 32 °C

☑ with pool cover

Image: Input dialog for swimming pool, *Pool* page; example: outdoor pool

The primary deciding factor for losses and gains is the pool surface and, to a lesser extent, the pool shell insulation to the soil. The volume is decisive for calculating temperature changes.

The pool measurements are entered directly for round and free-form pools and via length and width for rectangular pools. The mean depth of the water is determined from this information. In free-form pools, the longest length of the pool is used for approximate determination of the pool geometry.

The maximum swimming pool temperature defines the temperature up to which the pool can be heated by solar power, and must always be higher than the desired temperature. A high maximum temperature allows longer operating periods of the collector loop, by definition increasing the swimming pool heating requirements and the solar fraction. The control of the auxiliary heating ensures that the pool is regulated with a hysteresis of 0.5 Kelvin.

Outdoor pools

The other fields are only relevant and can therefore only be completed for outdoor pools.

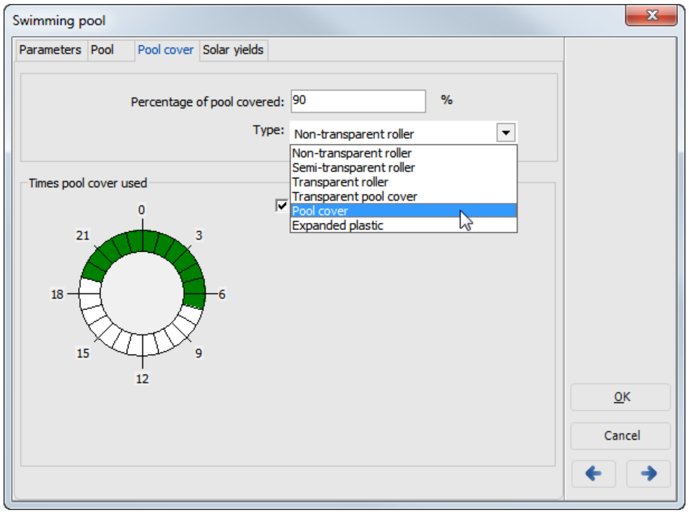
The color of tiles defines the absorption of solar irradiation on the pool wall and therefore how much of the irradiated energy onto the pool surface can be used to heat the pool water.

The prevailing wind speed is decisive for the convection and evaporation losses and therefore for total losses. Wind speeds are supplied with the climate file for the location. Define the geographical location of the swimming pool in its geographical environment, e.g. in a wooded area, a residential estate, or in the open. Enter whether windshields are available at the pool which can reduce convection and evaporation losses.

5.5.3 Swimming Pool: Cover

System Definition › Swimming pool › Pool Cover

If you tick the *with Pool Cover* checkbox on the *Pool* page, the *Pool Cover* page appears.



Percentage of pool covered: 90 %

Type: Non-transparent roller

Image: Input dialog for swimming pool, Pool Cover page; example: outdoor pool

A swimming pool cover lowers convection and evaporation losses, but at the same time reduces the use of radiation gains to the pool surface. Various coverings are available which variously influence these effects.

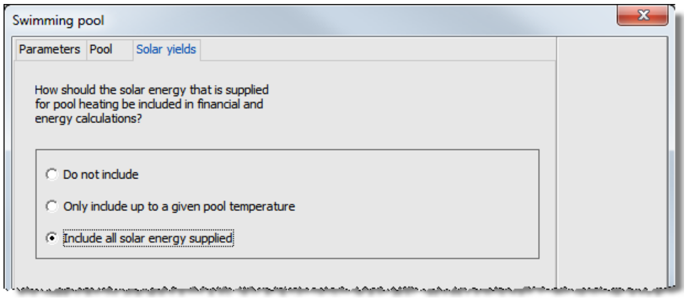
For structural reasons, many coverings only partially cover the swimming pool. A *Percentage of Pool Covered* of 100% means that the pool is completely covered without any gaps or similar.

Define the *Times Pool Cover Used* by clicking the clock (green field = covered). These times can be set the same for all days of the week or defined separately for each day.

5.5.4 Swimming Pool: Solar Yields

System Definition › Swimming pool › Solar Yields or system schematic

On the *Solar Yields* page, you can define whether and to what extent the energy supplied to the swimming pool from the collector arrayis taken into account in the energy and economic calculations. If you only want to consider the supplied energy up to the swimming pool temperature, a further input field appears in which you can enter the swimming pool temperature.



How should the solar energy that is supplied for pool heating be included in financial and energy calculations?

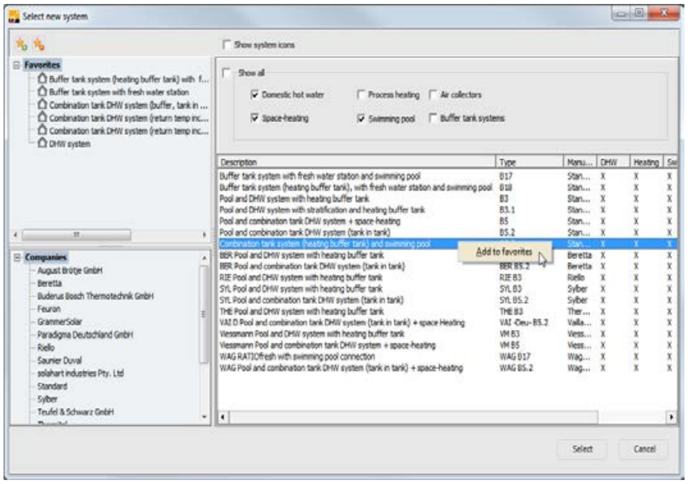
○ Do not include

○ Only include up to a given pool temperature

● Include all solar energy supplied

Image: Input dialog for swimming pool components, *Solar Yields* page

6 System Selection



☐ Show system icons

☐ Show all

☑ Domestic hot water ☐ Process heating ☐ Air collectors

☑ Space-heating ☑ Swimming pool ☐ Buffer tank systems

Description	Type	Manu...	DHW	Heating	Sw
Buffer tank system with fresh water station and swimming pool	B17	Stan...	X	X	X
Buffer tank system (heating buffer tank), with fresh water station and swimming pool	B18	Stan...	X	X	X
Pool and DHW system with heating buffer tank	B3	Stan...	X	X	X
Pool and DHW system with stratification and heating buffer tank	B3.1	Stan...	X	X	X
Pool and combination tank DHW system + space-heating	B5	Stan...	X	X	X
Pool and combination tank DHW system (tank in tank)	B5.2	Stan...	X	X	X
Combination tank system (heating buffer tank) and swimming pool		Stan...	X	X	X
BER Pool and DHW system with heating buffer tank		Beretta	X	X	X
BER Pool and combination tank DHW system (tank in tank)	BER B5.2	Beretta	X	X	X
RIE Pool and DHW system with heating buffer tank	RIE B3	Riello	X	X	X
SYL Pool and DHW system with heating buffer tank	SYL B3	Sylber	X	X	X
SYL Pool and combination tank DHW system (tank in tank)	SYL B5.2	Sylber	X	X	X
THE Pool and DHW system with heating buffer tank	THE B3	Ther...	X	X	X
VAI D Pool and combination tank DHW system (tank in tank) + space Heating	VAI -Deu- B5.2	Vaila...	X	X	X
Viessmann Pool and DHW system with heating buffer tank	VM B3	Viess...	X	X	X
Viessmann Pool and combination tank DHW system + space-heating	VM B5	Viess...	X	X	X
WAG RATIOfresh with swimming pool connection	WAG B17	Wag...	X	X	X
WAG Pool and combination tank DHW system (tank in tank) + space-heating	WAG B5.2	Wag...	X	X	X

Image: System selection with system icons and filters

On starting, you must first select a system.

The system is the solar system you select with a predefined collector loop configuration, storage loop with corresponding tank type, consumption loop, and the associated control strategy. The separate components can be exchanged in the *system definition*.

There are several groups of systems:

- Standard systems,
- Swimming pool systems,

in T*SOL Pro only:

- Air collector systems,
- Large-scale systems,
- Company systems August Brötje, Beretta, Buderus Bosch Thermotechnik, Feuron, GrammerSolar, IVAR, Paradigma, Riello, Solahart, Sylber, Teufel & Schwarz, Thermital, Vaillant, Viessmann, Vokera, Wagner, Weishaupt

in T*SOL Expert only:

- Solar local district heating systems

è How to proceed:

1. Go to the *System Selection* .
2. You can choose to display the systems as schematic diagrams or as lists.
3. Select a system.
   Systems, which have been tested by Solar Collector Certification Program (SRCC) can be found either by sorting the column SRCC or by using the search applied to the column SRCC searching for "yes".
4. You will be asked if you wish to copy the current parameters to this system.
5. Now you can set the system's further parameters via the *system definition*.

6.1 Standard Systems

System Selection

System	Dual coil indirect hot water tank	Solar tank / buffer tank	Single coil heating buffer tanks	Combination tank / internal heat exchag.	Auxiliary heating	Heating loop	External heat exchanger	DHW standby tank	DHW heating	Fresh water station	2 Collector Loops = East-West-Installation
A1 - DHW systems with dual coil tank	x				o						x
A2 - DHW systems (2 tanks)	x	x			x						x
A3 - DHW systems w. heating buffer tank	x		x		x	x					
A4 - DHW systems (2 tanks) with heating buffer tank		x	x		x	x		x			
A5 - Combination tank systems				x	x	o					x
A6 - Buffer tank systems	0	x			x	o	x	x	x		
A7 - Thermosyphon systems					o						
A10 - System with continuous flow heater	x				C						x
A12 - System with external heat exchanger and fresh water station					o	o	x			x	x
A17 - System with buffer tank and freshwater station	x	x			o	o				x	x
A18 - System with buffer tank and freshwater station		x					x			x	x

C = continuous flow heating, x = available, o = optional

In addition, every system includes the following:

- Collector loop connection, contains
    - Collector array (see chapter 10.4), contains
        - Collector (see chapter 10.3)
        - Shading

6.1.1 A1 - DHW Systems with Dual Coil Tank

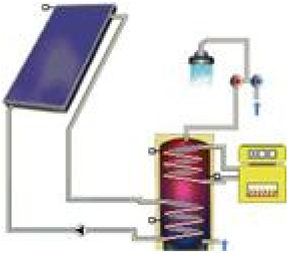


Image: A1 - DHW system

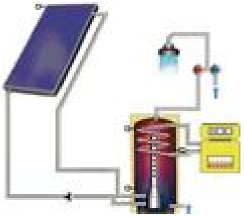


Image A1.1 DHW system with stratification

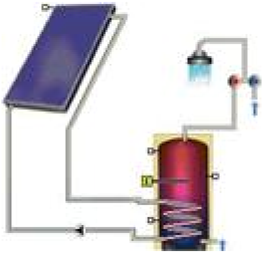


Image: A1.2 - DHW system with electric heating element

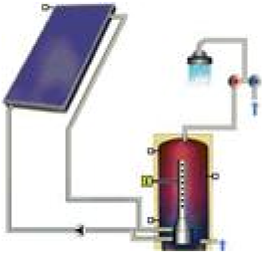


Image: A1.3 - DHW system with electric heating eleme

This is the most simple type of system with just a single tank (or tank group), which serves as both a solar and standby tank.

This system is recommended for the redevelopment of small-scale systems where no existing DHW tanks can be used.

The standard systems available differ from one another with respect to the presence of stratification and in the type of additional water heating (auxiliary heating or an electric heating element in the tank).

The system consists of the following components:

- Collector loop connection, contains
    - Collector array, contains
        - Collector
        - Shading
- Dual coil DHW tank
- Auxiliary heating

6.1.2 A2 - DHW Systems (2 Tanks)

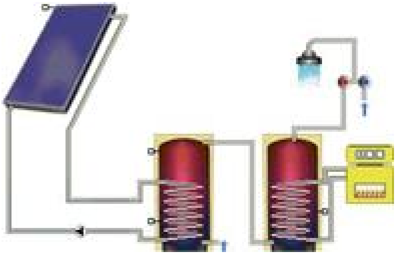


Image: A2 - DHW system with two tanks, without stratification

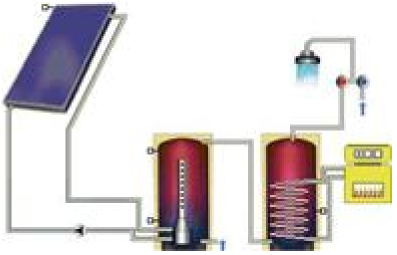


Image: A2.1 - DHW system with two tanks, with stratification

This is a system with two tanks or tank groups. The first serves as a solar tank; the second, downstream, as a standby tank. This configuration is ideal if several tanks are planned for the system on account of its size or an existing standby tank is to continue being used.

On the *System Definition › Control* page, you can schedule destratification for the event that the upper temperature in the solar tank is higher than in the standby tank. The pump is switched on and off by the temperature difference between the solar tank and the standby tank.

In addition, an *anti-Legionnaire's switch* can be used to briefly heat the tank group. A fixed time period on one or more days of the week is defined for this.

The system consists of the following components:

- Collector loop connection, contains
  - Collector array, contains
    - Collector
    - Shading
- Dual coil DHW tank
- Single coil solar tank (see chapter 10.5)
- Auxiliary heating

6.1.3 A3 - DHW System with Heating Buffer Tank

Image: A3 - DHW system with heating buffer tank

Image: A3.1 - DHW system with heating buffer tank and stratification

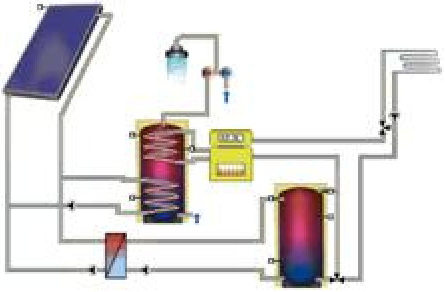


Image: A3.2 - DHW system with heating buffer tank and external heat exchanger

This system allows the solar system to provide space heating. Two tanks are loaded from the collector loop, with the hot water tank being loaded preferentially to the heating buffer tank. Under *System Definition › Control*, the priority of the DHW circuit over the auxiliary heating is therefore preset.

The system consists of the following components:

- Collector loop connection, contains
  - Collector array, contains
    - Collector
    - Shading
- Dual coil indirect hot water tank
- Auxiliary heating
- Heating loop
- Single coil heating buffer tank

6.1.4 A4 - DHW Systems (2 Tanks) with Heating Buffer Tank

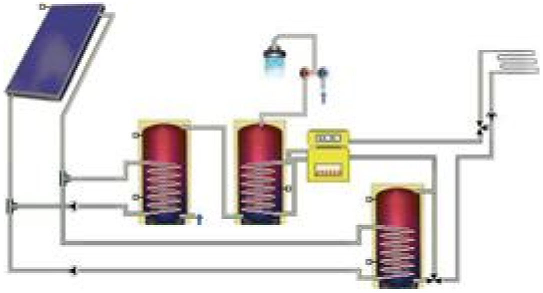


Image: A4 - Two tank systems with heating buffer tank, without stratification

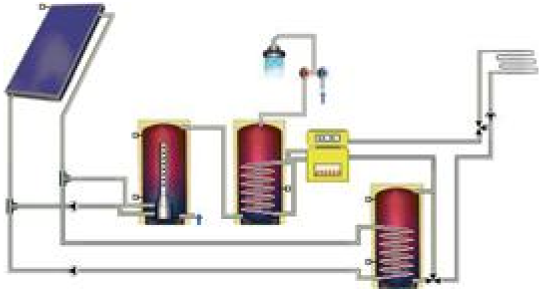


Image: A4.1 - Two tank systems with heating buffer tank, with stratification

The two tank system is expanded by a buffer tank for space heating.

The boiler maintains the upper areas of both the DHW standby tank and the heating buffer tank at the required desired temperature.

On the *System Definition › Control* page, you can schedule destratification for the event that the solar tank has a higher temperature than the standby tank. The pump is switched on and off by the temperature difference between the solar tank and the standby tank.

In addition, an anti-Legionnaire's switch can be used to briefly heat the tank group. A fixed time period on one or more days of the week is defined for this.

The priority of the DHW circuit over the auxiliary heating is preset when selecting an A4 system.

The system consists of the following components:

- Collector loop connection, contains
  - Collector array, contains
    - Collector
    - Shading
- DHW standby tank (see chapter 9.5)
- Solar tank
- Auxiliary heating
- Heating loop
- Single coil heating buffer tank

6.1.5 A5 - Combination Tank Systems

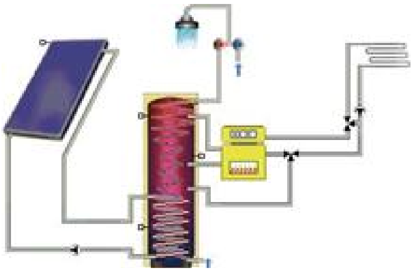


Image: A5 - Combination tank system for hot water and heating

Image: A5.1 - Combination tank system for DHW only

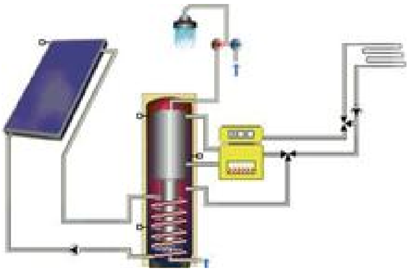


Image: A5.2 - Combination tank system (tank in tank) for hot water and heating

Image: A5.3 - Combination tank system (tank in tank) for DHW only

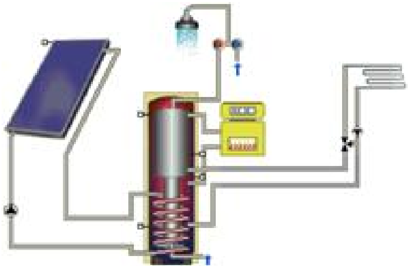


Image: A5.4 - Combination tank system (tank in tank) for hot water and heating

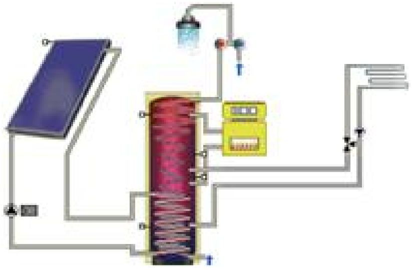


Image: A5.5. - Combination tank system for hot water and heating

The A5 standard systems available differ from one another in the combination tank they use. The tank in tank system consists of a relatively small DHW tank and a larger tank enclosing it. In the lower area, this is heated by the solar system, while the upper area is heated by the auxiliary heating.

The other type of combination tank contains an internal heat exchanger for DHW supply which runs through the entire tank. It is also heated by the solar system in the lower area and by the auxiliary heating in the upper area.

On the *System Definition › Control* page, the priority of the DHW circuit for the auxiliary heating can be set.

The system consists of the following components:

- Collector loop connection, contains
    - Collector array, contains
        - Collector
        - Shading
- Combination tank (tank in tank / internal heat exchanger see chapter 10.6.3.4)
- Auxiliary heating

- where required, heating loop

6.1.6 A6 - Buffer Tank Systems

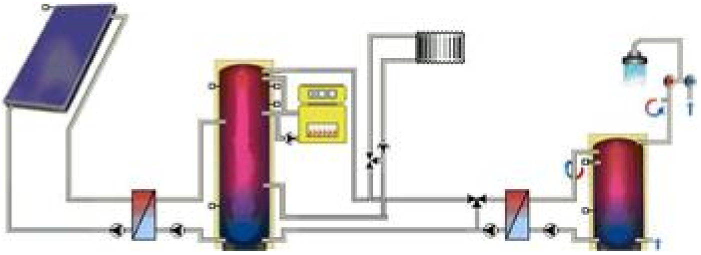


Image: A6 - Buffer tank system for hot water and heating

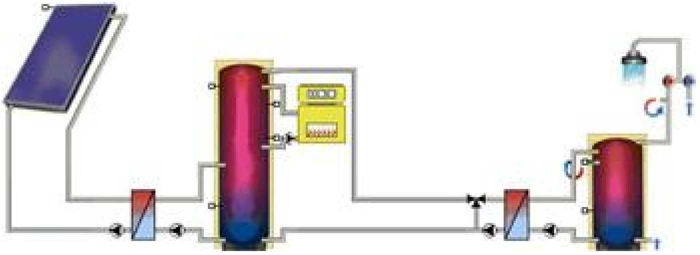


Image: A6.1 - Buffer tank system for DHW only

These large-scale systems are characterized by a buffer tank with auxiliary heating and external heat exchanger. They differ from one another with regard to space heating.

On the *System Definition › Control* page, the priority of the DHW circuit is set. This causes the DHW standby tank to be supplied first in the event of insufficient boiler power.

The system consists of the following components:

- Collector loop connection, contains
    - Collector array, contains
        - Collector
        - Shading
- where required, heating loop
- Buffer tanks
- Auxiliary heating
- DHW supply (see chapter 9.5), contains
    - External heat exchanger
    - DHW standby tank (see chapter 10.6.3.8)

6.1.7 A7 - Thermosyphon Systems

Image: A7 - Thermosyphon system with continuous flow heater, stand-alone

Image: A7.1 - Thermosyphon system without continuous flow heater

Thermosyphon systems operate on the difference in density between hot and cold water. They therefore require no circulation pumps and additional control loops.

