T*SOL® Pro

Version 5.5

Design and Simulation of thermal solar systems

User Manual

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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

- New project administration: now only one file (*.tsprj), which also contains the related climate data. This makes it easier to exchange projects between different computers.
- Import Meteonorm *.dat files; you can create your own climate data (hourly values for irradiation and temperature) by entering monthly values.
- Roof layout with PhotoPlan.
- The design assistant now calculates reliable recommendations with the help of the minutes simulation.
- New: You receive design recommendations and standard values for collector area, storage tank volume and boiler capacity.
- The tank losses that would arise also without the use of a solar system are calculated on the basis of the storage geometry and the target values. During calculation of the energy supplied by the solar loop, additional tank losses are set off, which are primarily those created in summer i.e. generated through operational availability and the solar buffer. The solar fraction contribution calculated in this way is lower, but better comparable with the fraction of solar systems in which tank losses can be definitely assigned to the solar

system and have also already been deducted from the solar yield. Solar loop yields that are only used to generate tank losses are thus now a thing of the past.

- For combination tank systems, the fraction (domestic hot water) and the heating fraction are determined and displayed individually (previously: total solar fraction), as the fraction e.g. for funding applications must be separately given.
  In every time increment, the T*SOL simulation balances if the yields contribute to the fraction of domestic hot water and thermal heat supply, the circulation losses and the tank losses or the heating of the storage tank content. Thus the origin (solar loop or supplementary heating) of the heat is known, meaning heat delivery can be distributed.
- The Financial Analysis has been significantly extended and reworked. In addition to one-off grants, yield-dependent remuneration is now also taken into account. The results were expanded to include important finance mathematics variables.
  A graphic in the dialog box displays the most important variables. An exportable table represents the annual values (input and output, cash flow ...).
  T*SOL can now make the economic efficiency of a solar system clear to both project client and investor.
  The economic efficiency is integrated into the (project) presentation.
- New buffer tank system C6
- Completely modified and validated swimming pool algorithms, see: www.valentin.de/Schwimmbadalgorithmen
- Automatic detection of the valid proxy server

-> You can find all new features related to this and the latest releases on our website:
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 and other objects (buildings, trees etc.)
- 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
- Convenient comparison of several systems with parallel variant editing within a project
- Balancing of energy, pollutant emissions and costs

- Calculation of standard evaluation parameters for solar thermal systems such as system efficiency, solar fraction etc.
- Detailed presentation of results in reports and visuals
- Financial Analysis 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 and indoor pools can be integrated within the solar cycle.

Large-scale systems module*: Large-scale systems are integrated.

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

With T*SOL, both shade from the horizon and from objects close to the system is calculated. For the objects, consideration can be made for seasonal variations in light transmission (e.g. leaves on trees).

* Swimming pool and Large-scale systems modules can be purchased individually, and they are part of the T*SOL Pro set.

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.

Additionally, graphs can show the course of energy and other values, over any given period. They can be saved as a table in text format and copied from the clipboard into other programs.

Economic Efficiency Calculation

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

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
- Boston
- Peking
- Kapstadt
- Delhi
- Kinshasa
- Melbourne
- Moskau
- Prague
- Rio de Janeiro
- Rom
- San Francisco
- Washington
- Würzburg

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, Windows 7, Windows 8
- Graphics: OpenGL Version 1.1 (for Photo Plan), printer driver
- Software: .Net-Framework 4.0 (The .NET framework will be downloaded 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:

- Internet connection for updates and climate data
- You should set your monitor to display *Small Fonts* via the Windows control panel.

2.2 Installation

Image: Installation set-up assistant

To install the program, please click on the installation file setup_tsol_pro.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 program 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.