Two systems differentiated by an optional continuous flow heater for auxiliary heating are available for calculation purposes.

Under *System Definition* , you can enter the type of collector, the continuous flow heater (fuel and power), and DHW consumption.

In contrast to other systems, the parameters for the tank are predefined. Circulation is not possible.

6.1.8 A10 - System with Solar Tank and Continuous Flow Heater

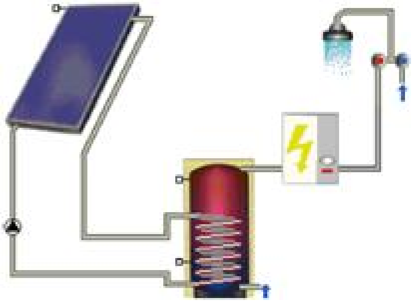


Image: A10 - System with continuous flow heater

Single coil tank with solar loading. This system uses acontinuous flow heater to set the desired DHW temperature when solar power is insufficient for this purpose. In contrast to system A16, a circulation system can be installed here.

Under *System Definition*, you can enter the power and fuel (electricity, oil, natural gas) for the continuous flow heater.

6.1.9 A12 - System with External Heat Exchanger and Fresh Water Station

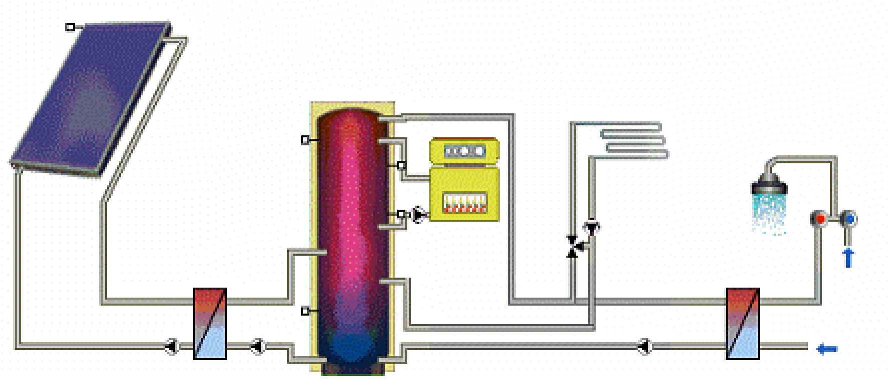


Image: A12 - System with external heat exchanger and fresh water station

This system heats utility water via a fresh water station. The collector array heats the buffer tank, from which the solar energy supplies heating (optional) and the fresh water station, which operates in a continuous flow process. If the energy from the buffer tank is insufficient, the auxiliary heating operates on the upper area of the buffer tank.

6.1.10 A17/A18 - Systems with Buffer Tank

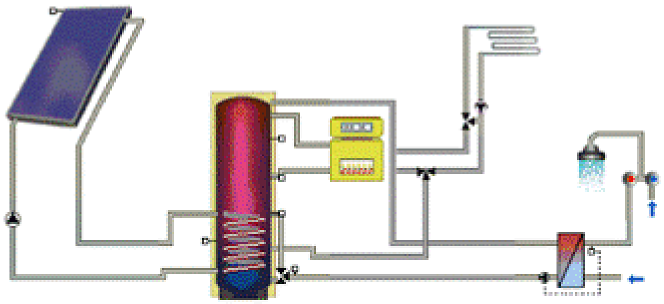


Image: A17 - System with buffer tank and fresh water station

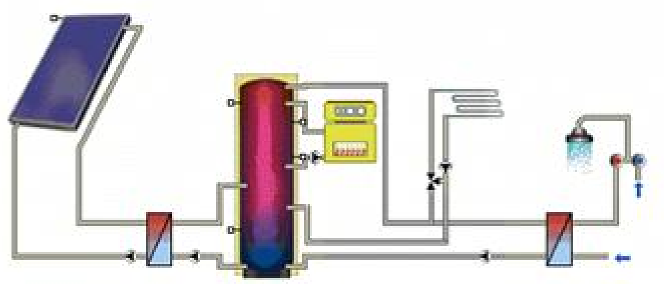


Image: A18 - System with buffer tank and fresh water station

This system heats utility water via a fresh water station which operates in a continuous flow process.

In A17, the auxiliary heating heats the tank and, via the return increase, the heating loop; in A18, it only heats the tank, as there is no return increase.

Heating can additionally be incorporated in the system.

6.2 Swimming Pool Systems

In comparison with the standard systems, these systems additionally include a swimming pool component.

Using T*SOL, an outdoor pool can be integrated within the solar cycle.

In addition to calculating the solar yield for DHW supply and building heating, the influence of a solar system on the temperature of a swimming pool is calculated. The additional energy which must be generated by auxiliary heating (if the pool is to be maintained at a target temperature) is also calculated.

System	Dual coil DHW tank	Solar tank	Auxiliary heating	Heating loop	Single coil heating buffer tank	DHW standby tank	Combination tank / internal heat exchanger	External heat exchanger	DHW Supply	Fresh water station	Swimming pool
B1 - Swimming pool and DHW systems	x		x					o			x
B3 - Swimming pool and DHW systems with heating buffer tank	x		x	x	x			o			x
B5 - Swimming pool and combination tank DHW system + space heating			x	o			x	o			x
B6 - Simple swimming pool systems			o					o			x
B17 - System with buffer tank, fresh water station, and swimming pool		x	x							x	x
B18 - System with buffer tank (heating buffer), fresh water station, and swimming pool			x		x					x	x

x = available, o = optional

In addition, every system includes the following:

- System is possible as indoor or outdoor pool.
- Collector loop connection, contains
  - Collector array, contains
    - Collector
    - Shading
  - External heat exchanger (except system B6)
- Swimming pool

6.2.1 B1 - Swimming Pool and DHW Systems

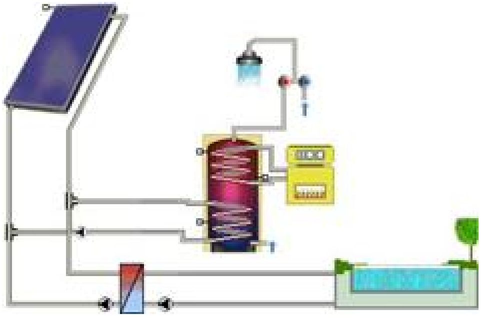


Image: B1 - Swimming pool and DHW system without stratification

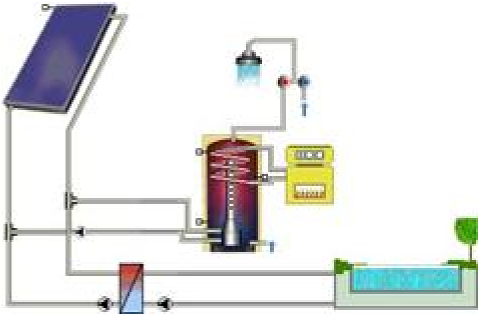


Image: B1.1 - Swimming pool and DHW system with stratification

The two systems differ from one another by the presence of stratification.

The system additionally features the following components:

- Dual coil DHW tank
- Auxiliary heating
- where required, external heat exchanger

6.2.2 B3 - Swimming Pool and DHW Systems with Heating Buffer Tank

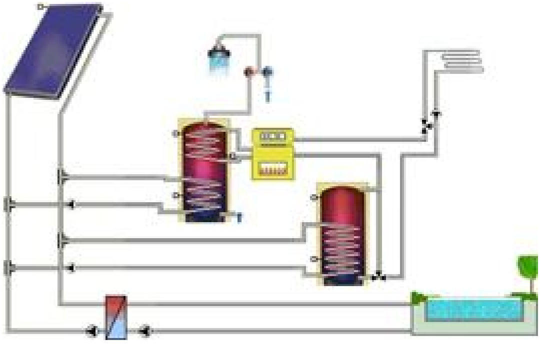


Image: B3 - Swimming pool and DHW system with heating buffer tank

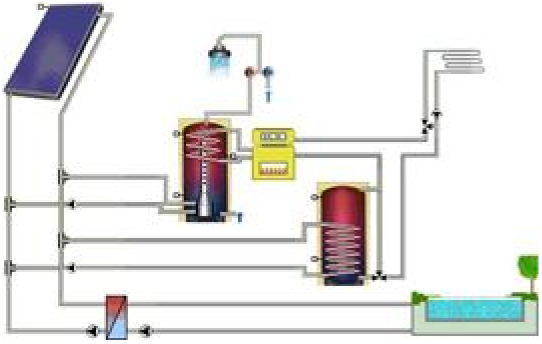


Image: B3.1 - Swimming pool and DHW system with heating buffer tank and stratification

In comparison with the B1 systems, these systems include a heating buffer tank and a heating loop. The heating buffer tank is defined on the *Collector Loop Connection › Buffer Tank* page.

The system additionally features the following components:

- Dual coil DHW tank
- Auxiliary heating
- Heating loop
- Single coil heating buffer tank
- where required, external heat exchanger

6.2.3 B5 - Swimming Pool and Combination Tank DHW System + Space Heating

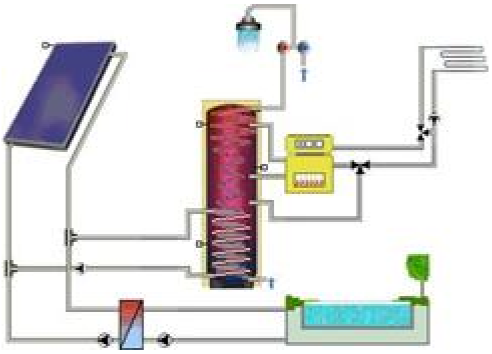


Image: **B5** - Swimming pool and combination tank DHW system + space heating

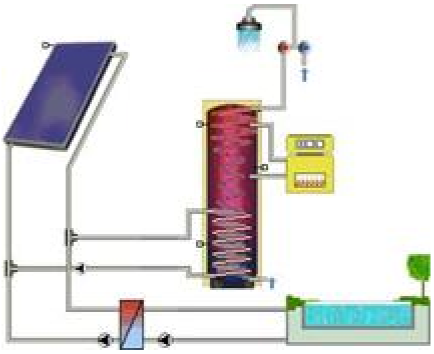


Image: **B5.1** - Swimming pool and combination tank DHW system

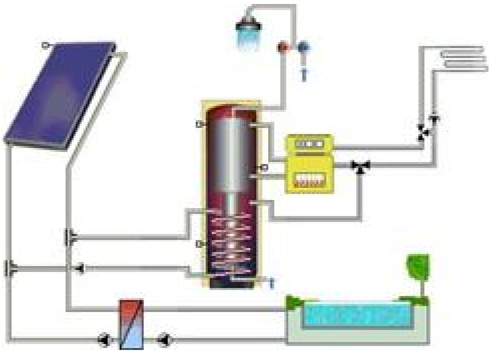


Image: **B5.2** - Swimming pool and combination tank system (tank in tank) for DHW and heating

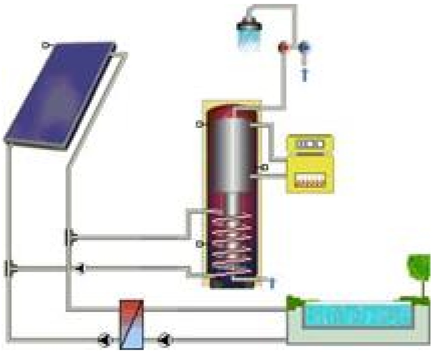


Image: **B5.3** - Swimming pool and combination tank system (tank in tank) for DHW only

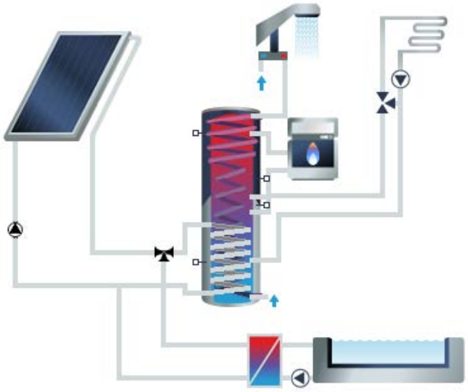


Image: **B5.5** - Swimming pool system with buffer tank (heating buffer), DHW, and space heating

The B5 systems contain either tank in tank systems or tanks with an internal heat exchanger and differ from one another with respect to the addition of heating.

The system additionally features the following components:

- Combination tank (tank in tank or int. heat exchanger)
- Auxiliary heating
- where required, heating loop
- where required, external heat exchanger

6.2.4 B6 - Simple Swimming Pool Systems

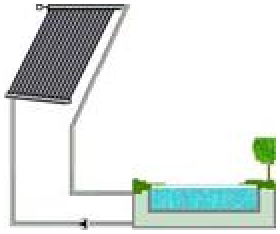


Image: **B6** - Swimming pool without heat exchanger or auxiliary heating

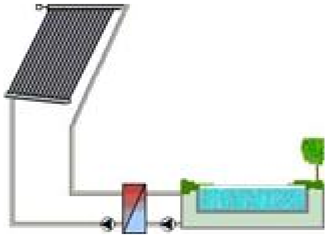


Image: **B6.1** - Swimming pool with heat exchanger and without auxiliary heating

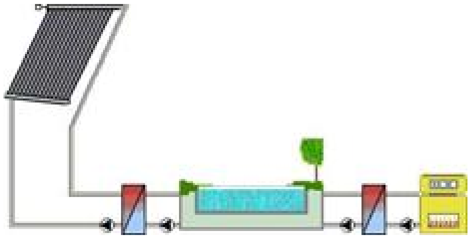


Image: **B6.2** - Swimming pool with heat exchanger and auxiliary heating

For these systems, which can only be used to heat pools, unglazed collectors are preferably used. Systems with and without auxiliary heating and heat exchangers are available.

The system additionally features the following components:

- where required, auxiliary heating
- where required, external heat exchanger

6.2.5 B17/B18 - System with Buffer Tank, Fresh Water Station, and Swimming Pool

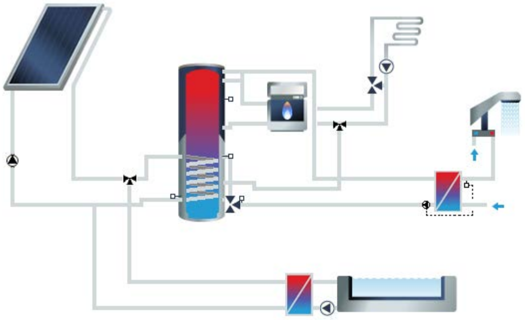


Image 13: B17 - Swimming pool system with buffer tank and fresh water station

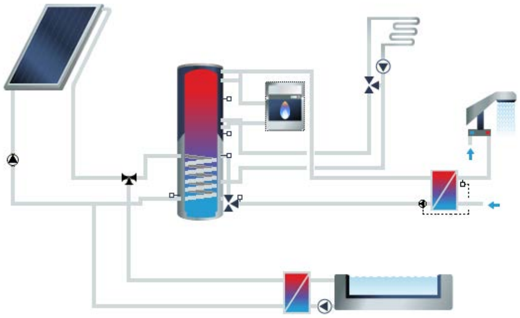


Image 14: B18 - Swimming pool system with buffer tank (heating buffer) and fresh water station

7 System Definition

System definition

The systems are made from individual components. Define or modify the properties of these components in the relevant dialog. You can access all parameter dialogs

-
- by double-clicking the relevant component in the system schematic.
- using the *Properties* context menu (right-mouse click).
- Go from one parameter dialog to the next, by using the arrow buttons ← →.

Just as the displayed system schematic changes depending on the system selected, so do the dialogs available.

è How to define a system:

1. Open the System Definition by double-clicking on the system schematic.
2. Go through the site data in order and all the components in this system and enter the required parameters.
3. The *Parameters* buttons take you to the respective parameter setting dialogs.
4. Click on the *Select* button to add database components.

   ! Data from the components database cannot be altered if they represent "real" components from manufacturing companies. Only data on "virtual" T*SOL database components can be modified!

5. Use the arrow buttons ← → at the bottom right of the dialog window to toggle between the dialogs of the individual components. This saves entries made just as clicking *OK*.
6. Click on *OK* to end entry and accept all changes. If you click the *Cancel* button, all changes in this dialog are reset.
7. Start the simulation.
8. Then you can do a financial analysis.
9. In addition, it can present a summary of the simulation results in project reports.

T*SOL Expert features an extra page in each case allowing values to be entered in addition to the standard values which are then applied to the results file.

7.1 Definition of the System/Variant and its Components

System Definition › System

You can access the *System Definition › System* page via

- the button or
- by double-clicking the system schematic where there are no components.

The system components are listed on the *Components* page. These vary depending on the selected system:

Solar Loop, *Collector Loop Connection*, *Auxiliary Heating*, Tank, *Swimming Pool* and *External Heat Exchanger*, and *Solar Loop Heat Exchanger*

The *Control* page is particularly important. Here, depending on the selected system schematic, you set the DHW circuit priority, the Anti-Legionnaire's Switch(see chapter 10.11.5), and the stratification.

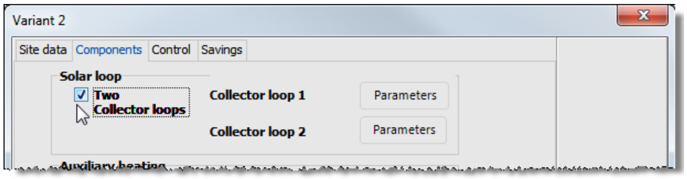
The *Savings* page contains parameters for calculating pollutants and fuel.

You can define a *reference system* which can be used to carry out the emissions calculation. The setting in the example shown will calculate the savings and the emissions reduction with an efficiency of 70 % in the simulation compared to the oil boiler otherwise used.

7.1.1 Two Collector Loops

System Definition › System › Components › Solar Loop

The option of *Two Collector Loops* has been integrated in systems A1, A2, A5, A12, A17, and A18. It is now possible to define and simulate two collector loops independently of one another there.



☑ Two Collector loops

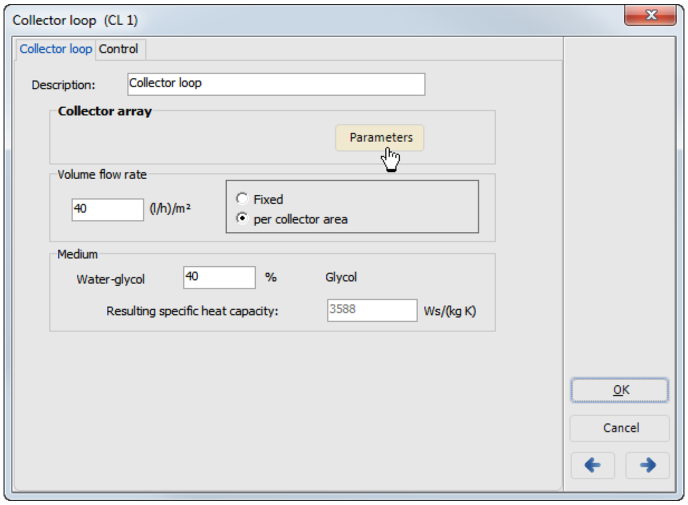
Image: *System Definition › Variants › Components* with option "*Two Collector loops*"

è How to proceed:

1. Selects a suitable system (A1, A2, or A5)
2. Go to *System Definition › System › Components*
3. Activate the *Two Collector Loops* option in the *Solar Loop* section.
4. The Collector Loop and Collector Array dialogs are separately displayed for the collector loop 1 (CL1) and collector loop 2 (CL2). Enter the *parameters*.

7.2 Collector Loop

System Definition › Collector Loop › Collector Loop or system schematic



Collector loop (CL 1)

Collector loop | Control

Description: Collector loop

Collector array

Volume flow rate

40 (l/h)/m²

○ Fixed

● per collector area

Medium

Water-glycol 40 % Glycol

Resulting specific heat capacity: 3588 Ws/(kg K)

Image: Dialog for connecting the collector loop

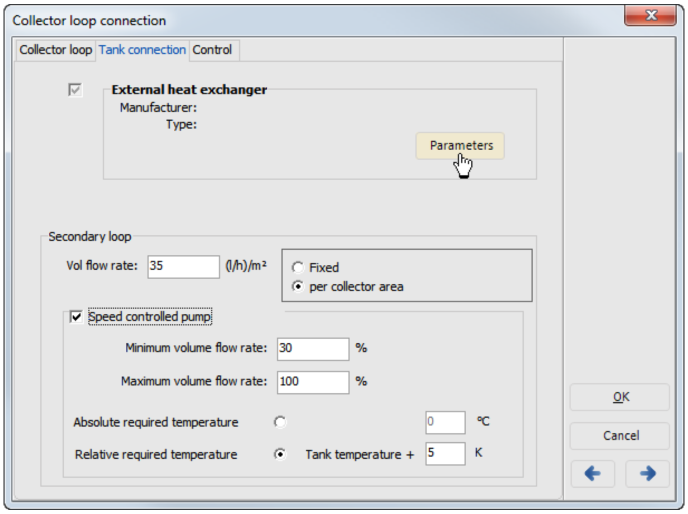
The *Collector Array* is defined via the *Parameters* button on the *Collector Loop* page.