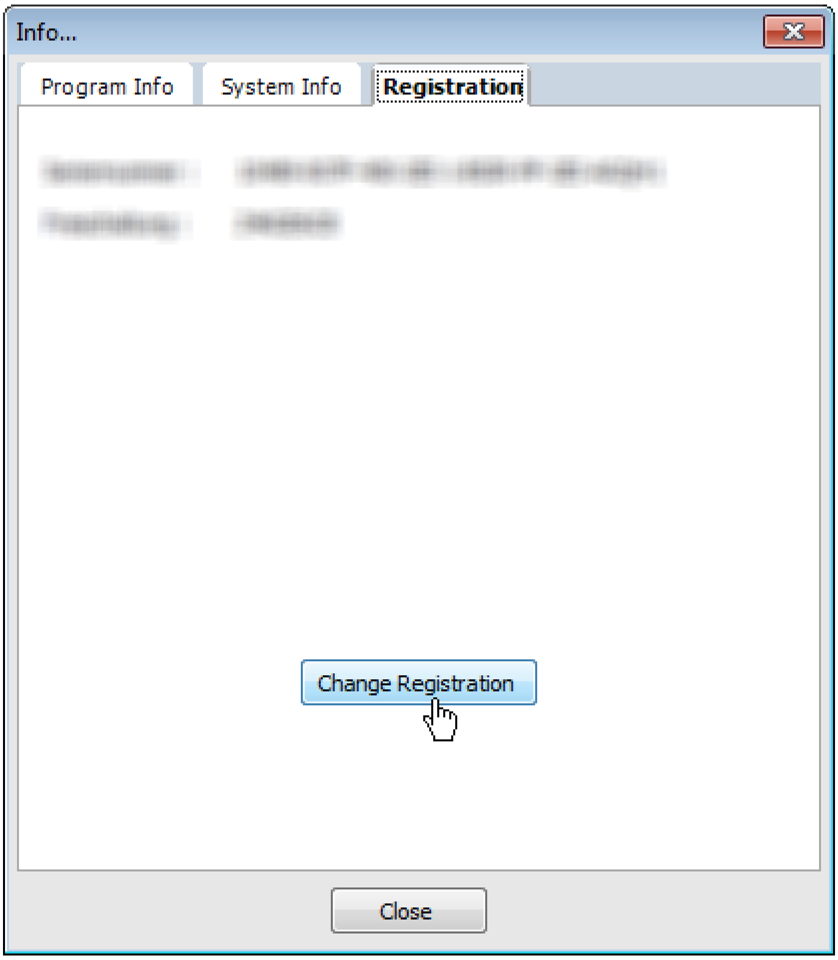
2.3 Program Registration

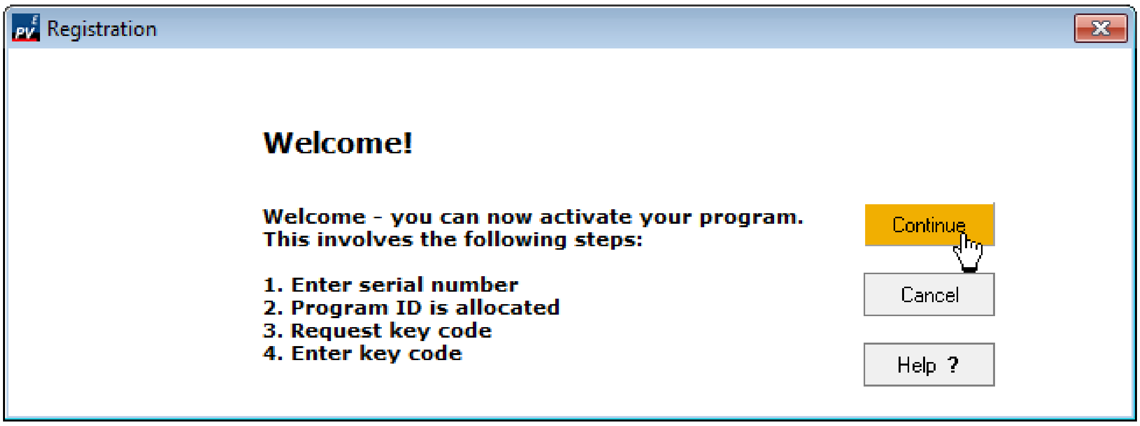
Menu *Help › Info › Registration ›* button *Change Registration*

You can change the status of the program from *demo version* to *full version* by registering.

1. To do this, click on the *Register Full Version* button when the program starts.
2. To register the program, you require a serial number .
3. Activate the program by using a key code you receive in the course of the registration.

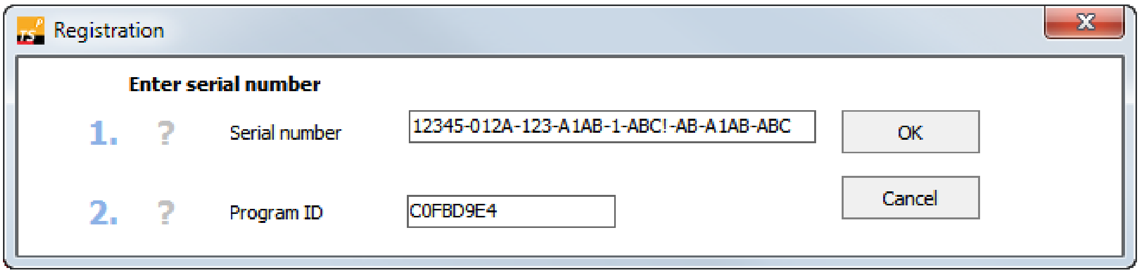
Change the registration in the menu *Help › Info › Registration*.




Registration
Welcome!
Welcome - you can now activate your program.
This involves the following steps:
1. Enter serial number
2. Program ID is allocated
3. Request key code
4. Enter key code
Continue
Cancel
Help ?

2.3.1 Serial Number

Menu *Help › Info › Registration ›* button *Change Registration*



If you have purchased the program, you will have a serial number.
This is made up of a combination of digits and letters, which you will have to enter without any spaces in between, but including the special characters (hyphens).

You will find the serial number either on the CD case or on the invoice. Alternatively, if you made your purchase online, you will have been notified by e-mail.

2.3.2 Program ID

The program ID is allocated specifically for your computer and is only valid for use on your computer. A valid serial number, issued on purchase of the program, is required to obtain an ID.

The program ID is automatically provided as soon as you enter the serial number.

It is not possible to enter the program ID yourself.

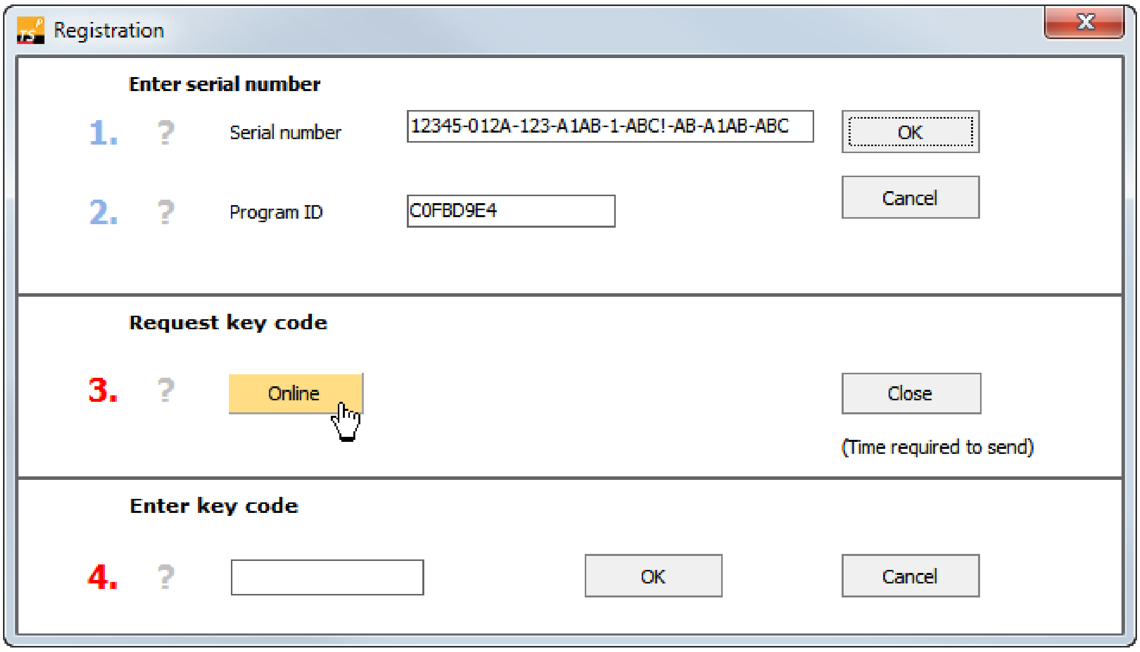
You will need to let us know the program ID when registering, so that we can send you your key code.

2.3.3 Request the Key Code

Menu *Help* › *Info* › *Registration* › button *Change Registration* › (1.) button *OK*

You can activate your program in two different ways.

Request a Key Code Online



This method requires that your computer has internet access.
Click on the *Online* button to open a form, where you can enter all the information required to receive a key code. The fields marked with an * must be completed.
After you have completed the form, you can send it straight off – the recipient's e-mail address is entered automatically for your convenience.
After sending the e-mail, the activation key code is displayed. Additionally, this key code will be sent to the given email address.