The volumetric flow ratestates how many liters of heat transfer medium are to flow through the collector in total per hour or per square meter. This volumetric flow rate crucially defines which temperature is transported in the flow of the collector loop. The calculation of the collector array pipe diameter is also dependent on this entry.

Water or a water/glycol mixture can be used as the heat transfer medium. The resulting specific heat capacityis then displayed.

7.2.1 Tank Connection / External Heat Exchanger

System Definition › Collector Loop › Tank Connection



Collector loop connection

Collector loop | Tank connection | Control

☑ **External heat exchanger**

Manufacturer:

Type:

Secondary loop

Vol flow rate: 35 (l/h)/m²

○ Fixed

● per collector area

☑ Speed controlled pump

Minimum volume flow rate: 30 %

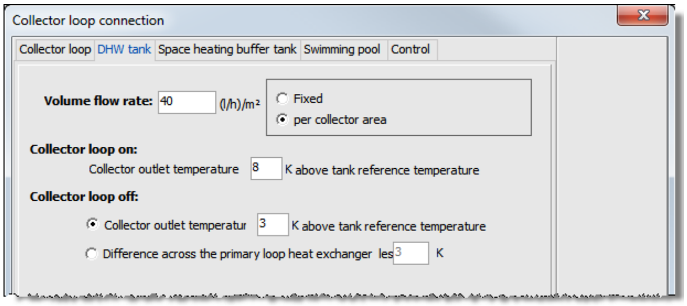
Maximum volume flow rate: 100 %

Absolute required temperature ○ 0 °C

Relative required temperature ● Tank temperature + 5 K

Image: Dialog *Connection › Collector Loop › Tank Connection* for systems with external heat exchanger

In systems with an external heat exchanger, the *Collector Loop Connection* features the additional *Tank Connection* page, on which the *heat exchanger* can be selected. For the secondary loop, you can enter the volumetric flow rate as an absolute value or per m² of collector surface area. The *Speed Controlled Pump*option in the secondary loop means that the volumetric flow rate of the pump is controlled in this way to reach the target temperature. You can set a fixed target temperature or enter one relative to the tank temperature.



Volume flow rate: 40 (l/h)/m²
○ Fixed
● per collector area

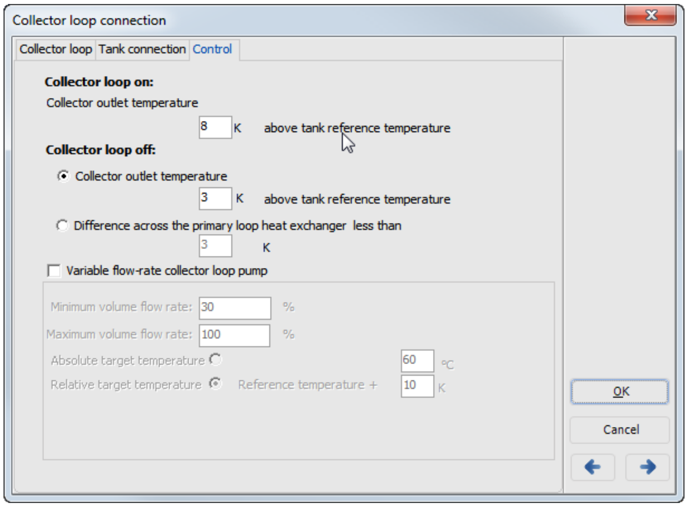
Collector loop on:
Collector outlet temperature 8 K above tank reference temperature

Collector loop off:
● Collector outlet temperatur 3 K above tank reference temperature
○ Difference across the primary loop heat exchanger les 3 K

Image: Dialog *Connection › Collector Loop*, connection of a dual coil DHW tank

7.2.2 Control

System Definition › Collector Loop › Control

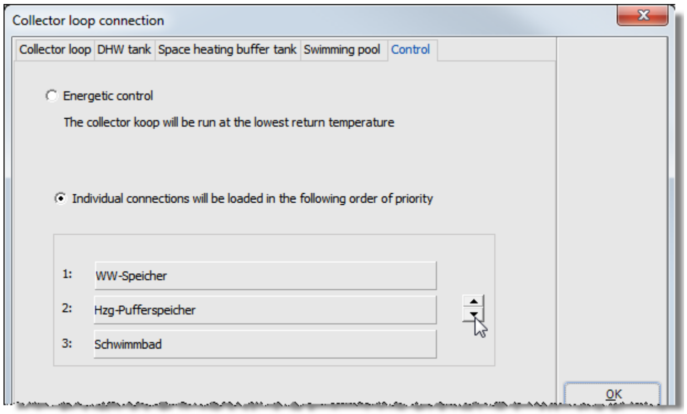


Collector loop on:
Collector outlet temperature
8 K above tank reference temperature

Collector loop off:
● Collector outlet temperature
3 K above tank reference temperature
○ Difference across the primary loop heat exchanger less than
3 K

☐ Variable flow-rate collector loop pump
Minimum volume flow rate: 30 %
Maximum volume flow rate: 100 %
Absolute target temperature ○ 60 °C
Relative target temperature ● Reference temperature + 10 K

Input dialog for connection to collector loop, *Control* page



○ Energetic control
The collector koop will be run at the lowest return temperature

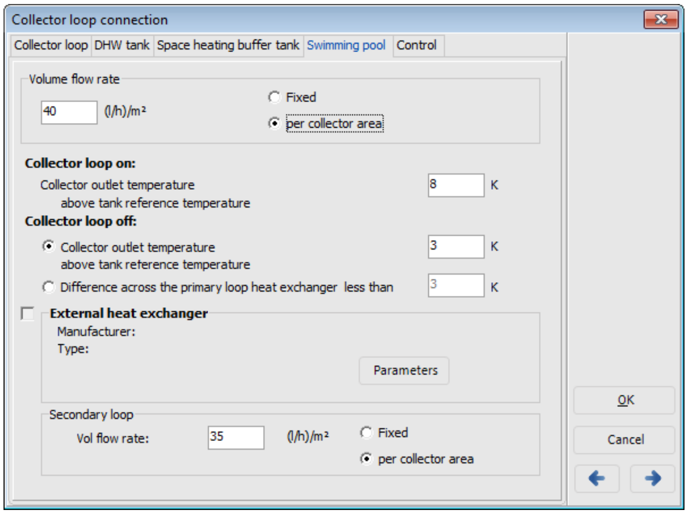
● Individual connections will be loaded in the following order of priority

1: WW-Speicher
2: Hzg-Pufferspeicher
3: Schwimmbad

Input dialog for connection to collector loop, *Control* page, more than one tank

7.2.3 Swimming Pool in Collector Loop

System Definition › Collector Loop Connection › Swimming Pool or Control



Volume flow rate
40 (l/h)/m²
○ Fixed
● per collector area

Collector loop on:
Collector outlet temperature above tank reference temperature 8 K

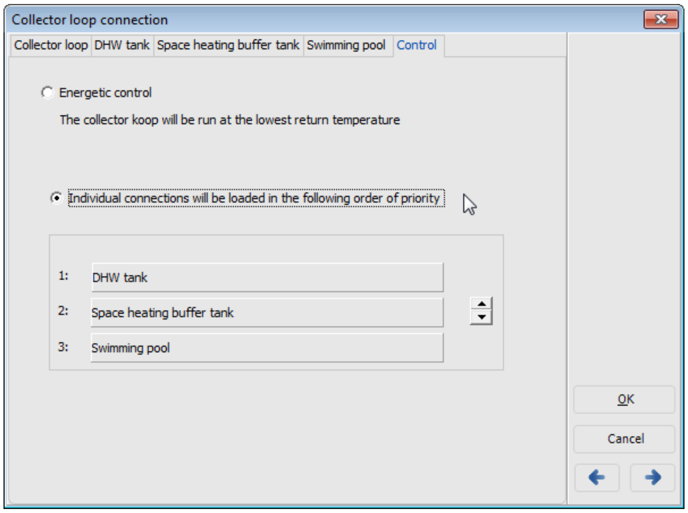
Collector loop off:
● Collector outlet temperature above tank reference temperature 3 K
○ Difference across the primary loop heat exchanger less than 3 K

☐ **External heat exchanger**
Manufacturer:
Type:

Secondary loop
Vol flow rate: 35 (l/h)/m²
○ Fixed
● per collector area

Image: Collector loop connection dialog for swimming pool systems

If you have selected a system with Swimming Pool, this dialog then contains the extra page *System Definition › Collector Loop Connection › Swimming Pool*, on which you can define the connection to the collector loop. Set the volumetric flow rate, the switching conditions for the collector loop pump, and the external heat exchanger. The loading sequence for the connections is defined on the *Control* page.



○ Energetic control
The collector koop will be run at the lowest return temperature

● Individual connections will be loaded in the following order of priority

1: DHW tank
2: Space heating buffer tank
3: Swimming pool

Image: Input dialog for connection to *collector loop › Control* page Example: system with dual coil DHW tank, heating, swimming pool

The order of priority for loading the connections from the collector loop pump is defined on the *Control* page. The default setting corresponds to a temperature difference control.

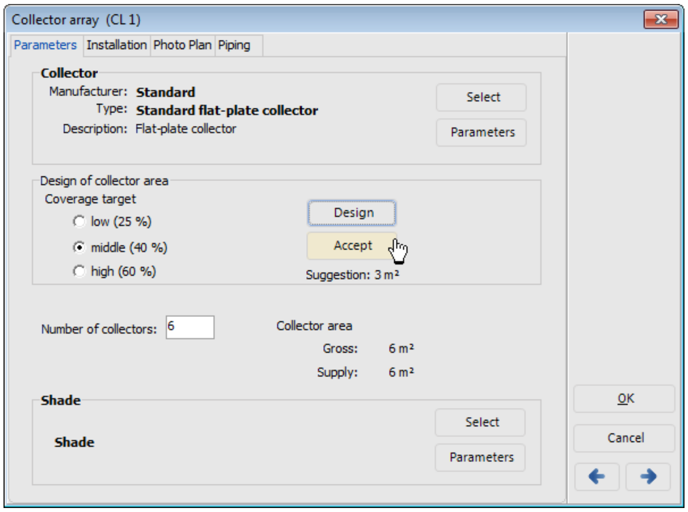
Select either energy control, in which the collector loop is run at the lowest return temperature, or a specific loading sequence.

To do this, click on the relevant component and move it up or down by using the arrow buttons.

7.3 Collector Array

System Definition › Collector Array or system schematic

The values of the collector array are recorded over several pages.



Collector
Manufacturer: **Standard**
Type: **Standard flat-plate collector**
Description: Flat-plate collector

Design of collector area
Coverage target
○ low (25 %)
● middle (40 %)
○ high (60 %)
Suggestion: 3 m²

Number of collectors: 6
Collector area
Gross: 6 m²
Supply: 6 m²

Shade
Shade

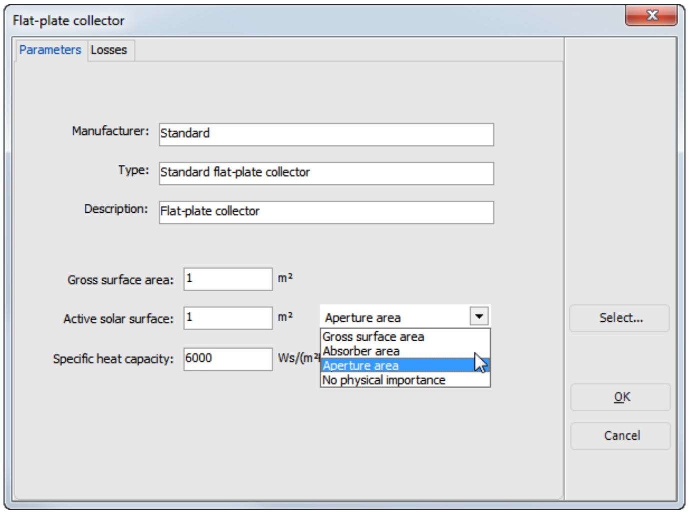
Image: Dialog for defining the collector array

è Proceed as follows:

1. Click on the *Select* button to access the collectors database, select one (see chapter 10.3 Collector). You can choose from a wide range of flat-plate and evacuated tube collectors.
2. Define its properties via the *Parameters* button. The characteristic data required for the simulation vary depending on the type of collector.
3. Configuration of the collector surface
   - Define your ● target coverage (-> see Glossary: Solar_fraction).
   - Click on *Configure*. The collector surface and thus the number of collectors is estimated based on the monthly solar irradiation and the amount of DHW required. - You can *accept* this number or enter an alternative number.
4. The crucial factor determining the yield of the solar system is *shading*. Click on *Select* to choose a type of shading.
5. Define the details of the type of shading via its *Parameters*. For a definition of shading profiles, please see chapter 7.3.2Shading.
6. Define the geometric arrangement of the collectors on the *Installation* page.
7. Define properties for calculating piping losses on the *Piping* page, see chapter 10.4.4 Piping.
8. Save all entries by clicking *OK* or go to the next dialog using the arrow button →.

7.3.1 Collector Parameter

System Definition › Collector Array › Collector › Select or system schematic



Manufacturer: Standard

Type: Standard flat-plate collector

Description: Flat-plate collector

Gross surface area: 1 m²

Active solar surface: 1 m² Aperture area

Specific heat capacity: 6000 Ws/(m²

- Gross surface area
- Absorber area
- Aperture area
- No physical importance

Image: Entering the collector areas and specific heat capacity.

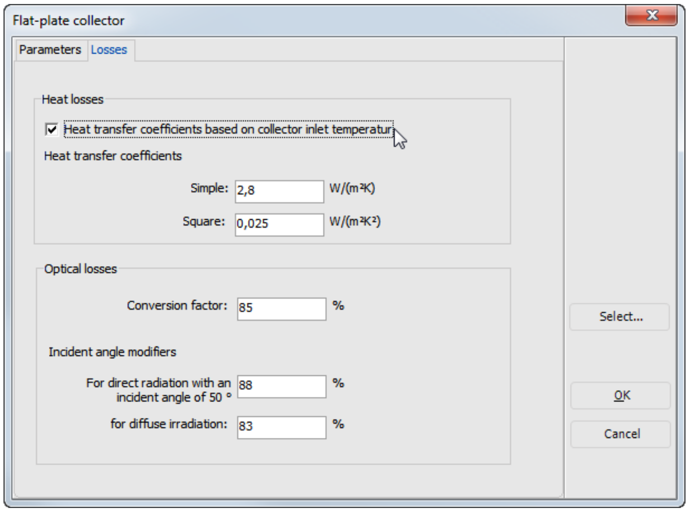
In order to specify the collector array, you must first *select* a collector.

The gross surface areais calculated from the external dimensions of the collector; however, the specific collector characteristic values typically do not relate to the gross surface area but an active solar surfacetaken from the reports by testing institutes.

Depending on the test institute, the active solar surface in flat-plate collectors is the absorber area or the aperture area. In evacuated tube collectors (e.g. with mirror constructions with vertical absorber), the active solar surface is frequently unrelated to real-world practise and is a purely theoretical value.

7.3.1.1 Collector – Thermal Losses

System Definition › Flat-Plate / Tube Collector › Losses / Thermal Losses



Heat losses

☑ Heat transfer coefficients based on collector inlet temperatur

Heat transfer coefficients

Simple: 2,8 W/(m²K)

Square: 0,025 W/(m²K²)

Optical losses

Conversion factor: 85 %

Incident angle modifiers

For direct radiation with an incident angle of 50 °: 88 %

for diffuse irradiation: 83 %

Image: Calculation of thermal and optical collector losses

The energy absorbed by the collector and output to the collector loop less heating losses is calculated as follows:

$$P = G_{dir} \cdot \eta_o \cdot f_{IAM} + f_{IAM_{diff}} \cdot G_{diff} \cdot \eta_o - k_o \cdot (T_{Cm} - T_A) - k_q \cdot (T_{Cm} - T_A)^2$$

with G_{dir} Part of solar irradiation striking a tilted surface

G_{diff}	Diffuse solar irradiation striking a tilted surface
T_{Cm}	Average temperature in the collector
T_A	Air temperature
f_{IAM}	Incident angle modifier

After deduction of optical losses (conversion factor and incident angle modifiers), a part of the absorbed radiation is lost through heat transfer and radiation to the environment. These losses are described by the heat transfer coefficient.

The heat transfer coefficient k states how much heat the collector releases into the environment per square meter of active solar surface and temperature difference between the average collector temperature and the environment in degrees Kelvin.

It is split into two parts, the simple and the quadratic part. The simple part k_o (in W/m²/K) is multiplied by the simple temperature difference, the quadratic part k_q (in W/m²/K²) by its square. This gives rise to the efficiency parabolae usually stated. Und? Relevance?

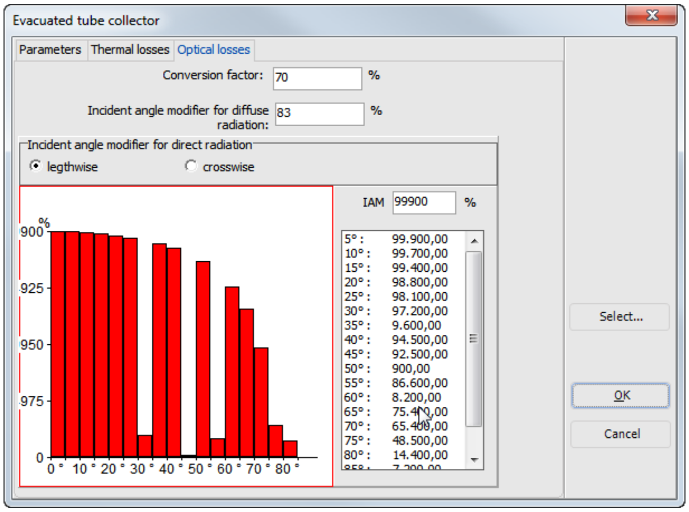
The specific heat capacity states the amount of heat per square meter of active solar surface that the collector, including its heat transfer medium content, can store at a temperature increase of 1 Kelvin. It is stated in Ws/m²K. This decides how quickly the collector reacts to the irradiation. The influence of this value is only significant for relative small pipeline networks, as the capacity of the pipeline network otherwise takes priority.

After leaving the dialog by clicking *OK*, the system schematic view is updated with the type of collector selected.

The SRCC box indicates whether this collector has been tested according to the Solar Collector Certification Program and that the simulation therefore uses different collector temperatures, respectively.

7.3.1.2 Collector – Optical Losses

S ystem Definitions › Flat-Plate / Tube Collector › Losses / Optical Losses



Conversion factor: 70 %

Incident angle modifier for diffuse radiation: 83 %

Incident angle modifier for direct radiation

● legthwise ○ crosswise

IAM 99900 %

5° :	99.900,00
10° :	99.700,00
15° :	99.400,00
20° :	98.800,00
25° :	98.100,00
30° :	97.200,00
35° :	9.600,00
40° :	94.500,00
45° :	92.500,00
50° :	900,00
55° :	86.600,00
60° :	8.200,00
65° :	75.400,00
70° :	65.400,00
75° :	48.500,00
80° :	14.400,00

Image: Calculation of optical collector losses of a tube collector

The conversion and incident angle modifiers determine the optical losses, i.e. how much of the irradiated energy is lost through reflection on glass and the absorber. The remainder is absorbed by the collector.

The conversion factor(in %) states amount absorbed with irradiation vertically to the collector surface area.

Incident angle modifiers describe the additional reflection losses when the sun is not positioned vertically above the collector surface area.

A constant diffuse incident angle modifier is stated for diffuse irradiation. For the direct fraction of radiation, this is defined using the incident angle. In the process, flat-plate and evacuated tube collectors are treated differently.

For flat-plate collectors, the loss factors for all incident angles are calculated from the incident angle modifier for the incident angle at 50% deviation from the vertical.

For evacuated tube collectors, the reflection losses differ depending on whether the irradiation is reflected lengthwise or crosswise to the tube. Due to the multitude of different designs, these dependencies cannot be specified by one input value. The incident angle modifiers must be given lengthwise and crosswise to the tube at 5° intervals for all incident angles between 0 and 90°. When crosswise, these modifiers can have a value higher than 100% due to concentration on curved glass or as a result of mirror constructions.

7.3.2 Shading

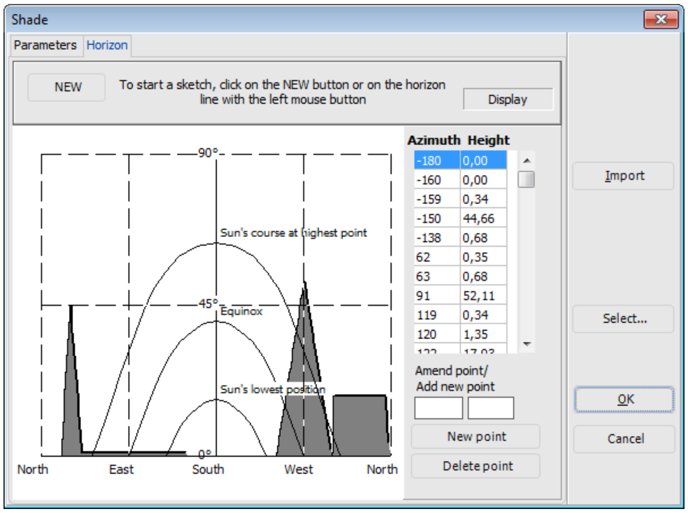
System Definition › Collector Array › Parameters › Shading

Shading is entered in the program in three steps. Define the general parameters, a *horizon*, and *objects* in the medium distance.

On the *Parameters* page, enter a new *reference* for every new shade.

7.3.2.1 Shading: Horizon

System Definition › Shading › Horizon



To start a sketch, click on the NEW button or on the horizon line with the left mouse button

Azimuth	Height
-180	0,00
-160	0,00
-159	0,34
-150	44,66
-138	0,68
62	0,35
63	0,68
91	52,11
119	0,34
120	1,35

Image: Definition of shading via horizon and individual objects

The resulting shade reduces the irradiation to the collector surface area.

In order to edit the horizon or objects which are relevant for the shading of your collectors, you must have made a note of the prominent points of the horizon line from your solar system. This can be done with a compass and protractor, with a sun path indicator, or with a digital camera and editing software.

A horizon point consists of the azimuth, i.e. the angle has measured from the horizontal and the respective height angle, also measured in angle degrees.

-> For definition of the azimuth refer to: 7.3.3 Installation è Define a new horizon by drawing with the mouse or by entering table values or by importing a complete horizon:

1. Start by clicking on the horizon line with the left mouse button. The current position of the cursor can be seen in the upper bar, given as *azimuth : height*.
   A dashed line is drawn between the starting point and the current position.
2. Click the next point using the left mouse button, thus confirming the dashed line.
   The horizon line can only go from left to right. As a result, no dashed line can be seen if you move the cursor left of the (current) end point.
3. Stop drawing by clicking the right mouse button.
4. Redrawing lines can only be done after completing the current sketch point and from an already defined point. The following text is displayed in the upper bar:
   To amend the horizon, click with the left mouse
   button exactly on the horizon line.

   It can be difficult to click on the existing horizon line where this is vertical. Rather enter a fitting individual object. This is done on the *List of Objects* page. The *Shading from Individual Objects* dialog opens.

1. Or enter the vertices of the horizon in the table directly. The start and end point are already entered, as are any generated with the mouse.
2. Define a point via *New Point* first.
3. Add a point to the table using *Add new Point*. On being entered, the point appears in the sketch.
4. You can remove the selected point (blue background) by clicking *Delete Point*.

1. Or import horizon lines created with the horizON and calculation software by clicking the button .
2. You can delete the horizon at any time by clicking the *New* button.

To print out the shade diagram, you must copy the activated dialog to the clipboard with the key combination *ALT+PRINT* and paste it into a word processing program such as Microsoft Word via the menu *Edit › Paste*. As an example, you will then see image 10.4.3, can scale and print it out.

7.3.3 Installation

System Definition › Collector Array › Installation

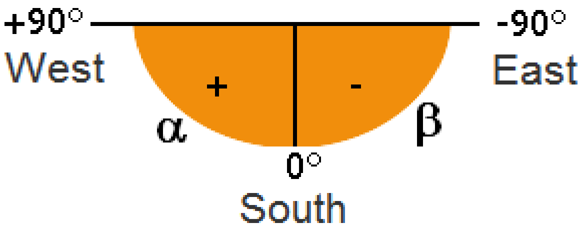
The position of the collector array is defined on the *Installation* page.

Enter the *orientation*, which describes the position of the collector area. It is independent from the location, therefore it is the same for the northern and southern hemisphere.

The azimuth angle is calculated and displayed. It describes the deviation of the standard angle of the collector surface area from the south (northern hemisphere) or from the north (southern hemisphere), respectively.

Orientation		Northern Hemisphere	Southern Hemisphere
North	0	180	0
East	90	-90	90
South	180	0	180
West	270	90	-90

Azimuth



Azimuth for installing the collector array on the northern hemisphere

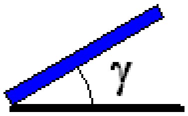


Image: Tilt angle for installing the collector array

The *tilt angle* γ (inclination) describes the angle between the horizontal and the collector surface area.

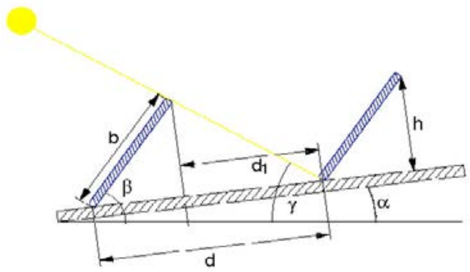
γ = 0° -> The collectors are flat on the ground.

γ = 90° -> The collectors are vertical.

The irradiation process calculates irradiation to the tilted surface from the orientation and tilt angle, which is then shown in the table at the bottom of the page.

7.3.3.1 Minimum distance between mounted collectors

System Definition › Collector Array › Installation › Calculation



Defaults:

Description	Value	Unit
b	1,00	m
h	0,50	m
Beta	30,00	°
Gamma	19,50	°
Gamma at	21.12. 12:00	-

Entries:

Alpha 0,00 ° (Alpha < 25.00)

Results:

Description	Value	Unit
d	2,28	m
d1	1,41	m

Image: Dialog for defining the minimum distance between mounted collectors

The minimum distance of mounted collectors is calculated in this dialog, on the condition that the collectors should not shade each other at 12.00 pm on the winter solstice.

The suggested distance is a function of the tilt ß (beta), the solar angle γ (gamma) at 12.00 pm on 21/12, and the installation height (b) of the collector.

The program then calculates the minimum distance between the collectors *d* between the supporting points of the collectors and the free distance *d1* between the collectors.

è How to proceed:

1. Enter the width *b* of the collector.

2. Enter the angle *alpha* of the installation surface.

The height *h* of the collector array is calculated by the program.

The tilt angle *ß* is taken from the *Collector Array* dialog.

The solar position *γ* at 12.00 pm on December 21 is calculated by the program.

3. Exit the calculation by clicking *OK*.

Mutual shading of the collectors is not taken into consideration in the calculations.

7.3.4 Roof layout with Photo Plan

System definition › Collector array › Photo Plan

Page *PV module › Preview of the roof configuration with Photo Plan*

Using Photo Plan, you can create a photorealistic plan of your roof areas.

è How to proceed:

1. There are two detailed instructional videos on how to use Photo Plan (see below). It is recommended that you view the introductory video.
2. With just a few entries on the geometry of the roof, it is possible to gain an impression of the future look of the roof areas. You require only a photo of the roof. Photo Plan imports the dimensions for the selected module from T*SOL.
3. Here you can export the roof with some solar thermal modules as a Photo Plan project, and import it into PV*SOL in order to fit the remaining area with photo-voltaic modules in PV*SOL. Of course, you can also do this in the reverse order.
4. Since in the case of solar thermal modules - unlike PV modules - the roof is not generally covered with modules, you must also enter the number of modules (rows and columns) as well as the frame color when selecting the *solar thermal systems* product.
5. In addition, Velux® skylights and Braas® roof tiles can be included and displayed.
6. The finished photo and number of modules is imported from T*SOL.

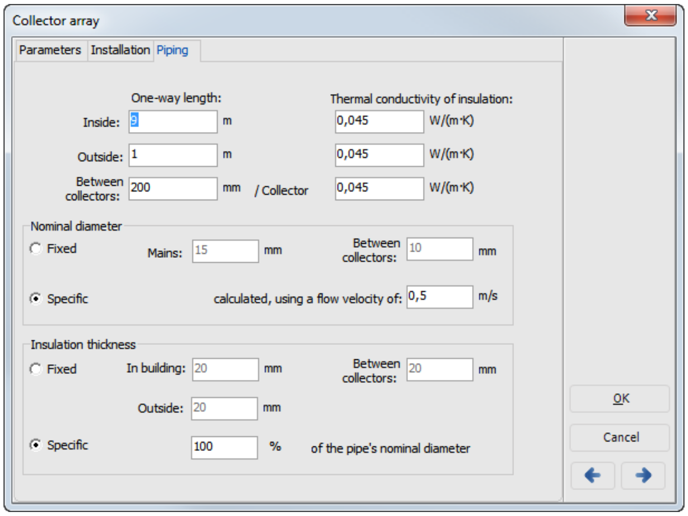
è See also:

- Photo Plan - Introductory video: http://valentin-tutorials.s3.amazonaws.com/PhotoPlanTutorials/EN/PhotoPlan_EN_1/PhotoPlanEN1.html

- Photo Plan - Advanced functionality: http://valentin-tutorials.s3.amazonaws.com/PhotoPlanTutorials/EN/PhotoPlan_EN_2/PhotoPlanEN2.html

7.3.5 Piping

System Definition › Collector Array › Piping



One-way length:
Inside: 9 m
Outside: 1 m
Between collectors: 200 mm / Collector

Thermal conductivity of insulation:
0,045 W/(m·K)
0,045 W/(m·K)
0,045 W/(m·K)

Nominal diameter
○ Fixed Mains: 15 mm Between collectors: 10 mm
● Specific calculated, using a flow velocity of: 0,5 m/s

Insulation thickness
○ Fixed In building: 20 mm Between collectors: 20 mm
Outside: 20 mm
● Specific 100 % of the pipe's nominal diameter

Image: Dialog for the piping of the collector array

The following information is entered on the *Piping* page:

The single length of piping and the thermal conductivity coefficient for insulation is subdivided and entered for inside, outside, and between the collectors. The distinction influences the calculation of piping losses.

The nominal diameter of the pipes in the solar loop can be directly entered or calculated.

If you select specific, the program calculates the pipe diameter after you have entered the flow velocity. As the calculation results in inexact values, the program automatically selects the next large DIN nominal pipe diameter. Manual changes are possible at any time.

The thickness of insulation can be entered exactly or as % of nominal diameter. In this case, the following insulation thicknesses are available: 20mm, 30mm, 40mm, 50mm, 65mm, 80mm, and 100mm. For values up to 80mm, the thickness of the insulation is set to the next higher nominal diameter, while a nominal diameter of 100mm is calculated for values above 80mm. The specific setting of 100% is recommended, i.e. the thickness of the insulation approximates the nominal diameter.

7.4 Tanks

System Definition › Tank or system schematic

Different types of tanks are loaded depending on the system. The following tank types are included:

- Single coil DHW tank
- Dual coil DHW tank
- Heating buffer tank
- Combination tank (internal heat exchanger or tank in tank)

- Buffer tank (external heat exchanger)
- DHW tank (external heat exchanger)

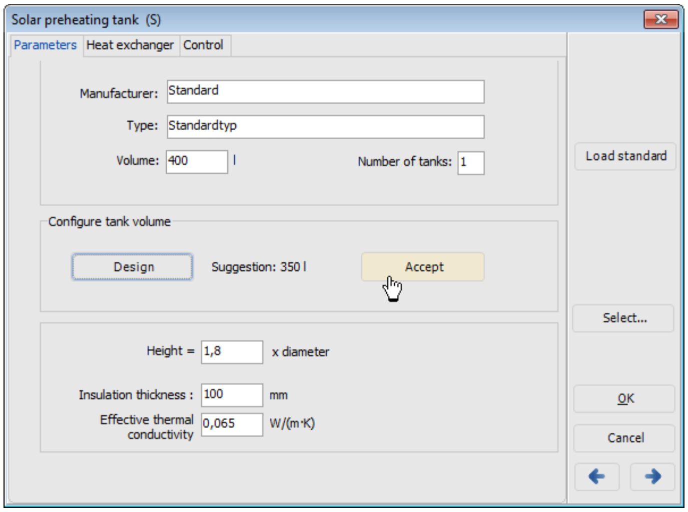
The values which must be input and therefore the pages in the input dialog vary depending on the tank.

è Chapter 7.4.1 describes general tank parameters.

è Chapter 7.4.2 describes parameters for specific tank types.

7.4.1 Tank Parameters

System Definition › Tank › Parameters



Manufacturer: Standard

Type: Standardtyp

Volume: 400 l

Number of tanks: 1

Configure tank volume

Design

Suggestion: 350 l

Accept

Height = 1,8 x diameter

Insulation thickness : 100 mm

Effective thermal conductivity 0,065 W/(m·K)

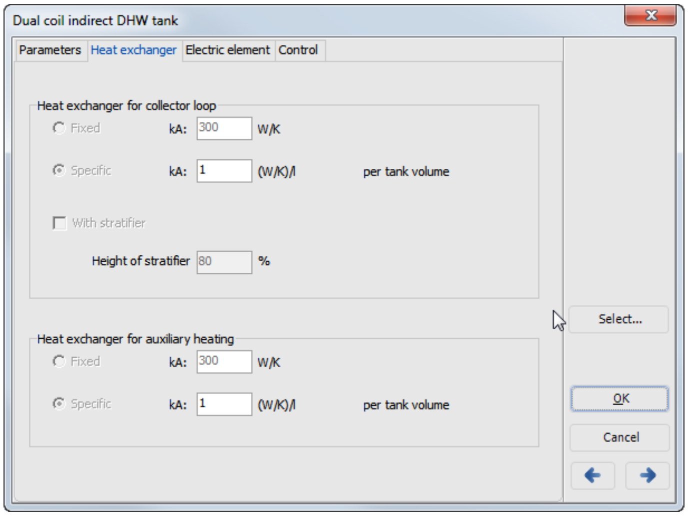
Image: Input dialog for tank parameters, example single coil tank

è Proceed as follows:

1. Select a tank by clicking the *Select* button to load a tank from the database.
   - OR: If you don't know the specific auxiliary heat, you can use the default auxiliary heat for the simulation:
     Click on *Load standard*. The standard rated output is always the same for any given type of system.
   - OR: Configuration of the tank volume
     - Click on *Design*. This enters correct tank volume for the given system and consumption.
     - You can *accept* this tank volume.
2. Where required, modify the pre-entered values.
   For standard tanks, you can modify the volume, the number of tanks, the relation of height / diameter, the insulation thickness, and the thermal conductivity on the *Parameters* page.
   The insulation properties are defined by the information on the thickness of the heat insulation and the thermal conductivity of the insulation. You set the thermal losses of the tank.
3. Save all entries by clicking *OK* or go to the next parameter dialog using the arrow button ← →.

Tank Heat Exchanger

System Definition › Tank › Heat Exchanger



Dual coil indirect DHW tank

Heat exchanger for collector loop

○ Fixed kA: 300 W/K

● Specific kA: 1 (W/K)/l per tank volume

☐ With stratifier

Height of stratifier 80 %

Heat exchanger for auxiliary heating

○ Fixed kA: 300 W/K

● Specific kA: 1 (W/K)/l per tank volume

Image: Tank dialog, Heat Exchanger page: example dual coil tank

The values shown on the *Heat Exchanger* page describe the quality of the internal heat exchanger used and cannot be modified. If you have selected a tank with stratification, the height of the stratifier in relation to the tank height is shown.

Tank Control

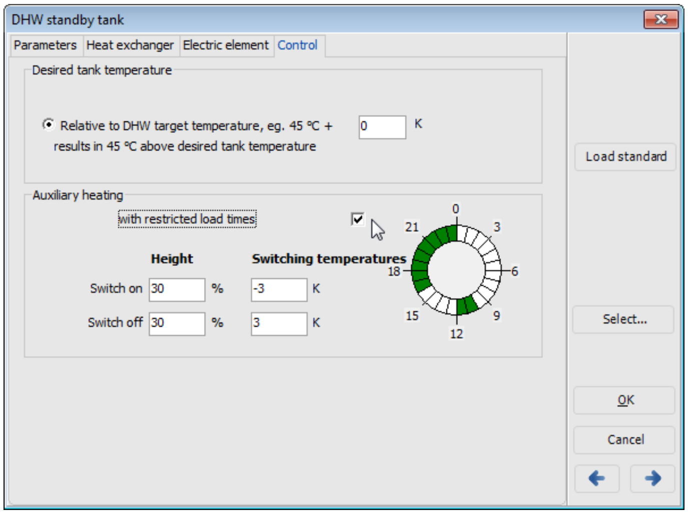
System Definition › Tank › Control

The majority of tank dialogs have a *Control* page on which the *switching temperatures*, like switch on/off, maximum temperature limit, can be set. The required values differ depending on the purpose of the tank.

7.4.2 Tank types

7.4.2.1 Single coil DHW tank

System Definition › Tank › Control or system schematic



DHW standby tank

Desired tank temperature

● Relative to DHW target temperature, eg. 45 °C + 0 K results in 45 °C above desired tank temperature

Auxiliary heating

with restricted load times ☑

	Height		Switching temperatures	
Switch on	30	%	-3	K
Switch off	30	%	3	K

Image: Single coil DHW tank, used as standby tank, Control page

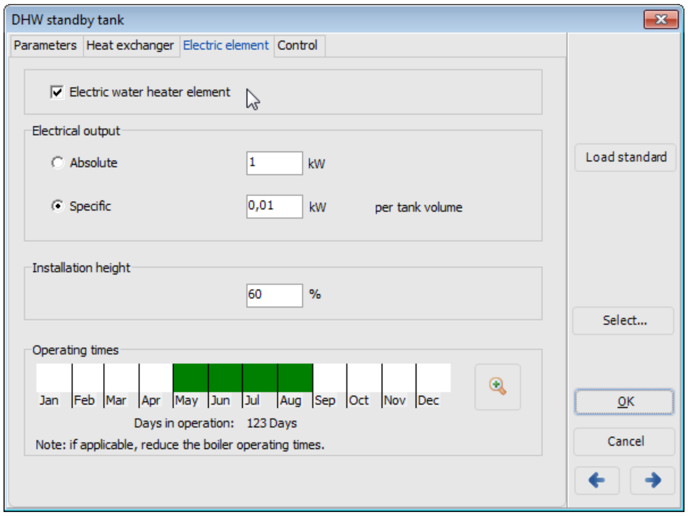
This tank type is used as a solar and standby tank in the two tank system (A2).

If it is used as a solar tank, the maximum temperature limit can be changed on the *Control* page. The positions of the measurement sensors for switching on and off and for limiting the maximum temperature are displayed.

For standby tanks,the *desired tank temperature* with respect to the DHW target temperature (see DHW Consumption) and the switching temperatures for the auxiliary heating are displayed and can be changed.

If the checkbox next to ☑ *With Restricted Load Times* is activated, the switching times can be defined using the clock (green area = tank can be loaded, gray area = tank is not loaded, irrespective of its operating state).

Under *Height*, the position of the temperature sensor in the tank for regulating the boiler is displayed. The switching temperatures are entered in relation to the desired tank temperature.



☑ Electric water heater element

Electrical output

○ Absolute 1 kW

● Specific 0,01 kW per tank volume

Installation height

60 %

Operating times

Days in operation: 123 Days

Note: if applicable, reduce the boiler operating times.

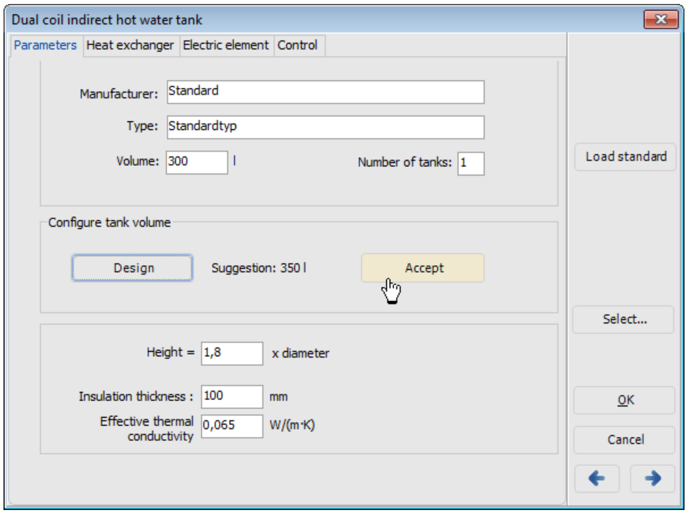
Image 10.6.4: Single coil DHW tank, used as standby tank, see Electric Heating Element

For the standby tank you can plan
- an ☑ *Electrical Heating Element* by ticking the checkbox you can enter its electrical output either as an absolute value or related to the tank volume.
- The respective other value is calculated and displayed.

The operating times of the heating element are defined by clicking the fields in the month bar for entire months or, by using the magnifier, for individual days.

7.4.2.2 Dual coil DHW tank

System Definition › Tank or system schematic



Manufacturer: Standard
Type: Standardtyp
Volume: 300 l
Number of tanks: 1

Configure tank volume

Suggestion: 350 l

Height = 1,8 x diameter
Insulation thickness : 100 mm
Effective thermal conductivity 0,065 W/(m·K)

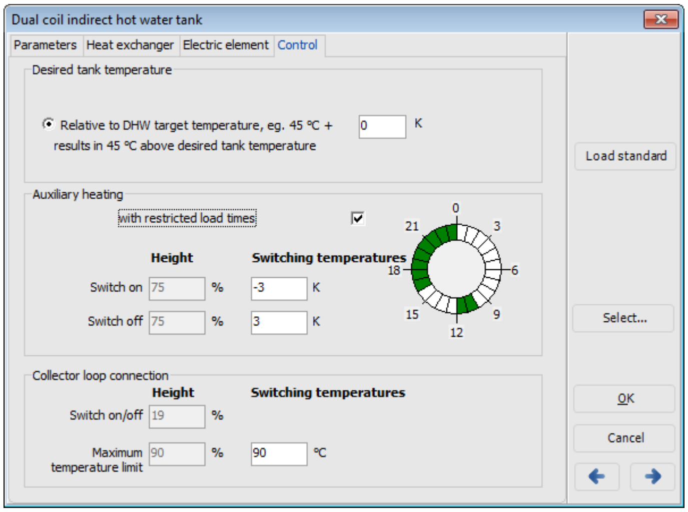
Image: Input dialog for dual coil DHW tank

The type of tank serves as a solar tank in the lower areaand as a standby tank below the bottom connection to the boiler.