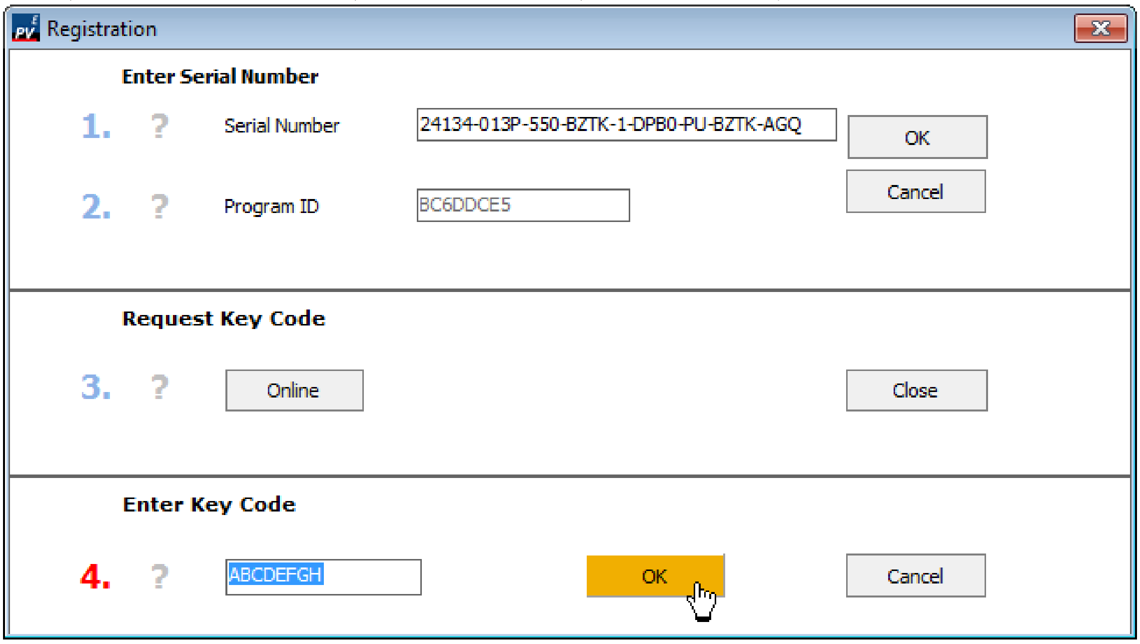
Request a Key Code by Telephone

If you do not have a fax or e-mail, you can request the key code by phone. In this case, you will need to give us your program ID when you call.

2.3.4 Enter the Activation Key Code

Menu *Help › Info › Registration ›* button *Change Registration ›* (1.) button *OK ›* (4.) button *OK*

Once you have received the key code, enter the key code into the input field "*4.* ".



Click the *OK* button. You will receive a message, confirming that your program has been activated.

2.4 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. PV modules or inverters.
- 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.

2.5 Software Updates via Internet

Menu *Help › Check for Updates*

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

-> How to update via the internet:

3. Go to the menu *Help › Check for Updates* to check immediately.

-> How to set the update check:

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

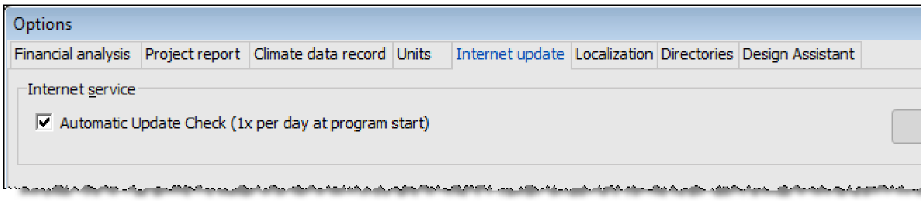


Image: window: Internet update preferences

2. 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 ...* .
3. 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.

2.6 Licensing Provisions

The license is displayed as .pdf file.

Licensing Terms

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.

3 Introduction

3.1 Functional Basics

With the increasing use of thermal insulation in buildings and the resulting reduction in heating energy requirements, the share of energy required for heating water in a building's total energy requirement is growing in significance.

Thermal solar systems can cover a considerable portion of this energy requirement. Current systems for solar water heating function highly reliably and enable annual energy yields of 350 to 500 kilowatt hours per m² of collector area. At the same time, they cut the emission of c. 100-150 kg of the greenhouse gas CO_2. Solar thermal systems directly use the sun's radiation and convert it into heat on an absorbing surface, which is particularly of use in the field of hot water supply.

A thermal solar system must carry out the following tasks:

- Conversion of the sun's irradiated energy into heat with the use of collectors
- Heat transfer to the storage tank via the piping system
- Storage of heat in buffer tanks until required by the user.

In the process, energy is lost at the collector, in the piping system, and in the storage tank. Minimizing these energy losses is the job of practical adaptation and planning of the solar system for each specific scenario.

The *system efficiency* serves to evaluate these losses. It is defined as the ratio of available energy from the solar system to the irradiated energy onto the collector area. The percentage of total energy available covered by solar power is termed the *solar fraction*.

3.1.1 Basic Construction of a Solar System

The key component of a solar thermal system is the *collector* or the *absorber*, which converts solar energy into heat and transports it by means of a heat transfer medium via piping systems and heat exchangers to a storage tank. In systems for hot water supply, the storage tank compensates for fluctations in energy supplies and requirements at varying times of the day. In large solar systems which also greatly contribute to heating energy supplies, an underground seasonal storage tank is usually constructed in a local heating system to compensate for seasonal variations in irradiation and energy demand. These seasonal supply systems are currently at the trial stage and will not be considered further here. Where the solar energy is insufficient, an auxiliary heating system supplies the outstanding amount of energy to cover requirements.

A controller monitors the operational state of the solar system and ensures the most efficient use of the energy irradiated. If there is a temperature difference between the storage tank and the collector, it switches on the circulation pump in the collector loop, ensuring heat transport to the storage tank.

3.1.2 How the Absorber and Collector Work

Black surfaces are particularly good at absorbing shortwave radiation of light and then converting it into heat. This physical property is used in the so-called absorbers. These are made from plastic or metal in the form of panels, mats, or pipes with a black surface which, depending on the quality of the absorber, is voltaic or otherwise finished. Abosrbers are the active part of a solar system.

Depending on the scenario and the level of the required temperature, a distinction is made between

• absorber systems and

• collector systems.

Absorber systems are not insulated or covered. The heat transfer medium flows directly through them. These are structually simple, affordable systems suitable for operating temperatures below 40° C. Their primary areas of application are heating swimming pool water and preheating service water.

Absorber mats, usually made from plastic, can be placed on flat or slightly inclined roofs, also retrospectively, with little construction work.

Collector systems with *flat plate collectors* contain an absorber (typically in metal) in a sealed housing fitted with a transparent cover and heat insulation on the rear side. The transparent covering reduces irradiation from the absorber to the environment, while the thermal insulation reduces heat losses on the rear side, enabling temperatures of over 150° C to be reached. Primary areas of use are in water heating and space heating. Flat plate collectors are available in various sizes from 1 to 10 m². Special designs (e.g. triangular) are also possible. They are integrated within the roof cladding in prefabricated modules or attached to the roof cladding and interconnected.