On the *Parameters*page, the volume per m² of collector surface area for the solar tank area and the percentage of average daily consumption for the part serving as the standby tank are calculated and shown.

On the *Heating Element* page, you can provide an *electric water heating element* for the tank:
- tick the checkbox ☑ *Electrical Heating Element* and enter its electrical output either as an absolute value or related to the tank volume.
- The respective other value is calculated and displayed.

The operating times of the heating element are defined by clicking the fields in the month bar for entire months or, by using the magnifier, for individual days.



Desired tank temperature

● Relative to DHW target temperature, eg. 45 °C + 0 K results in 45 °C above desired tank temperature

Auxiliary heating

with restricted load times ☑

	Height		Switching temperatures	
Switch on	75	%	-3	K
Switch off	75	%	3	K

Collector loop connection

	Height		Switching temperatures	
Switch on/off	19	%		
Maximum temperature limit	90	%	90	°C

Image: Input dialog for dual coil DHW tank, *Control* page

è Define on the *Control* page:

1. The desired tank temperature with respect to the DHW target temperature (see *DHW Consumption*),

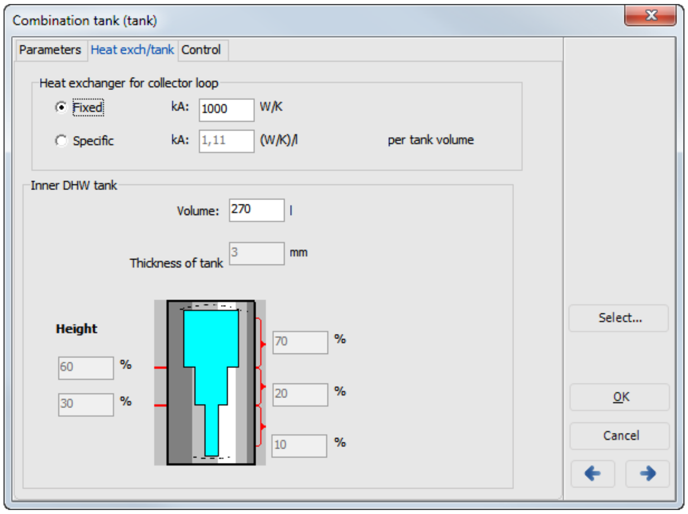
2. the switching temperatures for the auxiliary heating can be changed.
   Under *Height*, the position of the temperature sensor in the tank is displayed.
   The switching temperatures are entered in relation to the desired tank temperature.
3. If the checkbox next to ☑ *With restricted load times* is activated, the switching times can be defined using the clock (green area = tank can be loaded, gray area = tank is not loaded, irrespective of its operating state).
4. In the *Collector Loop Connection* section, the position of the measurement sensors for switching on and off the collector loop and the *maximum temperature limit* of the tank are displayed. The maximum temperature limit can be changed.

7.4.2.3 Combination tank

System Definition › Tank or system schematic

Combination tank in tank

System Definition › Tank › Heat Exchanger / Tank



Heat exchanger for collector loop
● Fixed kA: 1000 W/K
○ Specific kA: 1,11 (W/K)/l per tank volume

Inner DHW tank
Volume: 270 l
Thickness of tank 3 mm

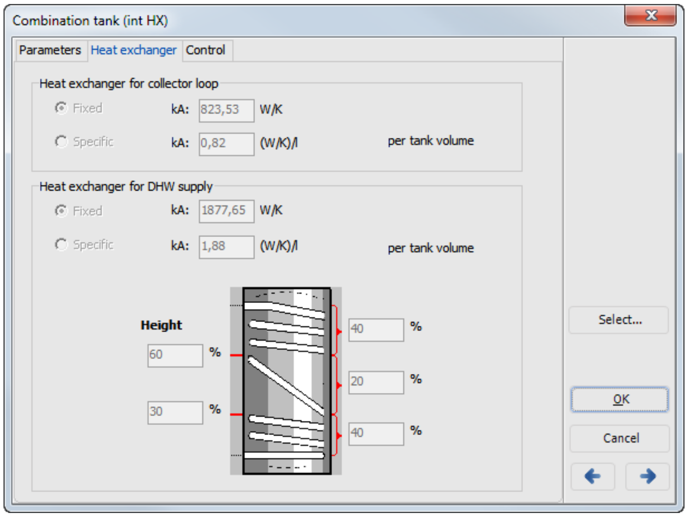
Height
60 %
30 %
70 %
20 %
10 %

Image: Input dialog for tank in tank system, *Heat Exchanger / Tank* page

On the *Heat Exchanger / Tank* page, the internal tank for supply of hot water volume is defined. The geometry of the internal tank is displayed only and cannot be changed.

Combination tank with internal heat exchanger

System Definition › Tank › Heat Exchanger



Heat exchanger for collector loop

● Fixed kA: 823,53 W/K

○ Specific kA: 0,82 (W/K)/l per tank volume

Heat exchanger for DHW supply

● Fixed kA: 1877,65 W/K

○ Specific kA: 1,88 (W/K)/l per tank volume

Height

60 %

30 %

40 %

20 %

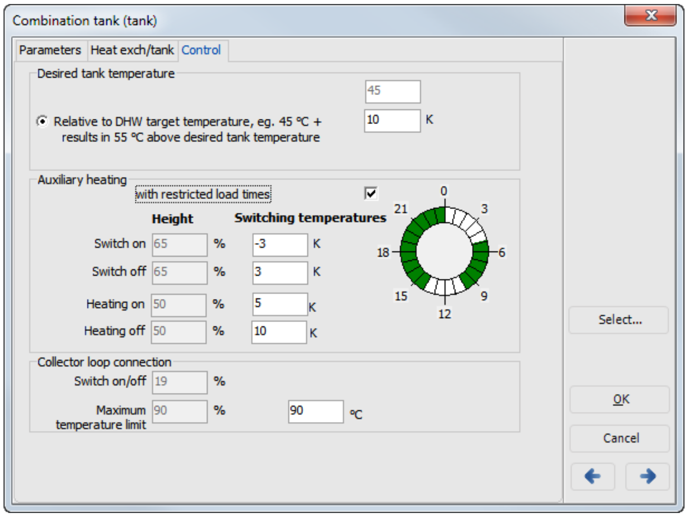
40 %

Image: Input dialog for combination tank with internal heat exchanger, *Heat Exchanger* page

On the *Heat Exchanger* page, the definition and distribution of the internal heat exchanger for DHW supply (heat exchanger parameters) are displayed, but cannot be modified.

Combination tank control

System Definition › Tank › Control



Desired tank temperature

45

● Relative to DHW target temperature, eg. 45 °C + results in 55 °C above desired tank temperature 10 K

Auxiliary heating

with restricted load times ☑

	Height		Switching temperatures	
Switch on	65	%	-3	K
Switch off	65	%	3	K
Heating on	50	%	5	K
Heating off	50	%	10	K

Collector loop connection

Switch on/off 19 %

Maximum temperature limit 90 % 90 °C

Image: Input dialog for combination tank, *Control* page

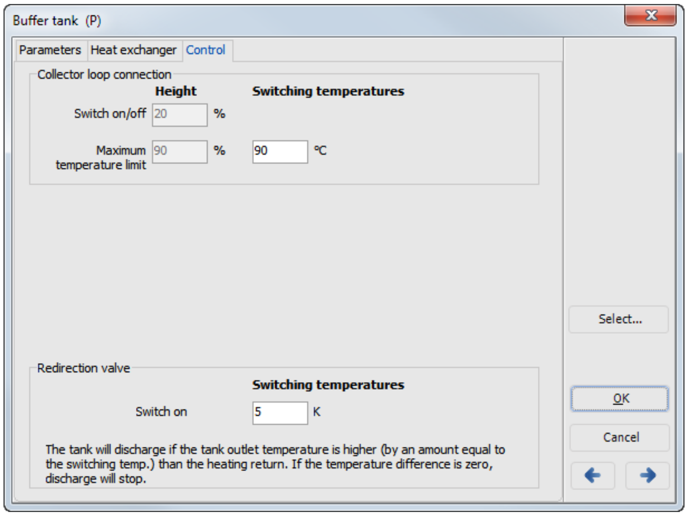
Both the desired tank temperature relative to the DHW target temperature and the switching temperatures for switching on the auxiliary heating relative to the input desired tank temperature at the temperature sensor of the auxiliary heating are entered under Control. Please note that the desired tank temperature must be considerably higher than the DHW target temperature, so that corresponding heat transfer between the DHW tank or the internal heat exchanger and the external buffer capacity can take place.

In the *Collector Loop Connection* section, the position of the measurement sensors for switching on and off the collector loop and the *maximum temperature limit* of the tank are displayed. The maximum temperature limit can be changed.

In the *Redirection Valve* section, the temperature difference for switching the three-way valve in the heating return is defined. If the total of tank temperature in the boiler return and input temperature is higher than the temperature in the heating return, the heating return is redirected in the tank, which is therefore unloaded.

7.4.2.4 Heating buffer tank

System Definition › Tank › Control or system schematic



Collector loop connection

	Height		Switching temperatures	
Switch on/off	20	%		
Maximum temperature limit	90	%	90	°C

Redirection valve

	Switching temperatures	
Switch on	5	K

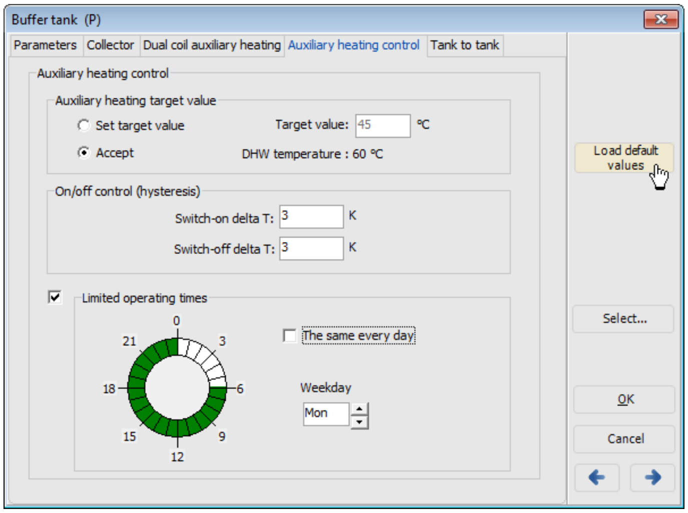
The tank will discharge if the tank outlet temperature is higher (by an amount equal to the switching temp.) than the heating return. If the temperature difference is zero, discharge will stop.

Image: Input dialog for heating buffer tank, *Control* page

On the *Control* page, the single coil heating buffer tanks have the same input parameters as the single coil DHW tanks with the sole addition of an input field for defining the switching temperature of the three-way valve in the *Redirection Valve*section. Here, the temperature difference for switching the three-way valve in the heating return is defined. If the total of upper tank temperature in the boiler return and input temperature is higher than the temperature in the heating return, the heating return is redirected in the tank, which is therefore unloaded.

7.4.2.5 Buffer tank with external heat exchanger

System Definition › Tank › Lower Collector Loading o or *› Cont. Auxiliary Heating* or *› Flow*



Auxiliary heating control

Auxiliary heating target value

○ Set target value Target value: 45 °C

● Accept DHW temperature : 60 °C

On/off control (hysteresis)

Switch-on delta T: 3 K

Switch-off delta T: 3 K

☑ Limited operating times

☐ The same every day

Weekday: Mon

Image: Input dialog for buffer tank with external heat exchanger, *Auxiliary Heating Control* page

Systems A18, B18, A17, B17 contain buffer tanks

The buffer tanks with direct loading and unloading can take varying forms depending on the system schematic selected.

On the separate pages, the inlets and outlets of the different piping pairs for loading and unloading the tank as well as the respective specific losses of the piping inlets and the installation height of the temperature sensors are displayed but cannot be modified.

On the *Lower Collector Loading* (buffer tank with auxiliary heating) or *Upper Collector Loading* (buffer tank without auxiliary heating) pages, only the maximum tank temperature may be entered.

No changes can be made on the *Dual Coil Auxiliary Heating* page.

On the *Cont. Auxiliary Heating* page, the desired tank temperature for the auxiliary heating is defined and entered in relation to the desired tank temperature for the switch-on / switch-off temperatures of the boiler.

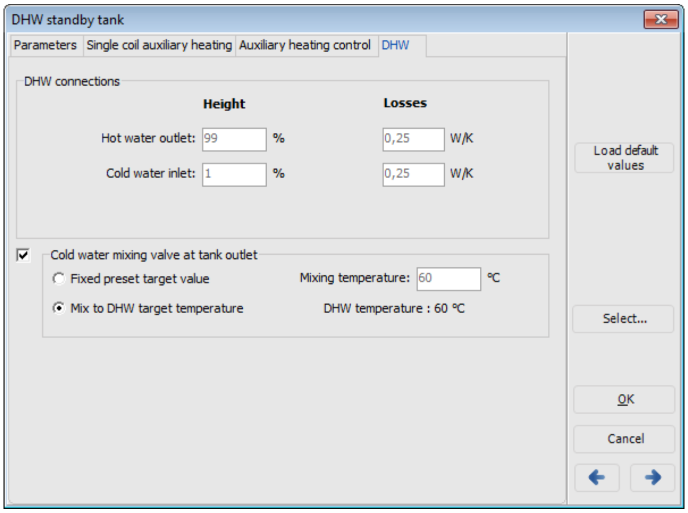
If you activate the *Fixed* field, you can predetermine the target temperature in the buffer tank. On activating the *Accept* field, the buffer tank target temperature, depending on operating state and requirements, is either the temperature required to load the water heater or for supplying the heating loop.

In the limited operating times field, the auxiliary heating of the tank can be cut off for specific times of the day.

The *Flow* page specifies the connections for unloading the tank.

7.4.2.6 DHW tank with external heat exchanger

System Definition › Tank › DHW or system schematic



DHW connections

Height Losses

Hot water outlet: 99 % 0,25 W/K

Cold water inlet: 1 % 0,25 W/K

☑ Cold water mixing valve at tank outlet

○ Fixed preset target value Mixing temperature: 60 °C

● Mix to DHW target temperature DHW temperature : 60 °C

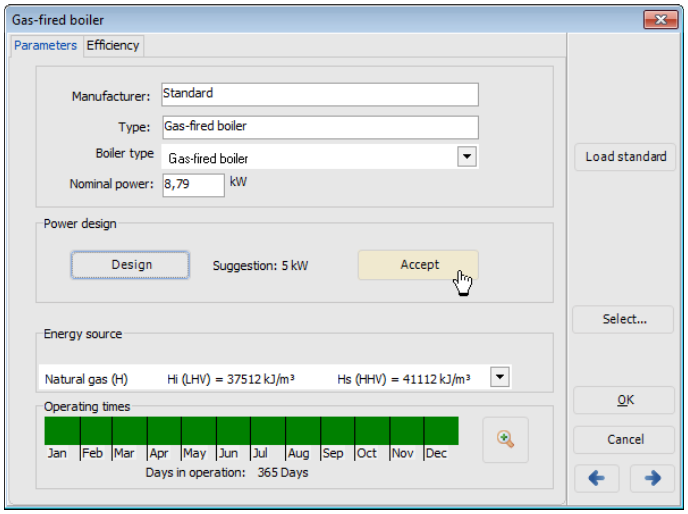
Image: Input dialog for *DHW tank* with internal heat exchanger, *DHW* page

The DHW standby tank and preheating tank with direct loading and unloading can take varying forms depending on the system schematic selected.

These tanks only differ from buffer tanks in the additional *DHW* page, on which a cold water mixing valve at the tank outlet can be set in addition to the display of connection heights and connection losses.

7.5 Auxiliary Heating

System Definition › Gas Boiler › Parameters or system schematic



Manufacturer: Standard

Type: Gas-fired boiler

Boiler type Gas-fired boiler

Nominal power: 8,79 kW

Power design

Suggestion: 5 kW

Energy source

Natural gas (H) Hi (LHV) = 37512 kJ/m^3 Hs (HHV) = 41112 kJ/m^3

Operating times

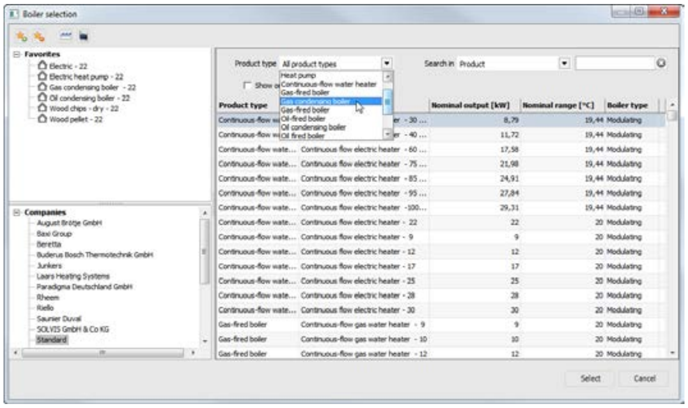
Days in operation: 365 Days

Image: Input dialog for auxiliary heating

The auxiliary heating ensures that the target tank temperature set in the tank dialog is maintained when solar irradiation is insufficient and, in systems with space heating, also supplies the heating loops.

è Proceed as follows:

1. Open the auxiliary heating by clicking *Select*.



Product type		Nominal output [kW]	Nominal range [°C]	Boiler type
Continuous-flow wa	er - 30 ...	8,79	19,44	Modulating
Continuous-flow wa	er - 40 ...	11,72	19,44	Modulating
Continuous-flow wate...	Continuous flow electric heater - 60 ...	17,58	19,44	Modulating
Continuous-flow wate...	Continuous flow electric heater - 75 ...	21,98	19,44	Modulating
Continuous-flow wate...	Continuous flow electric heater - 85 ...	24,91	19,44	Modulating
Continuous-flow wate...	Continuous flow electric heater - 95 ...	27,84	19,44	Modulating
Continuous-flow wate...	Continuous flow electric heater -100...	29,31	19,44	Modulating
Continuous-flow wate...	Continuous flow electric heater - 22	22	20	Modulating
Continuous-flow wate...	Continuous flow electric heater - 9	9	20	Modulating
Continuous-flow wate...	Continuous flow electric heater - 12	12	20	Modulating
Continuous-flow wate...	Continuous flow electric heater - 17	17	20	Modulating
Continuous-flow wate...	Continuous flow electric heater - 25	25	20	Modulating
Continuous-flow wate...	Continuous flow electric heater - 28	28	20	Modulating
Continuous-flow wate...	Continuous flow electric heater - 30	30	20	Modulating
Gas-fired boiler	Continuous-flow gas water heater - 9	9	20	Modulating
Gas-fired boiler	Continuous-flow gas water heater - 10	10	20	Modulating
Gas-fired boiler	Continuous-flow gas water heater - 12	12	20	Modulating

Image: Dialog for boiler selection

2. Select one of the auxiliary heating systems types:
3. Heat pump

4. Continuous-flow water heater

    - Gas-fired boiler
    - Gas condensing boiler
    - Gas-fired boiler (small)
    - Oil boiler
    - Oil condensing boiler
    - Oil-fired boiler (small)
    - Wood-fired boiler
    - Solid fuel boiler
    - Pellet-fired boiler
    - District heating
    - Combined heat and power station (CHP)

5. Select one of the auxiliary heating systems by clicking it in the list on the right side.

6. Confirm the selection *Select*. The dialog *‹auxiliary heating type›* › *Parameters* is displayed again.
OR: If you don't know the specific auxiliary heat, you can load the standard auxiliary heat for the simulation:
- Click on *Load standard*. The standard rated output is always the same for any given type of system.
OR: Configuration of the output
- Click on *Design*. This enters correct output for the system and consumption.
- You can *accept* this output.

7. Set the *Operating Times* of the boiler:
Click on the month fields to set operation for entire months (green area = boiler in operation).

An annual view can be accessed by clicking on the magnifier 🔍, in which you can switch individual days on and off.

8. Save all entries by clicking *OK* or go to the next parameter dialog using the arrow button ← →.

Efficiency

System Definition, e.g. *System Definition › Gas Boiler › Efficiency*

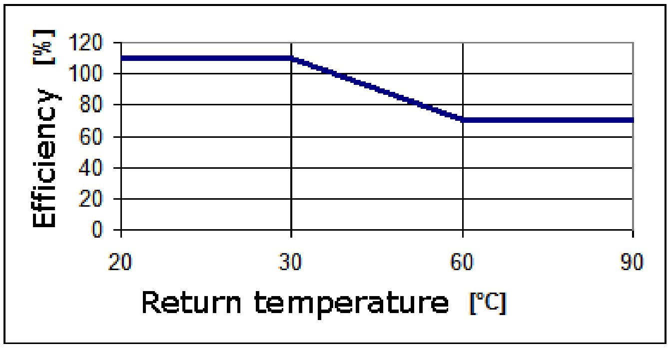


Image: Definition of efficiency curve in relation to the return temperature

On the *Efficiency* page, you can set the *Heating Efficiency* for heating using two variables, depending on the return temperature:

The efficiency calculation will use either the lower heating value H_u (LHV) or the higher heating value H_o (HHV). The other value is displayed only.

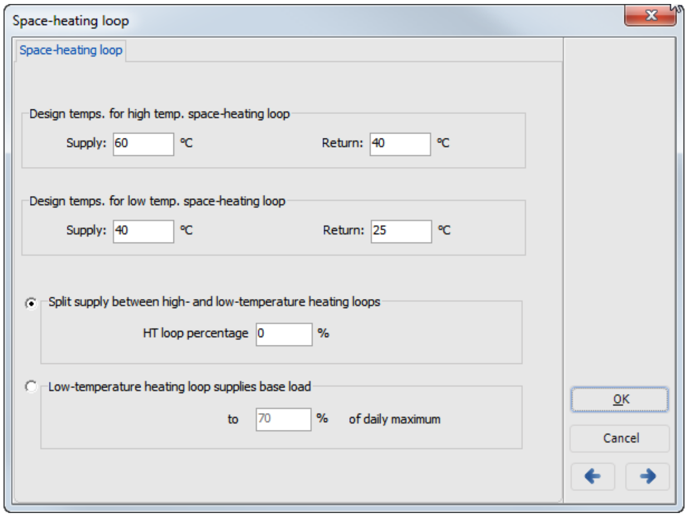
! Define on the page *System Definition › System› Savings*, whether calculations should be made in relation to the higher or lower heating value for this system.

! Define on the page *Options › Site Data › Units*, whether calculations should be made in relation to the higher or lower heating value for all new projects.

For outside temperatures above 14°C and without heating, the fixed efficiency for DHW supply is used for calculation.

7.6 Heating Loop

System Definition › Heating Loop



Design temps. for high temp. space-heating loop
Supply: 60 °C Return: 40 °C

Design temps. for low temp. space-heating loop
Supply: 40 °C Return: 25 °C

● Split supply between high- and low-temperature heating loops
HT loop percentage 0 %

○ Low-temperature heating loop supplies base load
to 70 % of daily maximum

Image 10.8.1: Input dialog for the heating loop

The operating conditions of the heating loops must be set for all systems with space heating.

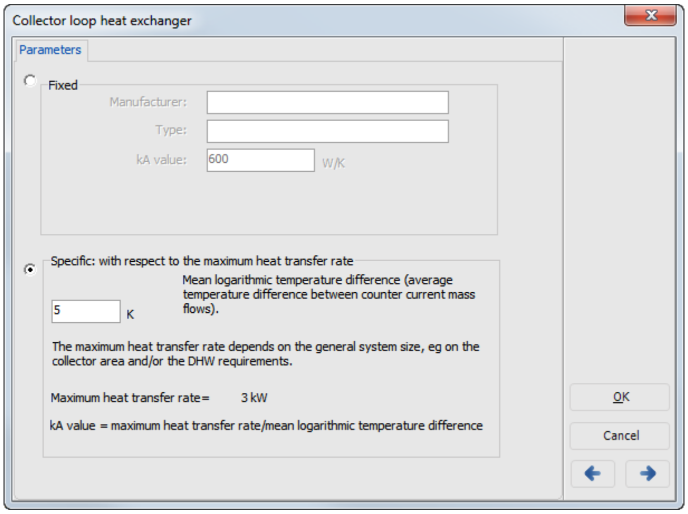
è Proceed as follows:

1. Define two heating loops, e.g. a high-temperature space heating loop (radiator) and a low temperature space heating loop (underfloor) via the respective supply and return temperatures. The two heating loops need not have different supply temperatures.

2. You can change the percentage split between the heating loops.
   0% means, this loop is removed from the system.
3. Choose between:
   percentage ● *split supply between high- and low-temperature heating loops*,
   or you can also determine up to what percentage of the daily maximum only the ● *low-temperature loop supplies base load*.

7.7 External Heat Exchanger

System Definition › External Heat Exchanger or system schematic


Collector loop heat exchanger

Parameters

○ Fixed

Manufacturer:

Type:

kA value: 600 W/K

● Specific: with respect to the maximum heat transfer rate

5 K Mean logarithmic temperature difference (average temperature difference between counter current mass flows).

The maximum heat transfer rate depends on the general system size, eg on the collector area and/or the DHW requirements.

Maximum heat transfer rate= 3 kW

kA value = maximum heat transfer rate/mean logarithmic temperature difference

Image: Input dialog for the external heat exchanger

The quality of heat exchange can be defined in this dialog. Either the kA value or a specific value of the mean logarithmic temperature difference, from which the kA value can then be calculated, is entered. A suitable value for maximum output is hereby calculated from the system parameters.

If you enter a kA value, this value is used for the simulation without conversion. The logarithmic temperature difference is accordingly displayed, but has no further influence on the simulation.

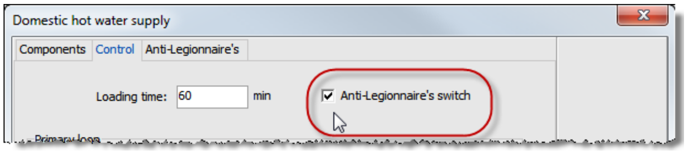
In external heat exchangers for connection to a collector array, this value is calculated from 500 W/m² collector surface area.

In external heat exchangers for connection of the buffer tank discharge to the DHW supply, P_{max} is calculated from the pump flow rates and the maximum possible temperature difference.

In heat exchangers for auxiliary heating of a swimming pool, Pmax is calculated by the power which would be required to heat the swimming pool from the cold water temperature to the target swimming pool temperature within 12 hours.

7.8 Anti-Legionnaire's Switch

System Definition › DHW Supply

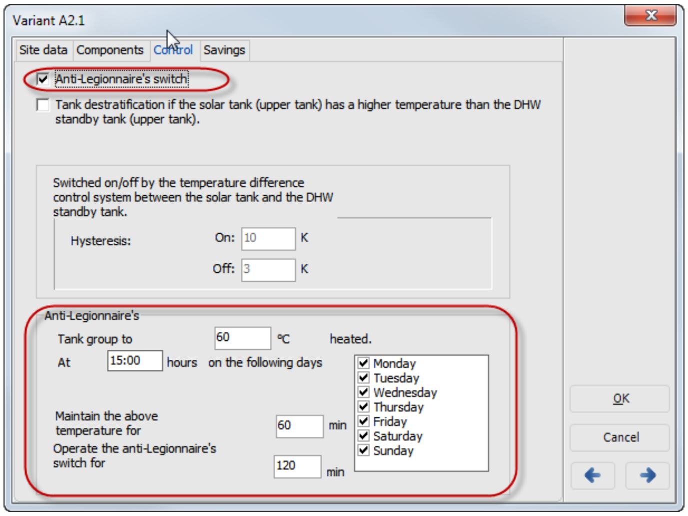

Domestic hot water supply

Components Control Anti-Legionnaire's

Loading time: 60 min

☑ Anti-Legionnaire's switch

Image: Input dialog for Legionnaire's switch



☑ Anti-Legionnaire's switch

☐ Tank destratification if the solar tank (upper tank) has a higher temperature than the DHW standby tank (upper tank).

Switched on/off by the temperature difference control system between the solar tank and the DHW standby tank.

Hysteresis: On: 10 K

Off: 3 K

Anti-Legionnaire's

Tank group to 60 °C heated.

At 15:00 hours on the following days

☑ Monday
☑ Tuesday
☑ Wednesday
☑ Thursday
☑ Friday
☑ Saturday
☑ Sunday

Maintain the above temperature for 60 min

Operate the anti-Legionnaire's switch for 120 min

Here, you can enter the temperature to which the tank is to be heated. In addition, you can enter the time and duration of validity of these control parameters. The maximum operating time is relevant in the event that the set temperature is not reached.

The entries in the image show that the tank is heated to 60 °C every day at 3.00 pm, maintained at this temperature for 60 minutes, and the anti-Legionnaire's switch is switched off at the latest after 120 minutes, even if 60 minutes at 60 °C have not yet been reached.

The reference sensor for switching off this control is different in every system:

- Buffer tank system: Temperature sensor *Switch off auxiliary heating* in the DHW standby tank
- Systems with Solar and Standby Tank: Temperature sensor *Collector array on / off* in the solar tank
- Systems with dual coil DHW supply: Temperature sensor *Anti-Legionnaire's switch* in the DHW standby tank

8 Calculations

Once you have selected a system, provided it with climate data, and defined your parameters, you can run a simulation.

8.1 Simulation

Simulation

After setting the parameters of the solar system, you can now simulate its operational state over the period of a year. A detailed description of the simulation calculations can be found in chapter 3.2 Bases of Calculation.

è How to proceed:

1. If you start the simulation via the button, it will be immediately calculated with the currently preset values. By default, the simulation is run for one year from 1/1 to 12/31.
2. Click on the Visualization symbol to observe the temperature profiles in the system.

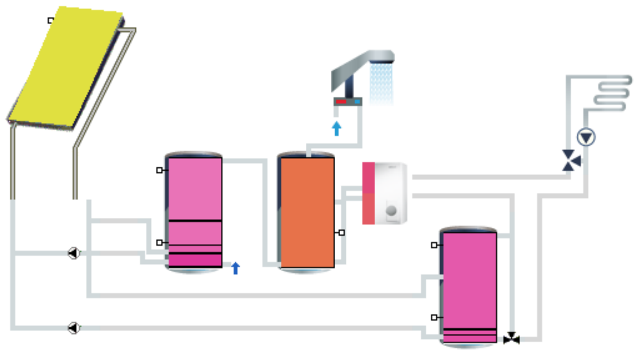
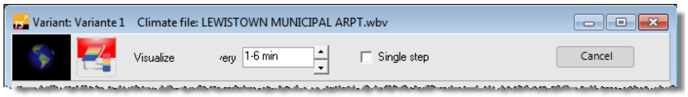


Image: Visualization: display of component temperatures during the simulation.

Example DHW system (2 tanks) with stratification and heating buffer tank



Variant: Variante 1 Climate file: LEWISTOWN MUNICIPAL ARPT.wbv

Image: Visualization: setting the simulation interval during the simulation.

The size of the simulation interval varies between one and six minutes depending on the inertia of the system resulting from the capacity and energy supply. Set your desired simulation interval and, if you wish, switch to a view in single steps. The respective time is displayed in the footer bar of the window.

Click on the symbol again to return to the quick mode.

3. At the end of the simulation, a selection dialog for project reports, graphical evaluation, and the financial analysis opens.

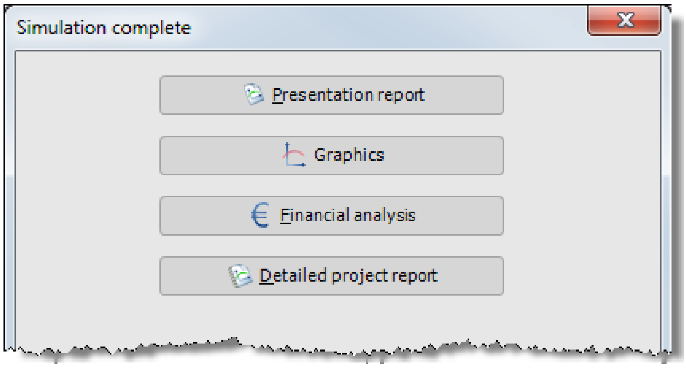
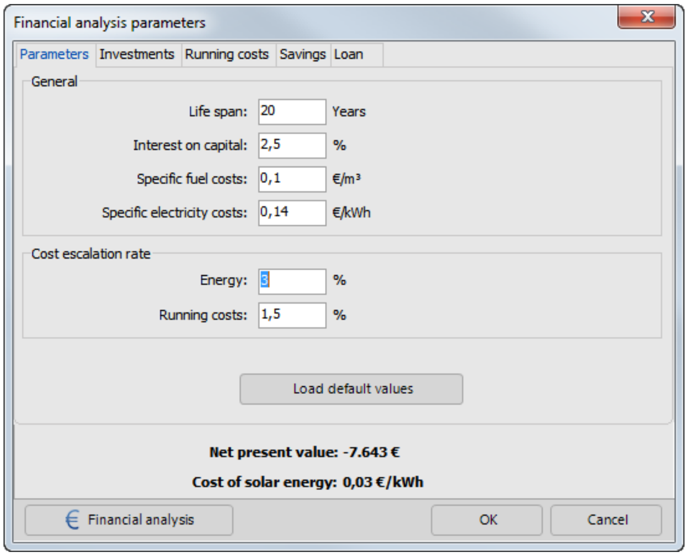


Image: Selection dialog at end of simulation

- However, you can also exit the dialog by clicking *Close* and continue to work via the menus or symbols.

8.2 Financial Analysis

€ *Financial Analysis*



General

Life span: 20 Years

Interest on capital: 2,5 %

Specific fuel costs: 0,1 €/m³

Specific electricity costs: 0,14 €/kWh

Cost escalation rate

Energy: 3 %

Running costs: 1,5 %

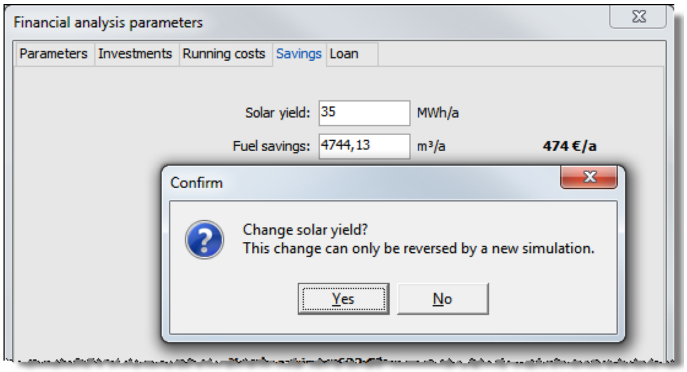
Net present value: -7.643 €

Cost of solar energy: 0,03 €/kWh

Image: Input dialog for financial analysis

The results of an annual simulation are the prerequisite for the economic efficiency calculation. A parameter setting dialog with several pages is opened.

The preset parameters are in part taken from the *Option s › Default settings › Financial analysis* dialog and can be changed here for the specific system.



Solar yield: 35 MWh/a

Fuel savings: 4744,13 m³/a **474 €/a**

Change solar yield?
This change can only be reversed by a new simulation.

Image: Changing the financial analysis parameters from the simulation

The other parameters are simulation results. If you modify these values, a warning appears to inform you that the change can only be reversed by running a new simulation.

! Until then, the program runs with the value entered manually here.

8.2.1 Results of the Financial Analysis

The *Net Present Value* and *Cost of Solar Energy* shown below are updated at the latest when the cursor is placed in a different input field following entry of these values. As a result, you can see the influence of the changes immediately.

For the net present value, savings and operating costs are discounted to the current day (life span, price increase rate) and compared with the investment costs less subsidies. Positive net present values indicate an investment which can be assessed as economically positive.

For the cost of solar energy, the investment costs less subsidies as well as the operating and maintenance costs in annuities (life span, price increase rate) are assessed in relation to the solar heat supplied.

Click on the button *Financial analysis* to access a preview of the results. This preview can be enlarged or reduced in size by using the magnifiers.

Financial Analysis Input Parameters

Page *Parameters*:

Life span
The period stated by the manufacturer in which the system can be expected to be in operation. Between 10 and 20 years are estimated for solar systems.

Interest on capital
The interest on capital is the interest rate at which capital for the investment must be borrowed from a bank or that at which the deployed capital could yield interest.

Price increase rate
The development of running and fuel costs play a key role for the net present value.

Page *Investments:*

Investments
The investments can be stated as a specific amount or as specific costs in €/m² of collector surface area.

Subsidy
The subsidy can be stated as a specific amount, as a percentage of the investments, or as a specific subsidy in €/m² of collector surface area.

Page *Running Costs*

Costs
The fixed running costs of the system can be stated as an annual amount or as a percentage of the investments per year.
The running costs of the pumps are results of the running time, pump output, and electricity costs calculated by the simulation.

Page *Savings*:

The specific fuel price is taken from the *Options › Site Data* dialog. It can be changed for the system under consideration.

By varying the values for the solar yield and the fuel savings calculated by the simulation, you can, for example, determine the values for which the system would be economically efficient.

! However, as these changed values no longer correspond to the simulation results, you will see a warning. It is a better idea to optimize your system and obtain better values this way.

Page *Loans*:

Up to three loans can be defined.

Loan capital
The amount of the loan taken out in €.

Term
Period of time agreed for paying back the loan.

In addition, either the annual installment or the loan interest must be entered. The respective other field is then automatically calculated by the program.

Annual installment
The constant annual installment with which the loan and interest are payed back within the term.

Loan interest
The interest rate which applies to the loan when it is taken out.
If the loan interest rate is lower than the capital interest rate, taking out the loan has the effect of a subsidy; if it is higher, the overall costs rise. With equal interest rates, they remain constant.

8.3 EnEV - German Energy Conservation Regulations

EnEV

You can calculate the annual yield of a solar system for a newly-built, purely residential building for the verification procedure in accordance with (Erneuerbare Energien-Verordnung, German Energy Conservation Regulations) EnEV 2009. This applies to both DHW supply systems and combination system. You are provided with a solar yield comparison, calculated from

- a standard method of calculation as per DIN-V 18599 with standard parameters,
- a standard method of calculation as per DIN-V 18599 with planning values of the selected system, and
- an annual simulation in T*SOL.

The resulting solar yield which is calculated can then be used in EnEV verification software.

è How to proceed:

1. Go to the *EnEV* dialog.

   Then consecutively click on the symbols in the symbol bar and provide required information in the input dialogs.

Building parameters

EnEV › Building Parameters

2. Enter the *Building Type*, as this is decisive for the hot water requirement (DIN V 18599-10, table 3).
3. Enter the *Geometry* of the building: the Heated Living Space, the Number of Storeys, and the Storey Height. If the Storey Height is greater than 4 meters, a warning is shown because the calculation of transfer and distribution losses in heating systems is only valid for rooms of up to 4 m height. This is due to the restriction to residential buildings.
4. Enter the Characteristic Length and the Width in accordance with DIN V 18599-5 appendix B. The pipe lengths required for calculating the transfer and distribution losses are calculated from this information.

   The derived parameters are needed for the further standard calculations. The Net Footprint, above all, is a key reference parameter (DIN V 18599-10, table 3, note a).

DHW supply

EnEV › DHW Supply

5. As only residential buildings are implemented in the present version, there are no further influence variables. For information, the equivalent DHW requirement at corresponding standard temperatures is displayed.
   The transfer losses in DHW supply are by definition zero. The distribution losses are calculated in accordance with DIN V 18599-8, chapter 6.2. The characteristic length and width of the building are required here.

Heating requirement

EnEV › Heating Requirement

6. Select your *energy* requirement.
7. If you have chosen *net energy*, select the type of heating equipment or *the temperature control*, the *over temperature* and the *radiator layout* in accordance with your system. For structurally integrated heating surfaces, enter the properties of the *temperature control*, and *insulation*.
8. Enter the corresponding monthly values in the table to the right. For net energy, the transfer and distribution losses are calculated as described above. In addition, the total value for the *heating output* is calculated.

   è This is described in more detail in chapter 8.3.1 Details on Heating Requirements

Parameters

EnEV › Parameters

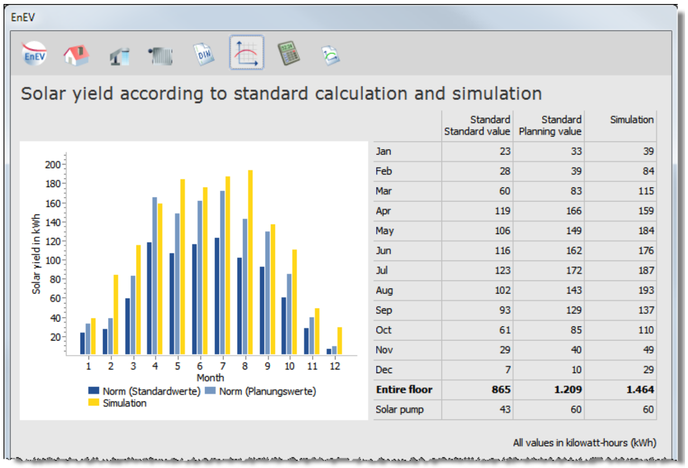
9. Move to the next dialog, Parameters, or directly to the simulation.
10. The overview lists the *Parameters of the solar system for the standard calculation as per DIN V 18599* for your information. From this, it can be seen whether the calculation in accordance with DIN V 18599 is made with DHW or a combination system.

    The table below shows the parameters which can be taken as a *Standard Value* aus der DIN from DIN V 18599 or as a *Planning Value* from the underlying system.