Evacuated tube collectors contain a metal absorber sealed in evacuated glass tubes. The vacuum ensures that heat losses are kept to a minimum, enabling temperatures of over 200° C to be reached. Areas of use are heating service water, space heating, and generating process heat, as well as solar cooling of buildings.

3.1.3 Task of the Storage Tank

As in all hot water systems, the storage tank's task is to balance peak demand and charging power in supplying hot water and in solar systems additionally compensates for time differences between solar energy supply and hot water requirements. It typically features a heat exchanger at the bottom, in which the transfer medium from the collector (usually a water-antifreeze mixture) transfers the solar energy from the collector to the storage tank's content.

Where required, the upper part of the storage tank is additionally heated by a conventional heating system, so that the hot water taken from the upper part is always at the required target temperature, irrespective of available solar energy. Larger solar systems use several storage tanks connected in series, of which the last one is used for reheating.

3.1.4 How the Controller Works

Solar systems principally use a so-called differential temperature controller. This control principle compares the temperatures at the absorber and in the storage tank. If the absorber temperature is a preset level above that of the storage tank, the circulation pump in the collector loop is switched on. The irradiation energy converted to heat in the absorber system is transported to the storage tank, whose temperature increases. When the temperature of the storage tank is equal to that of the absorber, no more energy can be supplied to the storage tank and the pump is switched off.

3.1.5 Economics of Solar Systems

Current solar systems are always bivalent, as they can never be solely responsible, at least not year-round, for supplying heating energy. They are therefore connected upstream with conventional systems and function as "fuel savers" by transporting more or less preheated water to the downstream heating system.

To consider the economics of a solar thermal system, the investment costs are applied to the lifetime of the system, taking into account simple interest and an amount for maintenance and operating costs. In relation to the annual heating amounts supplied, this gives the heating price in cents/kWh. The heating price for a kilowatt hour generated by solar energy is of the same order as the generation of hot water from electrical current, now considerably lower for larger systems.

This development will also enable and intensify the use of solar thermal systems in medium-rise housebuilds in the coming years. The money saved from the oncosts of burning fossil fuels is not included here. However, the slightly higher heating energy bills are becoming accepted by many tenants today as a result of an improved social image and a considerable improvement to residential surroundings with the visibly ecological "advertisement".

3.2 Calculation Basics

3.2.1 Design of a Solar System

Small systems in detached private homes are typically designed such that they largely reach a full supply outside the heating periods, so that the boiler can be shut down in the summer. Around 60 % of annual hot water requirements can be covered by solar energy in this way. Larger solar fractions, i.e. if a large proportion of water must be heated by solar energy in spring, autumn, or in winter, give rise to a surplus in the summer which cannot be used. The solar system is then no longer operating as effectively as possible. In other words, an increasing solar fraction reduces the efficiency of a solar system. For systems in multiple dwellings or social institutions in which the auxiliary heating cannot be switched off because of tenancy laws or other provisions, current solar systems are designed with a solar fraction of up to 30 %.

There are no simple methods to calculate the yield of a solar system precisely. The number of parameters which determine the performance of a system is too large, and includes not only the changeable, non-linear characteristic of the weather but also the dynamic processes in the system itself. Although there are rules of thumb, such as around 1-2 m² of collector area per person and 50 l storage content per m² of collector area, these apply at best for small systems in detached or semi-detached houses.

In larger systems, computer simulation is the only way to investigate the influences of ambient conditions, user behaviour, and of various components on the operational state of the solar system.

Solar systems can also be used for heating wherever heat is required in the summer or where solar energy can be used for cooling in summer. These systems can then also make an appreciable contribution to building heating in the spring and autumn.

A further use of solar systems for auxiliary heating is in the field of low-energy houses. There, the fraction of heating energy occupies the same order of magnitude as the hot water supply.

In buildings with current thermal insulation standards, designing solar systems with the option of seasonal storage for heating purposes, also in winter, is inadvisable. This results in very large collector areas and, at the time, high surplus energy in the summer, i.e. in systems with very poor efficiency and consequently very high solar heat prices.

To design or optimize a solar system with T*SOL®, the following steps must be followed:

3.2.2 Calculation of Energy Balance

A thermal energy balance is generated to calculate status and temperature changes during a simulation period. Mathematically, this means the numerical solution of a differential equation.

Temperature difference = (Total of all input and output energies)/(Total of all heat capacities

Balancing means that the total of all input energy, output energy, and storage of energy via the heat capacity of the system components must be equal to zero. This balancing is not carried out wholesale for the entire system but for the individual system components.

- Collector
- Collector loop
- Heat exchanger
- Tanks

For each of these components, the change in temperature is calculated with the above formula on the basis of energy input and output and the heat capacity of the respective component.

Energy input can be (dependening on the component):

- Irradiation,
- Heat supply to the heat exchanger,
- Heat transfer by mass flow due to consumption or circulation,
- Intermixture of storage tank layers.

Energy output can be:

- Heat losses by radiation from the collector (quadratic transmission coefficient),
- Heat losses at the insulation of the collector, the piping (collector loop or circulation), the valves, or the storage tanks,
- Heat transfer to the heat exchanger,
- Heat transfer by mass flow due to consumption or circulation,
- Intermixture of storage tank layers.

The *heat capacities* of the following components are taken into account:

- Collector
- Piping of the collector loop
- Storage tank content

3.2.3 Calculation of Irradiation

In the supplied climate files, irradiation to the horizontal plane is given in watts per square metre of active solar surface. The program converts this to the tilted surface during the simulation and multiplies it by the total active solar surface.

Here, the radiation must be split into diffuse and direct radiation. The splitting is carried out according to Reindl's radiation model with reduced correlation. Reindl's model depends on the Clearness Index and the solar elevation angle. [Reindl, D.T.; Beckmann, W. A.; Duffie, J.A. : Diffuse fraction correlations; Solar Energy; Vol. 45; No. 1, S.1.7; Pergamon Press; 1990]

These are then converted into irradiation on the tilted surface, using the anisotropic sky model by Hay and Davis. [Duffie,J.A.; Beckmann, W.A.: Solar engineering of thermal process; John Wiley & Sons, USA; second editions; 1991]

This model takes into account the anisotropy factor for circumsolar radiation and the ground reflection factor (= 0.2).

Irradiation on the collector area (active solar surface) is calculated from the radiation strength (W/m²) on the horizontal plane:

the height of the sun and the solar azimuth is determined on the basis of the date, time, and latitude.

On the basis of the height of the sun, the solar azimuth angle, the collector tilt angle, and the collector azimuth angle, the position of the sun relative to the collector surface is calculated. This allows conversion of the direct share of solar radiation on the horizontal plane into the direct share of solar radiation to the collector, taking into account the active solar surface. The position of the sun relative to the collector surface is also required when calculating the reflected irradiation (see incident angle modifiers in the collector equation).