Simulation

EnEV › Simulation

11. Click on the symbol to calculate the solar yield and simulate it.



Solar yield according to standard calculation and simulation

	Standard Standard value	Standard Planning value	Simulation
Jan	23	33	39
Feb	28	39	84
Mar	60	83	115
Apr	119	166	159
May	106	149	184
Jun	116	162	176
Jul	123	172	187
Aug	102	143	193
Sep	93	129	137
Oct	61	85	110
Nov	29	40	49
Dec	7	10	29
Entire floor	**865**	**1.209**	**1.464**
Solar pump	43	60	60

All values in kilowatt-hours (kWh)

Image: EnEV: graphic and tabular presentation of solar yield

12. Following this, the key results are displayed as a graph and table in monthly resolution. The energy requirement of the solar pump in the collector loop is also stated here.
13. Click on the symbol , to view further simulation results, heating energy yields, the solar yield, and the solar fraction.

    If the heating energy yields used in the simulation significantly differ (> 5%) from the defaults, a warning is shown.

EnEV-Project Report

EnEV › Project Report

Click on the symbol , to print out a report suitable for submission to the relevant authorities.

This completes the EnEV calculation.

8.3.1 Heating requirement details

EnEV › Heating Energy Requirement

The heating output is required for the calculations. This can either be entered directly or calculated from the net energy with the help of distribution and transfer losses.

As only residential buildings are considered, the following implicit assumptions are made:

- With night switch-off
- Operation from 6.00 am to 11.00 pm, i.e. 17 hours (DIN V 18599-10, table 3)
- Continuous operation at weekends due to being residential building (DIN V 18599-5, chapter 5.4.1)

Transfer losses are calculated in accordance with DIN V 18599-5, chapter 6.1, the distribution losses in accordance with chapter 6.2. For this, the characteristic length and width of the building is required.

In order to calculate transfer and distribution losses, further information on the type and design of the heating equipment must be entered. A distinction can be made between radiators and heating surfaces (DIN V 18599-5, table 7).

The following settings are available for radiators:

- Temperature control
    - Unregulated, with central flow temperature control

  - Control room
  - P controller (2 K)
  - P controller (1 K)
  - PI controller
  - PI controller (with optimization function, e.g. presence controller, adaptive controller)
- Over temperature (room reference temperature 20 °C)
  - 60 K (e.g. 90/70)
  - 42.5 K (e.g. 70/55)
  - 30 K (e.g. 55/45)
- Radiator configuration for calculating specific thermal losses via exterior construction elements (GS = glass surface)
  - Radiator configuration internal wall
  - Radiator configuration external wall
    - GS without radiation protection
    - GS with radiation protection
    - Normal external wall

The following settings are available for structurally integrated surfaces (heating surfaces). Electric heating is not offered by the program

- Temperature control
  - Unregulated
  - Unregulated with central flow temperature control
  - Unregulated with averaging (between inlet and outlet)
  - Control room
  - Two-step controller / P controller
  - PI controller
- System
  - Underfloor heating
    - Wet system
    - Dry system
    - Dry system with low overlap
  - Wall heating
  - Ceiling heating
- Specific thermal losses of laying surfaces
  - Surface heating without minimum insulation as per DIN EN 1264
  - Surface heating with minimum insulation as per DIN EN 1264
  - Surface heating with 100% better insulation than in DIN EN 1265

9 Results

T*SOL offers you a wide range of ways to evaluate the simulation results.

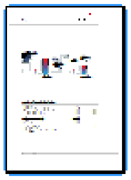
If changes have been made to the system since the last simulation, you will be advised of this and given the chance to run a new simulation.

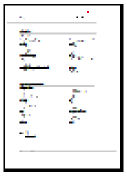
There is for each project a short presentation and a technical documentation.

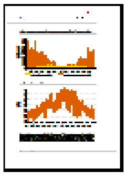
9.1 Project Report: Presentation

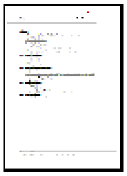
The presentation contains the system schematic, the site data, and the main results of the annual simulation.

If you have made changes to the system since the last simulation, a new simulation must first be run, in order to display the presentation.









At the top of the first page features the system schematic:

The information listed includes the type, number, and orientation of collectors, the volumes of the tanks, the nominal power of the boiler, the outlet and inlet temperature of the heating loop (where necessary, split into radiator and underfloor heating), and the average daily consumption and DHW target temperature for DHW consumption.

The results of the simulation are presented below:

- Irradiation onto the collector surface area (absolute and per m^2),
- Energy from the collectors and the collector loop (absolute and per m^2),
- Energy supply, solar energy for DHW (when space heating applies, referring to heating energy),
- Auxiliary heating energy,
- Fuel savings, CO2 emissions cut,
- Solar fraction, efficiency,
- Fraction of energy savings in accordance with DIN EN 12976.
- If you have defined a *Reference System* under *System Definition › System*, the calculation of pollutants is reported for this system.

Page 2: The parameters for location, DHW, and space heating are listed.

The system components are listed by manufacturer, type, and key technical parameters.

Page 3: shows a graph of the solar energy fraction of total consumption as well as the maximum daily temperatures in the collector.

Page 4: The presentation features an energy balance schematic (Sankey Diagram) to display energy.

You can print

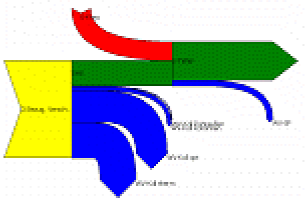
- the presentation,

- save it as an editable RTF file under *File › Save as RTF*, or
- as a PDF document under *File › Save As*.

A program such as Acrobat Reader (see website http://www.adobe.com) is required to view PDF files.

Sankey Diagram

Presentation › Page 5



The flow diagram shows the energetic flows:

Solar **irradiation** to the collector surface area is yellow.

Losses from the collector loop, tank, and piping are blue.

The additional **energy supplies** (boiler or swimming pool irradiation) are red.

The fractions which are transferred from one calculatory area to another as **net energy** are shown in green.

9.2 Project Report: Documentation

The documentation contains all the system's technical data and all simulation results per year and month, but no graphics.

For a complete overview over the system, you need both: presentation and documentation.

è See also:

10.2.2 Project Report

10 Options

Menu *Options*

The settings made here apply to all projects in T*SOL, i.e. are independent of the selected project. They are retained after closing the program.

10.1 Directories

Menu *Options › Directories*

The directoriescontaining the projects, components, load profiles, and climate files are displayed by clicking *Options › Drives*: When T*SOL is installed, the following drives are set as defaults:

Projects	My Documents\Valentin EnergieSoftware\TSOL basic \Projects
Climate	C:\Programs\Valentin EnergieSoftware\TSOL basic \Database\MeteoSynModul
Components	C:\Programs\Valentin EnergieSoftware\TSOL basic \Database\Components
Load Profiles	C:\Programs\Valentin EnergieSoftware\TSOL basic \Database\Profiles

There is generally no need to make changes here, but you can define Directories by clicking on the relevant button. A dialog opens, which you can use to define a new directory path which will then be used as the standard location, for example when opening or saving projects and variants.

Each user has their own project data in their (Windows-dependent) c:\\Valentin EnergieSoftware\T*SOL basic \:

File	**Directory**
Project .prj	.\Projects\(project name)*.prj
Variants .var	.\Projects\(project name)*.var
Results .erg	.\Projects\(project name)*.erg

By default, the individual components are searched and saved for all users in the Programs\Valentin EnergieSoftware\T*SOL basic \ folder.

File	**Directory**
Buffer Tank .kom	.\Database\Components\Buffer_Tank
Heat Exchanger .kom	.\Database\Components\Heat_Exchanger
DHW Tank .kom	.\Database\Components\DHW_Tank
Combination Tank .kom	.\Database\Components\Combination_Tank
Consumption Profiles .kom	.\Database\Profiles\Consumption
Shading .kom	.\Database\Profiles\Shade

10.2 Default settings

Menu *Options › Site Data*

The values defined here apply to all projects in T*SOL, i.e. are independent of the selected project. They are retained after closing the program.

10.2.1 Financial analysis

Menu *Options › Site Data › Financial analysis*

In the *Options › Site Data* dialog, you define largely constant data for the economic efficiency calculation on all projects on the *Financial analysis* page. These include the life span of the solar systems, the interest on capital, the specific investments, and the price increase rate for energy and running costs.

In the dialog *Financial analysis*, you can adjust these values for the current project.

10.2.2 Project Report

Menu *Options › Site Data › Project Report*

The layout of the project report can be set on the *Project Report* page:

- On the *Header* page, enter the first two lines of the presentation's header.
- You can load your company logo which then appears in presentations and add a cover page to the presentation containing information on the project you have entered in the *Project › General Project Data* dialog.
- On the *Final Text* page, you can edit the text which appears at the end of the T*SOL project report:
  "These calculations were carried out by T*SOL basic 5.0 – the simulation program for solar thermal heating systems. The results are determined by a math...".
- On the *Language* page, you set the language of the project report. Here, you can specify, for example, that T*SOL runs in German but that the presentation is created in French.
  Project report languages are: English, French, German, Italian, Portuguese, Spanish, Czech, Hungarian, Polish, Romanian, Slovakian, and Slovenian.

10.2.3 *Climate Data Record*

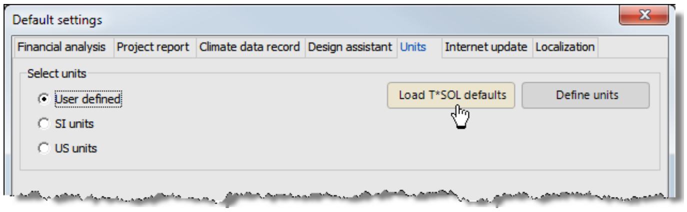
Menu *Options › Site Data › Climate Data Record*

On the *Climate Data Record* page, you can set the location which should be preset whenever a new project is created.

è See also:
Chapter 5.2 Climate Data

10.2.4 *Units*

Menu *Options › Site Data › Units*



Select units
● User defined
○ SI units
○ US units

Image: Dialog *Options › Site Data › Units*

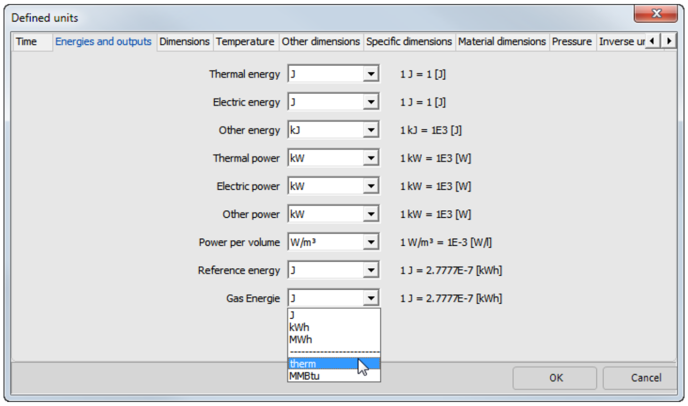
On the *Units* page, you can select a set of physical units for display or *define units* individually.

è Proceed as follows:

- Click on *Load T*SOL Default* to load the default units, which generally ensure a good representation..

OR:

- Select ● *User defined* and click the *Define Units* button, to define physical units individually.



Thermal energy	J	1 J = 1 [J]
Electric energy	J	1 J = 1 [J]
Other energy	kJ	1 kJ = 1E3 [J]
Thermal power	kW	1 kW = 1E3 [W]
Electric power	kW	1 kW = 1E3 [W]
Other power	kW	1 kW = 1E3 [W]
Power per volume	W/m³	1 W/m³ = 1E-3 [W/l]
Reference energy	J	1 J = 2.7777E-7 [kWh]
Gas Energie	J	1 J = 2.7777E-7 [kWh]

Image: Dialog *Options › Site Data › Units › Defined units*

- SI and US units can also be used in combination.

OR:

- Select *SI units*:
  All units are displayed in the official SI system. Individual values can then be displayed as very large or very small figures.

OR:

- Select *US units*:
  All units are displayed in US units. This applies to linear measurements, temperatures, and energy units.

T*SOL saves the selected units separately for every user in C:\<User>\<UserFiles>\Valentin EnergieSoftware\TSOL basic 5.0\units\einheiten.txt. If this file has inadvertently become corrupted, you can simply load the original values by clicking *Options › Units › Load T*SOL Default*.

The units used are divided into the following groups:

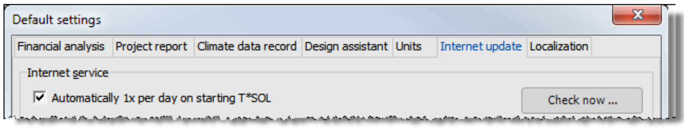
Group	Symbol of Selection Boxes	Unit Selection
Time	Time	s, min, h, d, a
Energy and power	Thermal energy	J, kJ, MJ, Wh, kWh, MWh, Btu, kBtu, MBtu
	Electrical energy	J, kJ, MJ, Wh, kWh, MWh, Btu, kBtu, MBtu
	Thermal power	W, kW, MW, Btu/hr, kBtu/hr, MBtu/hr, GBtu/h
	Electrical power	W, kW, MW, Btu/hr, kBtu/hr, MBtu/hr, GBtu/h
	Reference energy	J, kWh, MWh, kBtu, MBtu
Dimensions	Length	mm, m, km, inch, ft, yd
	Area	m², mm², km², in², sq.ft
	Volume	l, m³, cu.ft, gal
Temperature	Temperature	°C, °F
	Temperature difference	K, deg .F
Other values	Volume flow	l/h, l/min, l/s, gpm
	Speed	m/s, ft/s

Group	Symbol of Selection Boxes	Unit Selection
	Weight	kg, lbs
Inverse units	1/Ref. energy	kWh, kBtu
	1/ Area	m², sq.ft
	1/Volume fluid	l, gal
	1/Volume solid	kg, lbs

10.2.5 *Internet update*

Menu *Options › Site Data › Check for Updates*

On the *Internet updates* page, you can set the times at which T*SOL should check whether a new update is available on the server.



Internet service

☑ Automatically 1x per day on starting T*SOL

Image: window: Internet update preference

Prerequisites:

1. Formal prerequisite: Software maintenance agreement, refer to:
   in the EU and others: http://www.valentin.de/en/sales-service/customer-service/software-maintenance-agreement
   in the U.S.: http://valentin-software.com › Solar Thermal
2. Technical prerequisite: Active internet connection

è How to update via the internet:

3. If there is an active internet connection, the program checks whether a new update is available on the server according to the settings on the page Internet update:
   - daily at first program start
   - or on clicking *Check now ...* .

   If you are using a proxy server, you can enter the required settings here.
4. If a new release or new databases are available, the program will close and the installation program will be downloaded to the Desktop and run from there.

Proxy settings

T*SOL is using your computer's system proxy settings to connect to the network.

10.2.6 Localization

Menu *Options › Site Data › Localization*

Options relevant to specific locations can be set on the Localization page:

- *Regional settings:* Selecting "North America" ensures that you can only select those systems which are actually available there.
- *Display EnEV:* Standard calculation in accordance with EnEV is only meaningful if you plan to submit corresponding verification calculations to German authorities.
- *Fractional energy savings*: Is defined according to German standards (DIN) and can be displayed in the project report and under *System definition System* › Savings.

11 Languages

Menu *Language*

Here, you set the current language. Available languages are displayed.

Click on a language to select it.

Then you should 🖩 simulate again so that the results file is also translated.

T*SOL runs in these languages:

- German
- English
- French
- Spanish
- Italian

12 Help

Menu *Help*

You can access following topics by opening the *Help* menu.

- Click *T*SOL help* to open the user help with a table of contents, index, glossary and search function.
  Context-sensitive help can be called up at all times by pressing F1.
- Click *Manual* to open the user manual as a .pdf file.

- *Check for updates*: checks on our web page for software or database updates
  -> see also: Internet update
- *Solar thermal product palette*: This opens our website in your browser:
  in the EU and others: http://www.valentin.de: Products › Solar Thermal
  in the U.S.: http://valentin-software.com › Solar Thermal
- *Other Internet Services:*

	in the EU and others	in the U.S.
Onlineshop	http://www.valentin.de: Online Shop › Solar Thermal	http://valentin-software.com › Solar Thermal
Order forms	for T*SOL, additional modules: Pools, Large-Scale Systems: http://www.valentin.de/en/downloads › Order Forms › Order Form - Solar Thermal / Heat Pumps	http://valentin-software.com › Support › Order Forms
Valentin Software homepage	http://www.valentin.de/en	http://valentin-software.com/

  - Click *FAQ* to open the page on the T*SOL website which lists answers to frequently asked questions.
  - Click *Support* to open the page on our different customer services:
    in the EU and others: http://www.valentin.de/en/sales-service/customer-service
    in the U.S.: http://valentin-software.com › Support › Help zone
  - Click *Tutorials* to open the web page on which our tutorials are listed, http://www.valentin.de/en/support-service/product-training/tutorials.

- *Registration* see below
- Under *Help › Info*, you will find

General information	*Detailed information*	*Registration*
Program and release number, contact data for Dr. Valentin EnergieSoftware GmbH.	Version numbers for all program files, automatically gathered information on your operating system and hardware.	The serial number and activation code are displayed. If you have an internet connection, you can change the registration here or access an order form on our website.

13 Appendix

13.1 Literature on the Subject of Solar Thermal Systems

Quaschnig, V.: Renewable Energy and Climate Change, John Wiley & Sons, Chichester 2010

Duffie, J.A., Beckman, W.A.: Solar engineering of thermal processes. John Wiley & Sons New York 1991

Werner Weiss: Solar Heating Systems for Houses – A design Handbook for sola combisystems, James & James 2003

Solar Heating – Design and Installation Guide - CIBSE Domestic Services Panel 2007

Planning and Installing Solar Thermal Systems – A guide for installers, architects and engineers-Earthscane 2005

Peuser, Remmers, Schnaus – Solar Thermal Systems – James & James 2002

13.1.1 Literature in German

Quaschnig, V.: Erneuerbare Energien und Klimaschutz – Hintergründe, Techniken, Anlagenplanung, Wirtschaftlichkeit

Eicker, U.: Solare Technologien für Gebäude. B.G. Teubner Verlag 2001

Leitfaden Solarthermische Anlagen. Deutsche Gesellschaft für Sonnenenergie 2001

Remmers, K.-H.: Große Solaranlagen. Solarpraxis Berlin 2000

Müller, F.O.: Aktive thermische Solartechnik in mitteleuropäischen Breiten. Energie-Technik Müller Satteldorf 1993

Peuser, F.A., Remmers, K.-H., Schnauss, M.: Langzeiterfahrung Solarthermie. Solarpraxis Berlin 2001

Fa. Wagner & Co: So baue ich eine Solaranlage, Marburg / Cölbe 1996

DVGW Arbeitsblatt W551: Trinkwassererwärmungs- und Leitungsanlagen - Technische Maßnahmen zur Verminderung des Legionellenwachstums. Deutscher Verein des Gas- und Wasserfaches e.V. Bonn 1993

VDI 2067: Richtlinie Berechnung der Kosten von Wärmeversorgungsanlagen. VDI Verlag Düsseldorf

Schüle, R., Ufheil, M., Neumann, C.: Thermische Solaranlagen Marktübersicht Ökobuch Verlag Staufen b. Freiburg 1997

13.2 Glossary

Active solar surface m^2

The specific collector parameters are not usually related to the gross surface area but to the active solar surface, derived from the testing centre reports. Depending on the testing centre, the active solar surface of flat plate collectors is either the absorber area or the ⇢ aperture area. With evacuated tube collectors (e.g. with mirror constructions and vertically-standing absorbers), the active solar surface is often a purely theoretical value.

Annual heating requirement Q_h [kWh/a]

The total heat which must be supplied to the rooms of a building within one year to maintain a target temperature (building energy).

Annual heating requirement, specific, q_h [kWh]

The heat, based on the floor space, that must be yielded within a year to maintain a target temperature in the building (effective energy).

Annuity A

A series of equal payments, allowing for ⇢ lifetime and interest rate, for repayment of a capital debt. It is the product of annuity factor and investment sum.

Anti-Legionnaire's switch LEG

The guidelines of the German Association for Gas and Water specify that the entire content of the storage tanks and the piping in systems with a drinking water storage tank size of 400 liters and domestic hot water pipe content of over 3 liters must be heated to 60° once a day. The hot water storage tank is loaded in adjustable intervals in systems with an anti-Legionnaire's switch.

Annual energy requirement

-> Final energy requirement

Aperture A_a (m^2)

Largest projected area through which unconcentrated solar irradiation enters the collector. In flat plate collectors, the area of the collector covering through which solar irradiation can penetrate the inside of the collector housing (light penetration area). In evacuated tube collectors, the aperture is the product of the length and width of the absorber strip and the number of tubes. If evacuated tube collectors are fitted with a reflector (⇢ CPC), the aperture is equal to the product of the length and width of the mirror surface

Auxiliary heating AuxH

Ensures that the ⇢ target temperature is reached even when there is insufficient irradiation. Where applicable, it also supplies the heating loop. Usually refers to the boiler.

A/V ratio

The A/V ration is the quotient of area to volume and is displayed in the unit 1/m.