3.2.4 Calculating Collector Thermal Losses

Variant menu *System Definitions › Flat-Plate / Tube Collector › Losses / Thermal 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_{Km} 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.

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. This influence of this value is only significant for relative small pipeline networks, as the capacity of the pipeline network otherwise takes priority.

3.2.5 Calculation of Primary Energy Consumption

Consumption values, efficiencies, solar fractions, and other parameters can be calculated from the temperatures and the energy flows of the system.

The use of fuels by energy type (natural gas, oil, wood pellets, district heating) is calculated from the energy transferred to the auxiliary heating at the heat exchanger via the heat equivalent and the efficiency of the auxiliary heating. The efficiency of the auxiliary heating is determined depending on the return flow temperature, enabling simulation of the various efficiency levels at different capacity utilization of the heating system.

3.2.6 Calculation of CO2 Emissions

The CO_2 emissions saved by the solar system are calculated in the results summary. For this, it is necessary to know which type of primary energy is saved by the solar system. Emissions factors by fuel type are used to calculate the CO_2 emissions of a heating system. The following emissions factors are used in T*SOL®:

Fuel	Heating value	Emissions factor
Oil	36722 kJ/l	7.32748 g CO_2/kJ
Gas	41100 kJ/m³	5.14355 g CO_2/kJ
District heating		5.14355 g CO_2/kJ
Wood pellet	15490 kJ/kg	CO_2-neutral

Table 3.1: Heating values and emissions factors

3.2.7 Calculating Efficiency and the Solar Fraction

The collector loop efficiency is defined as follows:

$$\text{Collector Loop Efficiency} = \frac{\text{Energy output from the collector loop via the heat exchanger}}{\text{Energy irradiated onto the collector area (active solar surface)}}$$

The system efficiency is defined as follows:

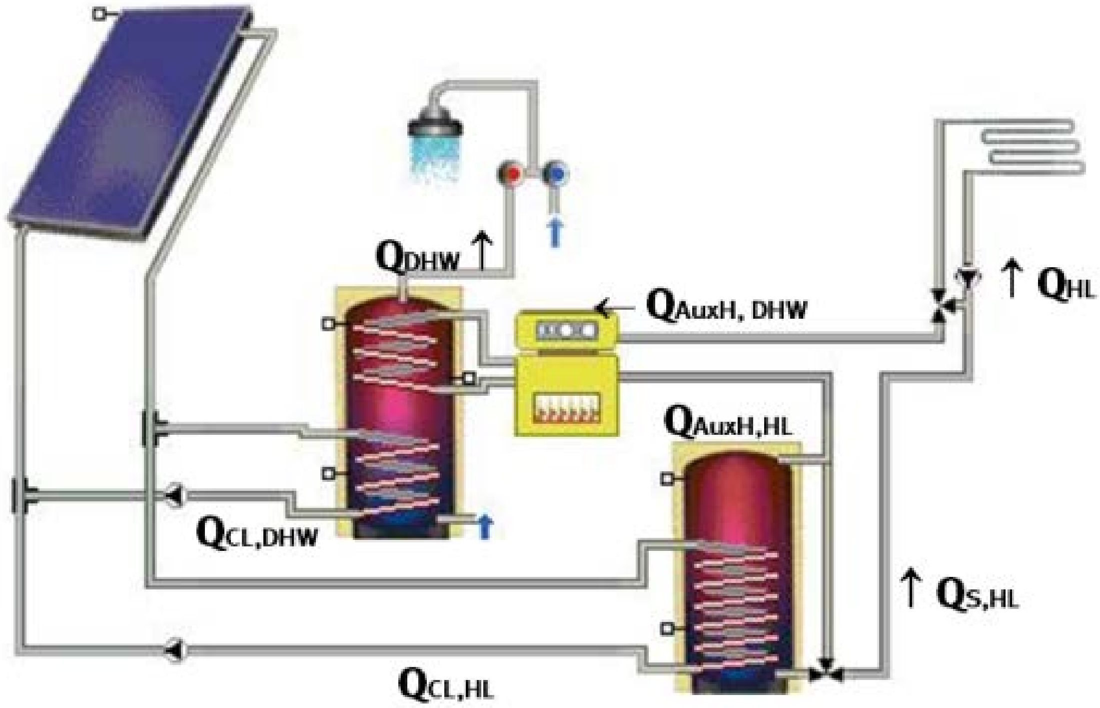
$$\text{Systemefficiency} = \frac{\text{Energy output from the solar system}}{\text{Energy irradiation onto the collector area (active solar surface)}}$$

The energy output by the solar system consists of the energy transferred from the solar storage tank (as a result of consumption and, where applicable, a recirculation system controlled in the solar storage tank) to the standby tank. As there is no difference between the solar and standby tanks in some systems (single storage tank model, e.g. bivalent storage tank or reheated buffer tank), the system efficiency of these cannot be calculated. The storage losses are therefore at the expense of reheating.

The solar fraction is defined as follows:

$$\text{Solar fraction} = \frac{\text{Energy supplied to the standby tank from the solar system}}{\text{Total energy supplied to the standby tank (Solar system + auxiliary heating)}}$$

The following applies to a solar system with bivalent storage tank (internal heat exchanger) for water heating and auxiliary heating:

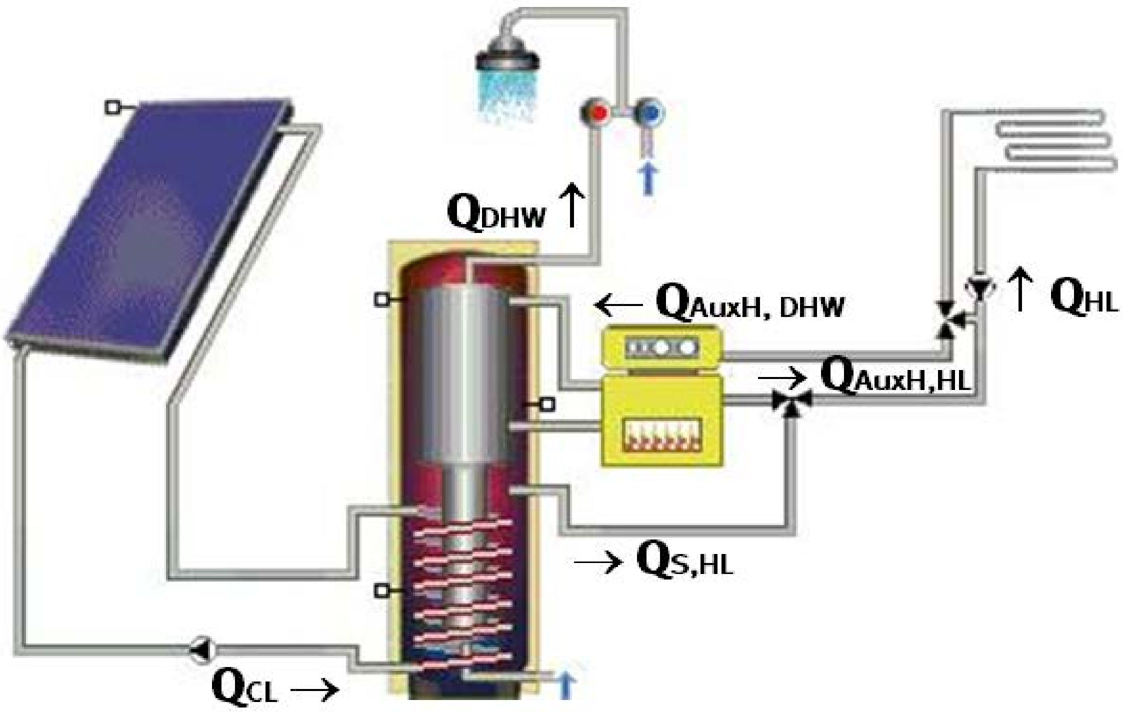


$$\text{Solar Fraction, total} = \frac{Q_{CL,DHW} + Q_{S,HL}}{Q_{CL,DHW} + Q_{SHL} + Q_{AuxH,DHW} + Q_{AuxH,HL}}$$

$$\text{Solar Fraction DHW} = \frac{Q_{CL,DHW}}{Q_{CL,DHW} + Q_{AuxH,DHW}}$$

$$\text{Solar Fraction Heating} = \frac{Q_{S,HL}}{Q_{S,HL} + Q_{AuxH,HL}}$$

The calculation for a solar system with a combined storage tank is as follows:



circulati
on)

$$\text{Solar Fraction, total} = \frac{Q_{CL}}{Q_{CL} + Q_{AuxH,DHW} + Q_{AuxH,HL}}$$

$$\text{Solar Fraction DHW} = \frac{Q_{CL} - Q_{S,HL}}{Q_{CL} - Q_{S,HL} + Q_{AuxH,DHW}}$$

$$\text{Solar Fraction Heating} = \frac{Q_{S,HL}}{Q_{S,HL} + Q_{AuxH,HL}}$$

The energy supply for heating drinking wateris the energy required to heat the cold water to the temperature of hot tap water. Losses from the storage tank or the circulation are not included here.

The fuel usedis the amount of fuel required to reheat the standby tank / the standby part of the storage tank to the target temperature. Heat losses from the storage tank and the boiler efficiency are included here.

3.2.8 Storage Tank Model and Operation

The stratified storage tank model uses storage layers of varying thickness, i.e. also of varying volume, whose number can vary depending on the operational state. The number of layers is not set, rather new layers are formed and the layer thickness is changed during the course of the simulation. This takes place via the feed-in and feed-out of volumes of water and the intermixture of temperature layers if the temperature stratification is reversed. The minimum layer thickness is defined by two system definitions: a layer cannot contain less than 1 % of the overall storage volume, and a temperature difference must be present between the layers.

3.2.9 Feed-In and Feed-Out

The cold water intake is always in the lowest storage tank layer, hot water is generally drawn from the highest layer. The inlets and outlets of the internal heat exchanger are set by the selected storage tank and are correctly represented in the storage tank view in the T*SOL® interface, as are the levels of the temperature sensor to control the collector loop and auxiliary heating.

3.3 Calculation of Economic Efficiency

The economics calculation in T*SOL®, according to the pay-off method, is based on the following formulae:

Investment Costs = Installation Costs – Subsidy

yearly Operating Costs = Pump Performance * Operating Time * Electricity Costs

The cash value (CV) of a price-dynamic payment sequence Z, Z*r, Z*r² ... over T years (lifetime) as per VDI 2067 is:

Cash value CV = Z * b(T,q,r)

$$\text{Cash value } b(T,q,r) = \begin{cases} \dfrac{1-(r/q)^T}{q-r} & \text{for } r <> q \\ T/q & \text{for } r = q \end{cases}$$

q: Simple interest factor (e.g. 1.08 at 8 % simple interest)

r: Price change factor (e.g. 1.1 at 10 % price change)

The following applies for the capital value (C) of the total investment:

$$\begin{aligned} C \quad = \quad & \Sigma[\text{CV of the price-dynamic payment sequence over lifetime}] \\ & - \text{Investments} \\ & + \text{Subsidies} \end{aligned}$$

The pay-back time is the period the system must operate for the investment to yield a cash value of zero. Pay-back times of over 40 years are not supported.

To calculate the heating price, the cash value of the costs is determined:

CV of costs = Investments + CV of Operating and Maintenance Costs

If the CV of the costs is converted into a constant sequence of payment (r = 1), then the following applies to this sequence Z:

Z = CV of Costs / b(T,q,r)

For r = 1, 1/b(T,q,r) becomes the annuity factor a(q,t) = q^T*(q-1)/(q^T-1) (again as per VDI 2067).

The heating price is then:

Heating Price = yearly Costs Z / yearly Energy Yield

3.4 Calculation of the Swimming Pool

The swimming pool is calculated as a 1-layer storage tank, including the following gains and losses:

- Evaporation losses at the surface
- Convection losses at the surface
- Transmission losses at the pool wall
- Irradiation gains at the surface
- Reflection losses at the surface
- Heat radiation at the surface
- Fresh water intake as a result of evaporation, pool discharge, and filter cleaning

The swimming pool heating requirement - to the extent that auxiliary heating is available - is defined as the total energy transferred from the solar system and the auxiliary heating to the swimming pool. Using the swimming pool heating requirement, the solar fraction of the swimming pool is derived.

There is the possibility that the target temperature cannot be reached in pools without auxiliary heating. As a result, the swimming pool heating requirement cannot be determined from the simulation. In this case, the swimming pool fraction is defined as the percentage of time in which the swimming temperature is above the target temperature to the total operating time.

A fraction of 100 % means that the pool temperature was reached or exceeded over the entire operating time.