Balance (B)

⇢ Energy balance

Balancing

⇢ Energy balance

Base load [W, kW]

Minimum load / output an energy supply system must make available constantly during a period of use.

Boiler **Boil**

Serves to convert chemical energy into heat.

Boiler efficiency **η [-]**

The boiler efficiency describes the relationship between the energy used by the boiler and the energy produced over a specific period of time.

Buffer tank **Buff**

A storage tank filled with domestic hot water, usually in steel. The heat is transferred either internally via a serpentine pipe or outside the tank by means of an external heat transfer medium.

Building energy requirement Q_b [kWh/a]

Generic term for heating requirements, cooling requirements, energy requirements for hot drinking water, lighting, humidification.

Calculation of pollutants

The solar system's CO2 emissions savings are calculated. This is based on the emissions factors of the fossil fuel under consideration for heat generation. The emissions factors used here depend on the (saved) fuel. (⇢ fuel savings) ⇢ CO2 emissions

Capital value V_0

Sum of all ⇢ cash values of investments, subsidies, savings, operating costs, and loan costs (each signed). The interest rate used is equal to that which would apply when borrowing capital for the investment from a bank or at which the capital used could yield interest.

Cash value [€]

Discounted future payments at the start of the period under consideration. A cash value is positive if it can be recorded as revenue and negative if the amounts represent costs. Items calculated are investments, subsidies, savings, and operating costs. ⇢ capital value

Circulation Circ

Circulation can be used for hot water preparation. This increases comfort (hot water is immediately available, even with long piping systems), but is also coupled with losses.

Clearness Index, K_t

$K_t = G/G_0$, using global irradiation G and extraterrestrian irradiation G_0

Climate C

Climate is the current atmospheric conditions or a sequence of atmospheric conditions at a specific place which run their course over a specific period of time.

Climate data

The climate data supplied with the program (for numerous locations) contains hourly median values for global radiation, outdoor temperature, and wind speed.

CO2 emissions [g, kg]

(Carbon dioxide) is the quantitively most significant greenhouse gas (GHG) released by human activity (in particular combustion of fossil fuels). ⇢ Calculation of pollutants

Collector Coll

Technical device for converting radiation energy into heat energy. Common types are flat plate and evacuated tube collectors.

Collector array CA

The collector array consists of the collectors and the piping.

Collector loop CL

Circuit containing the ⇢ collector or the ⇢ absorber and which is responsible for transporting heat from the collectors to the storage tank or heat transfer medium.

Collector loop connection

The collector loop connection represents the connection between the ⇢ collector array and the storage tank by flow and return.

Collector loop efficiency

Quotient of the energy emitted from the collector loop and the energy irradiated onto the collector area (active solar surface)

Compound parabolic concentrator CPC

Compound parabolic concentrator, reflectors used in evacuated-tube collectors for enlargement of the ⇢ aperture area in a geometrically optimized form as a parabolic trough.

Controller

The controller has the responsibility of ensuring optimal operation of the system. Control parameters can be set for various components. For storage tanks, for example, target temperatures, switching temperatures.

Cooled Cooled

Costs

Consumption of goods to create and sell services and other goods.

Daily consumption [l]

The average daily domestic hot water consumption. This is usually 35-45 liters per person and day at a water temperature of 50°.

Declared value for thermal conductivity λ [W/(mK)]

Value of the ⇢ thermal conductivity of a construction material or product under specific external and internal conditions which can be considered typical of the behavior of this product when installed in a component.

Default data Def.

Design temperature °C

Temperature determined by the relevant climate zone as per DIN EN 12831 supplement 1 table 1a. The design temperature is the maximum (necessary) temperature of the heating water which suffices at the lowest winter temperature for the heating system to provide the building with required amounts of heat.

Deverter / injection system

Special version of a control circuit. Particularly useful when the user is far away from the output but if required needs hot water promptly (often RLT)

DHW consumption DHW con

DHW requirement

⇢ Daily consumption

DHW requirement, specific, q_T

The heat, based on the floor space, that must be provided for heating domestic hot water. The guideline value from the EnEV is 12.50 kWh/m²a.

Diffuse radiation G_{diff} [W/m²]

Part of solar irradiation which strikes a horizontal or tilted surface via scattering through air molecules and mist particles or reflection on clouds.

DIN V 18599

"Energy efficiency of buildings, calculation of net, final, and primary energy requirements for heating, cooling, ventilation, domestic hot water, and lighting" Basis of calculation for the EnEV 2009 certifications for residential and non-residential buildings

Direct radiation G_{dir} [W/m²]

Part of solar irradiation which strikes a horizontal or tilted surface without changing direction.

District heating DistHeat

Heat supply for heating buildings and drinking water. In district heating, waste heat created during power generation (cogeneration) is used, among others. Transfer of heat is predominantly effected via underground piping.

DKE DKE

German Commission for Electrical, Electronic & Information Technologies of DIN and VDE. Organization in Germany responsible for creating standards and safety regulations in the field of electrical engineering, electronics, and information technology.

Domestic hot water WW

Domestic hot water typically refers to warm drinking water and in contrast to heating or buffer tank water can be consumed.

Effective surface A_N

Reference value for confirmation in accordance with the Energy Saving Ordinance (EnEV), derived from the gross volume of the building. All area-based values are based on A_N.

As a general rule, the living space is generally smaller than the floor space.

Efficiency Eff

The ⇢ collector loop efficiency and the ⇢ system efficiency are calculated.

Electric heating element el HE

Electrical auxiliary heating in the storage tank

Electrical power P_{el} [W, kW]

The electrical power states how much electrical energy is used in a specific unit of time.

Elevation angle

-> sun height

Energy E (Joule)

Energy is the ability to perform work. The forms of energy are divided into mechanical energy (kinetic and potential energy), thermal, electrical and chemical energy, radiation energy, and nuclear energy.

Energy balance

Comparison of incoming and outgoing energy flows in a system: the sum of energy supplied, energy released, and the storage of energy by the heat capacity of the system components must be equal to zero. Balancing is not carried out wholesale for the entire system but for the individual system components.

Energy balance scheme

⇢ Sankey graph

Energy input E, Q_{zu} [Wh, kWh]

Energy supplied to a component, e.g. irradiation, heat supply at the heat exchanger or heat transfer by mass flow due to consumption or circulation.

Energy output Q_{ab} [Wh, kWh]

Energy (heat) transferred from one component (collector loop, storage tank etc.) to another component or the environment.

Energy produced by solar system Q_{ab} [Wh, kWh]

Comprises the energy transferred to the standby tank from the solar tank due to consumption and any existing return circulation control in the solar tank.

Energy supply

⇢ Energy input

Expenditure factor

-> System expenditure factor

External financing

Part of the capital commitment is covered not by personal capital but by taking out loans. If the loan interest is higher than the capital interest, borrowing incurs further costs.

Final energy requirement Q_E [kWh/m²a]

Calculated amount of energy available to the system technology (heating system, ventilation and air-conditioning system, hot water heating system, light system) to ensure the set inside temperature, heating of warm water, and desired lighting quality over the whole year. This amount of energy includes the auxiliary power required to operate the system technology.

The final energy is transferred at the "interface" of the building's external envelope and thus represents the amount of energy required by the user for use as intended under normative boundary conditions. The final energy consumption is therefore stated by energy sources used.

DIN V 18599

Flow FL

Flow generally denotes the warmer string in a heat loop. In a solar loop, flow corresponds to the pipe from the collector to the storage tank.

Fresh water requirement

here: the domestic water supplied to the swimming pool for filling.

Fresh water station

Hygienic domestic hot water heating with the help of a plate heat exchanger in a continuous flow process, compact station with heat exchanger, pump, controller.

Fuel consumption

The calculation of fuel use (natural gas, oil, wood pellets, district heating) is derived from the energy transferred to the auxiliary heating heat exchanger via the fuel's heat equivalent and the auxiliary heating efficiency.

Fuel price [€/kWh]

The price for the stated final energy valid at the time of calculation. It must be entered in the currency given in Windows' country settings.

Fuel saving [€/a]

Fuels are primarily used to generate heat. In addition to reducing heat loss, the use of solar heat generates fuel savings. The program converts the available solar heat at any one time, using the respective auxiliary heating efficiency and the corresponding heat equivalent of the energy source, into fuel savings.

Global irradiance G (W/m²)

Hemispherical irradiation onto a horizontal surface.

Gross collector area A_G (m²)

Surface area of the collector excluding devices for attachment and the piping connection. Usually width by length. Calculated by the external dimensions of the collector; the specific collector parameters are not usually taken from the gross area but from the ⇢ active solar surface.

Heat consumption Hcon

Heat exchanger HE

Heat exchangers are used when heat is to be transferred between different heat transfer media. Internal and external heat exchangers are differentiated.

Heat gains Q_s, Q_i

Comprise the solar heat gains (dependent on the window area, type of window, and inclination) and the internal heat gains (e.g. produced by electrical appliances).

Heat load Φ_{HL} [W, kW]

⇢ Standard heat load

Heat loss rate [W/K]

Product of heat transfer coefficient and the surface of the heat exchanger. The value is equal to the quotient from transferred power and median logarithmic temperature difference at the heat exchanger.

Heat losses

Thermal losses occur through piping, radiation, and convection of heat in a collector. With selective absorber coatings, good thermal insulation or a vacuum, thermal losses can potentially be kept as low possible.

Heat requirement Q_h [kWh]

The heating capacity required to maintain a target room temperature in a building (net energy).

Heat requirement HR

⇢ Standard building heat flow requirement

Heat transfer coefficient U [W/(m²K)]

The heat transfer coefficient of a component describes the heat flow (heat lost) on a temperature difference of one Kelvin per square meter of the component. This is the crucial heat insulation property of outdoor components. The smaller the heat transfer coefficient, the better its insulation efficiency.

Heat transfer coefficient (heat loss coefficient) of the collector k_1 [W/(m²K)] k_2 [W/(m²K²)]

States how much heat the collector releases to its environment per square meter of active solar surface and temperature difference in Kelvin between the collector median temperature and the environment. It is split into two parts, the simple and the quadratic part. The simple part (in W/m²/K) is multiplied by the simple temperature difference, the quadratic (in W/m²/K²) by its square. This results in the typically stated efficiency parabolic curves.

Heat transformer

⇢ Heat exchanger

Heating cost

Calculated from the quotients of ⇢ investment, ⇢ operating costs, and the heat generated (taking into consideration ⇢ lifetime and ⇢ capital interest).

Heating flow Q Punkt Φ_{th} [W]

Represents a quantitative description of heat transfer processes. The heating flow is an amount of heat (heat output) transferred in a given time; direction of flow always from area of higher temperature to area of lower temperature.

Heating loop HL

A self-contained system for distributing heat from the heat generator to the user, flow and return flow temperatures are dependent, among others, on the transfer system to rooms to be heated. Two heating loops with different design temperatures can be defined in T*SOL, a high temperature heating loop for radiators and a low temperature LT heating loop for underfloor heating.

Heating network HN

Concentration of heating requirements in heating output units of varying size in the form of district or local heating networks.

Heating temperature limit T_{HG}

Minimum / maximum outdoor temperatures at which the heating is switched on or off. The heating temperature limit is dependent on the insulation class of the building.

High temperature circuit

A heating loop with high flow and return temperatures, e.g. for use in radiators and similar.

Incident angle modifiers K_θ

Describe the reflection losses when the sun is not perpendicular to the collector area.

Installation

The installation of the collector array is determined by the ⇢ tilt angle and the ⇢ orientation angle (azimuth). From the tilt angle and orientation angle, the ⇢ radiation processor calculates the irradiation on the tilted surface for a specific location.

Investment

Typically long-term, targeted capital commitment to generate future yields. Investment costs here correspond to the system costs, less any subsidies.

Irradiation model

The values saved in the ⇢ climate data for global radiation are divided into diffuse and direct parts according to the Reindl model.

Irradiation processor

Calculates irradiation on the tilted area from the ⇢ installation and ⇢ orientation angle of the collector array, taking into consideration the diffuse and direct parts.

Life (of loan)

Period of time agreed for repayment of a loan.

Lifetime

The period of time stated by the manufacturer in which the system should remain operable.

Load profile [W, kW] [%]

Hot water consumption dependent on time. The calculation is based on the definition of different daily, weekly and annual profiles.

Loading loop LL

⇢ Storage charging loop

Loading time [h]

Describes the period required for the storage tank to be loaded fully (supply of energy).

Loan capital

The amount of the loan taken out. It bears interest and must be repayed.

Loan interest

The amount of interest that has to be paid on a loan. If the loan interest rate is lower than the capital interest rate, borrowing a loan results in income from interest.

Local heating LH

Local heating describes the transfer of heat between buildings over relatively short distances in comparison with district heating.

Low temperature circuit

Heating loop with low flow and return temperature, e.g. for use with underfloor heating

MeteoSyn

Program for generating climate data.

Nominal size [-] [mm]

States the diameter of a pipe. DIN nominal piping sizes are used to calculate the collector loop piping widths. The term DN (diameter nominal) states the internal diameter. With copper piping, the outer diameter and the wall thickness of the material are stated.

Off off

Switch in a program dialogue box.

On on

Switch in a program dialogue box.

Operating costs [€/a]

Costs arising from operation of the system, e.g. maintenance costs, electricity costs. The ⇢ cash value and the ⇢ annuity of the operating costs are derived from the ⇢ capital interest, ⇢ rate of price increase, and the ⇢ lifetime.

Operating period (h)

Each respective component is active during the operating period. A component is not active during the specific time periods (hours, days or months) that have been switched off.

Orientation angle α (°)

(azimuth) Describes the angle of deviation of the collector area from the south in the northern hemisphere. It is 0° when the surface is facing due south. The azimuth is positive when facing west and negative when facing east. An orientation due west corresponds to a value of +90° and an orientation due east is -90°.

Pay-back time

Period of time required until the total of returns on an investment (static payback method) or its ⇢ capital value (dynamic payback method) reaches the amount of the investment. Here: the period of time the system must operate for the investment to yield a capital value of zero. The program does not calculate pay-back times of over 30 year.

Primary Pr

Primary energy requirement Q_p [kWh/a] [kWh/(m²a)]

Calculated amount of energy required for space heating and domestic hot water, which, in addition to energy content of the required fuel and the auxiliary power for the system technology, also includes amount of energy resulting from upstream process chains outside the building in extracting, converting, and distributing the respectively used fuels. - available in table form.

Primary loop

Heating loop in the heat generator with high temperatures for transferring heat with a heat transfer medium to the ⇢ secondary loop.

Process heating PH

Process heating is the heating required for a large number of technical processes and procedures (drying, cooking, melting, forging etc.). The process heating must typically be generated by combustion processes or electric current, can however in the best case be recovered in part as waste heat.

Proportional energy saving

as DIN CEN/TS 12977-2

Rate of price increase [%]

The prices for non-renewable energy sources are rising as a result of growing demand and increasingly scarce supplies. The development of operating costs and energy consumption play a crucial role in calculating the capital values of investments.

Redirection valve RV

⇢ Three-way valve

Return R

The return commonly describes the cooler string in a heating loop. In a solar loop, the return is the pipe from the storage tank to the collector.

Sankey graph

Graphic representation of energy or material flows using arrows, in which the width of the arrows is proportional to the width of the flow.

Savings

The simulation results include the reference fuel savings made during the simulation period through the use of the solar system.

Secondary loop

Heat consumer

Secondary loop

Contains the medium to be warmed, is heated by the ⇢ primary loop.

Simulation

Test of the influence of ambient conditions, user behavior, and the various components on the operating conditions of the solar system with the help of computer calculations

Simulation period

Total period of time for which the simulation is to run. Simulation periods of between one day and one year are possible

Simulation range

Time interval between two successive calculation steps. It varies between 1 and 6 minutes depending on the system and is set automatically.

Solar height

-> sun height

Solar azimuth α_s

Deviation of the respective position of the sun from the south, constantly changes as a result of changes in the sun's position, is 0° at 12.00 p.m. CET

Solar cooling SC

With the help of heat generated solar thermically, solar cooling is used to generate cooling or open sorption-based air-conditioning in a closed absorption or adsorption process.

Solar fraction **Frac sol**

The proportion of energy transmitted by the solar system to the standby tank to the total amount of energy transmitted to the standby tank (from the solar system and auxiliary heating).

Solar heat

Solar heat describes the conversion of solar energy into available heating energy.

Solar storage tank

The solar tank is the storage tank or part of a tank that is loaded from the collector array.

Solar yield (kWh/m^2)

Energy released by the collector loop within a specific period of time.

Space heating **HL**

All technical elements and systems which serve to generate, store, distribute, and transfer heat.

Specific heat capacity

The amount of heat per m^2 of active solar surface that the collector, including its heat transfer medium content, can store at a temperature increase of 1 Kelvin.

SRCC

Solar Rating and Certification Corporation - USA

Standard heat load Φ_{HL} [W, kW]

Standard DIN EN 12831 (August 2003) describes the calculating procedure to determine the output of the heat generator and the heating surfaces required under normal design conditions to ensure that the required standard indoor temperature is reached in the rooms used in the building.

Standard heat requirement $Q_{N,Geb}$ (W; kW)

Former term for heating load.

The standard heat requirement is the basis for the dimensioning of the heat generator (boiler, solar system ...). It states the required heating output to maintain the desired indoor temperatures (e.g. 20°C) in all rooms at the design outdoor temperature.

Standard outdoor temperature Θ_e [°C]

Outdoor air temperature used to calculated standard heat loss. It represents the lowest two-day median the air temperature has reached or dropped below 10 times in 20 years.

Standby storage tank

A system storage tank which is used exclusively for storing domestic hot water pre-heated to the target temperature (e.g. System A2).

Storage charging loop

Pump circuit for charging the storage tank ⇢ storage charging system

Storage charging system

Storage tank heating from bottom to top by means of a charging pump (storage charging loop), the heating surface can be located inside or outside the storage tank.

Storage model

Representation of loading and unloading processes

The stratified storage model uses storage layers of variable strength. The number of layers in not fixed but adjusted during simulation.

Storage regrouping

Heat transport from the solar storage tank to the standby tank. When activated, storage regrouping occurs when a higher temperature is present in the solar storage tank (top) than in the standby tank (top).

Storage tank ST

To bridge weather-related and/or seasonal fluctuations in irradiation, storage tanks are used to buffer heat. The volume of the storage tanks is governed by the heating requirement and the period of time to be bridged.

Stratification

Facility enabling layered loading of storage tanks. Typical stratifications are e.g. convection chimneys with radial openings.

Sun height, angle of elevation γ_s = sin h

Angle of the sun to the horizontal. The solar altitude angle depends on the daytime, the time of the year and the geographical location.

Suneye

Device to determine an optimal location for the solar system with the help of annual irradiation graphs and sun-active time of day data.

Supplementary heating

⇢ Auxiliary heating

Supply/removal **(To/Fro)**

Surface A

-> see Effective surface A_N

Swimming pool SP

Swimming pool water heat requirement

The total amount of energy generated by the solar system and auxiliary heating for the swimming pool.

System efficiency

Quotient of the available energy generated by the solar system and the energy irradiated onto the collector surface (active solar surface). It is a benchmark for the system's efficiency.

System expenditure factor e_P [-]

The system expenditure factor describes the ratio of primary energy absorbed by the system technology in relation to the available heat released by it. The smaller the value, the more efficient the system. In residential buildings, the value for the energy requirements of a system also takes account of preparation of a standard amount of hot water.

$e_P = Q_P / (Q_h + Q_{TW})$

-> Differentiation:
The expenditure factor describes the energetic quality of the heat generator under the conditions found in the building,
while the value for the energy requirements of a system describes the energetic quality of the entire heating system.

Target temperature

The minimum temperature of domestic hot water If the target temperature in the upper layer of the tank is not reached, the ⇢ auxiliary heating is switched on.

Target value Targ

Temperature T (°C)

The temperature is a material property and describes the ability of a body to generate internal energy in the form of heat.

Thermal buffer store

Contains heating water for heat storage.

Thermal conductivity λ [W/(mK)]

The thermal conductivity states the amount of heat passing through one square meter of a 1m-thick layer of building material in an hour when the temperature difference between the two surfaces is 1 Kelvin.
Criterion for assessing the quality of insulating material.

Thermal engineering

Thermal engineering describes all aspects of energy conversion, storage, and transfer in machines and apparatus with the exception of electrical energy.

Thermal equivalent

Conversion process making energy sources comparable by their heat content (heating value).

Thermosyphon system

Operation in a closed circuit according to the gravity filtration principle without the use of pumps or controls.

Tilt angle β (°)

(inclination) Describes the angle between the horizontal and the collector surface. This is 0° when the collectors are flat on the ground and 90° when they are vertical.

VDE

Association for Electrical, Electronic & Information Technologies

Volumetric flow rate Vᵽ Flow [l/h] [l/m^{2}h]

The movement of a volume of a medium in a unit of time through the cross-section of a tube. The volumetric flow rate for the collector array is stated in l/h and can be specified either absolutely or relative to the collector area.

Zero-loss collector efficiency η_0

States the proportion of radiated energy absorbed by the collector on vertical incidence when the median temperature of the heat transfer medium in the collector is equal to the ambient air temperature.

14 Index