4 Using the Program

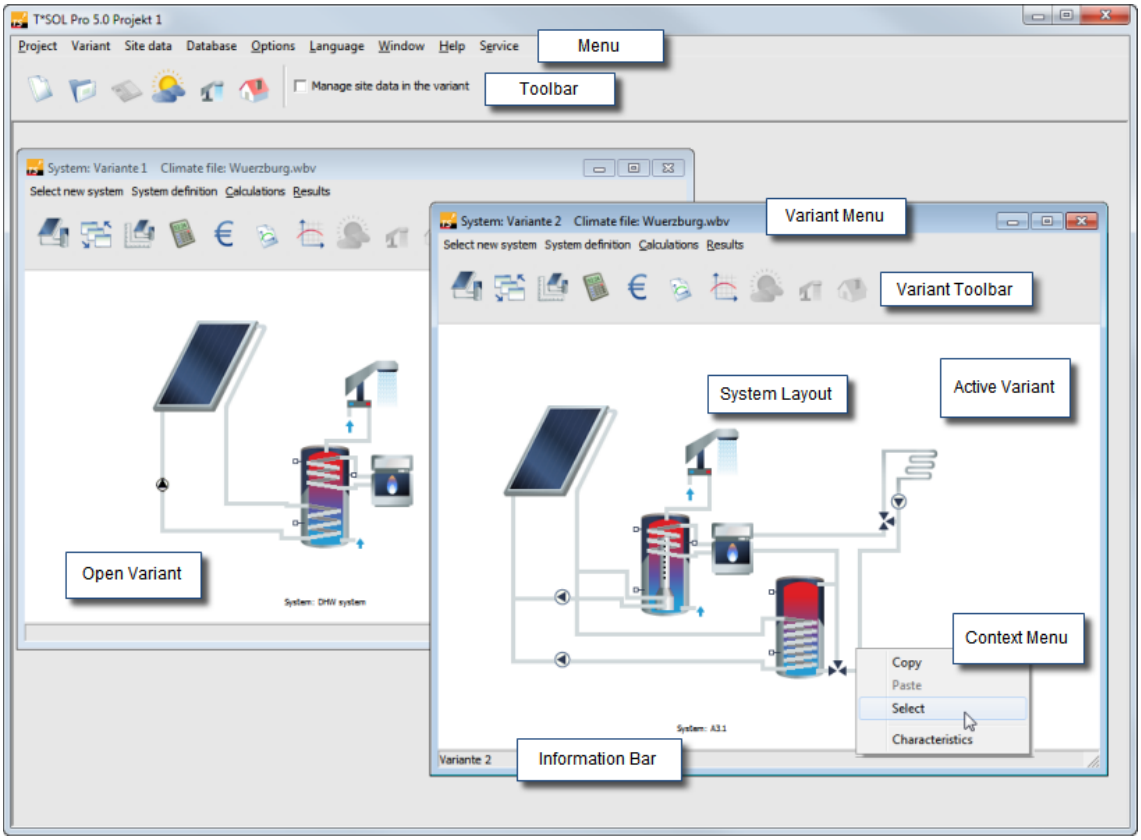


Image: T*SOL® user interface

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 you will use most frequently. If you hold the cursor over the symbol, a descriptive text against a yellow background appears.
- One or more variant windows, also with a toolbar.
- Other windows, dependening on which menu is open.

A variant window contains

- The variant menu,
- The variant toolbar,
- The system layout,
- Various context menus depending on where you right-click and
- An information bar at the bottom of the variant window.

4.1 Launching the Program

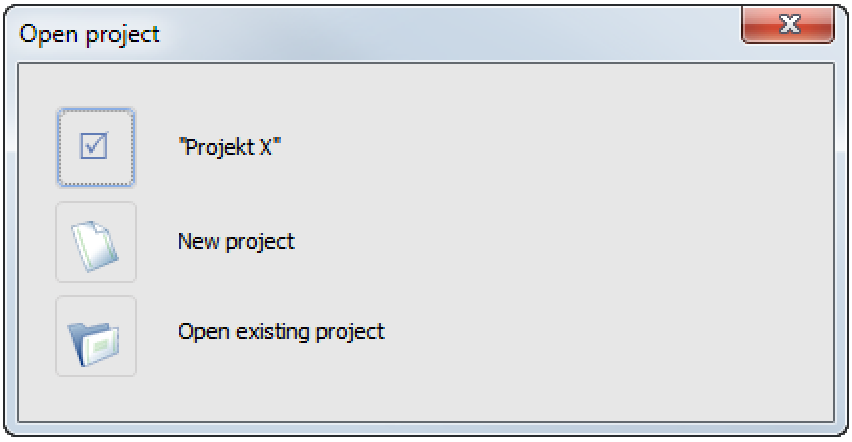


Image: Select project dialog

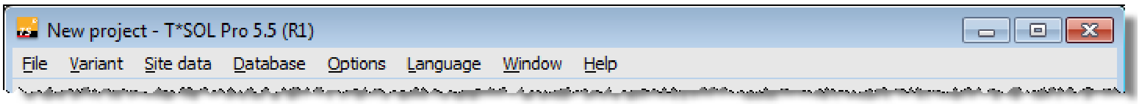
When you launch T*SOL®, you are asked first, which project you would like to start with.

The corresponding variants or a default variant are then displayed as a system layout in discrete windows.

4.2 Main Menu and Variant Menu

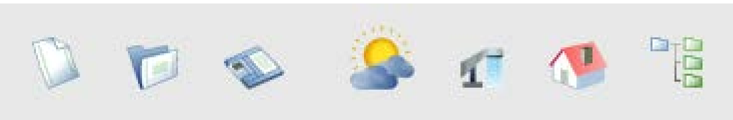
Main menu

All project-related and general functions can be accessed via the main menu.



Toolbar

Key functions can be accessed via the toolbar.

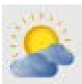


The symbol functions can be displayed by holding the cursor over the symbol and a descriptive text against a yellow background promptly appears.

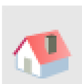
 Create new variant

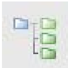
 Open variant

 Save variant

 MeteoSyn climate data

 Define hot water consumption

 Define heating requirements

Project tree: manage components and variants

- **See also:**

The detailed functions of the main menu are described in chapters 5, 6, 7, 8 and 13, 14, 15 and 16.

Variants menu and variants toolbar

Each variant is opened in a separate window. Related functions can be accessed via the variants menu.

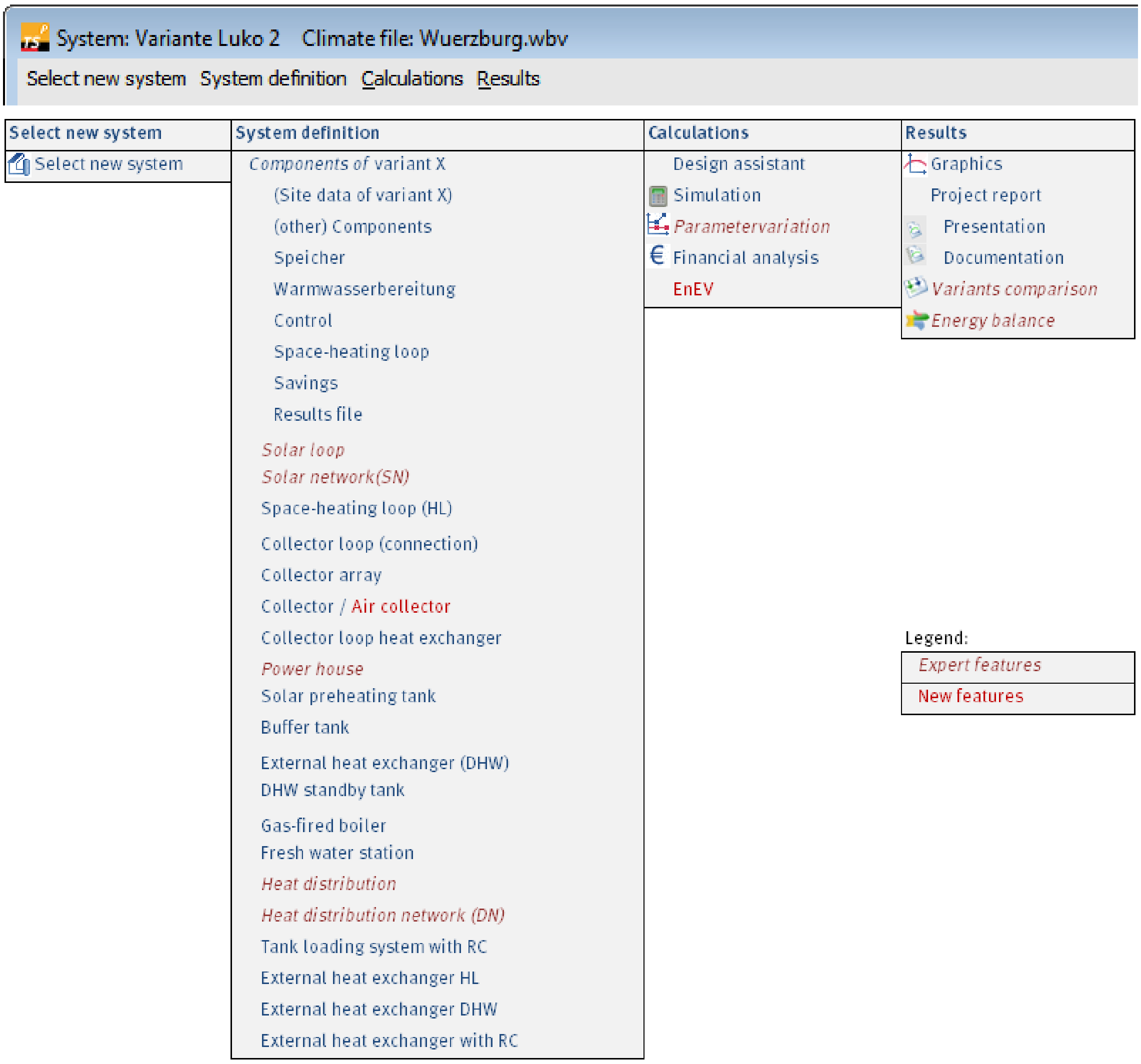
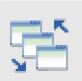


Image Variants menu. In T*SOL 5.0, new submenus are shown in red type. T*SOL Expert features are shown in brown type.

Key functions of the variants menu can also be accessed via the variants toolbar.

The symbol functions can be displayed by using so-called hints. For this, hold the cursor over the symbol and a descriptive text against a yellow background promptly appears.

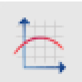
 Display system selection

 Open system definition

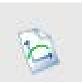
 Design assistant

 Start simulation

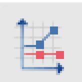
 Start financial analysis

 Create graph

 Energy balance (only T*SOL Expert)

 Create project presentation

 Create project documentation

 Parameter variation (only T*SOL Expert)

See also:

- Detailed technical information on system selection can be found in chapter 9 System Selection Variant Menu and on system definition in chapter 10 Variant Menu System Definition.
- Detailed instructions on calculations and simulation results can be found in chapters 11 Variant Menu Calculations and 12 Variant Menu Results.

4.3 System layout

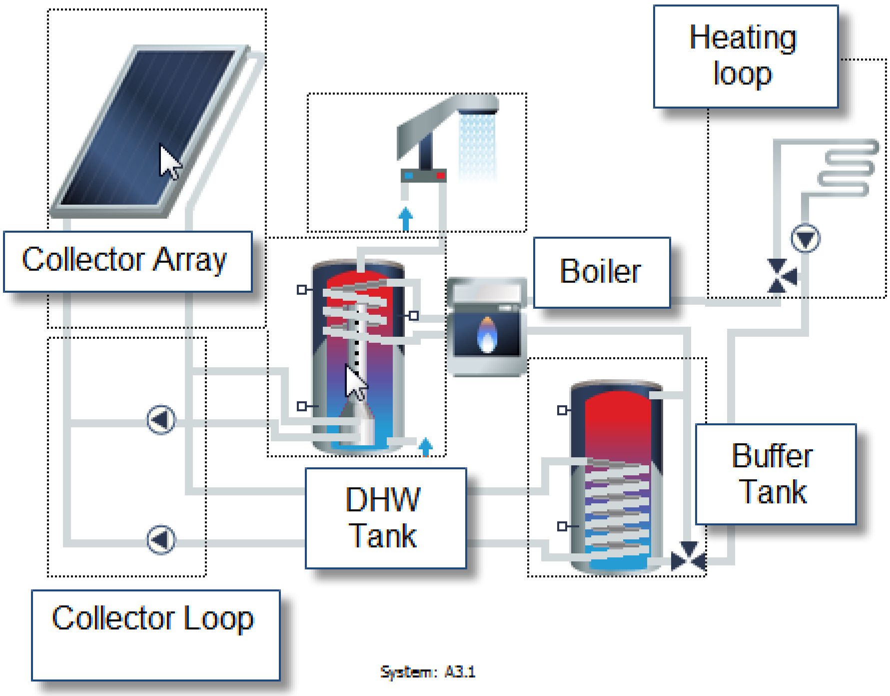


Image: System layout: component selection boundaries

Each selected variant is represented by a system layout.

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

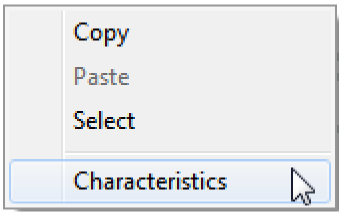


Image: System layout context menu

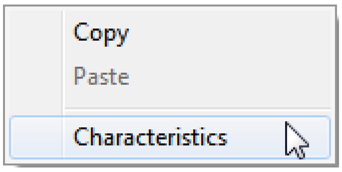


Image: Context menu for a component

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 variant, depending on the position of the cursor.

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

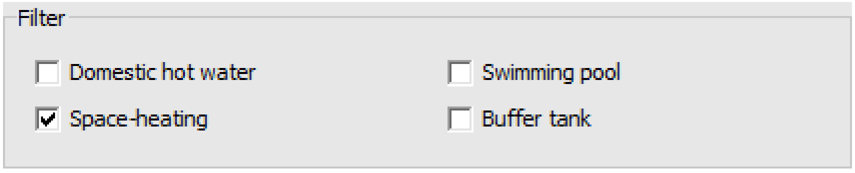
Use *Copy* and *Paste* to transfer components or the entire variant to another variant.

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.

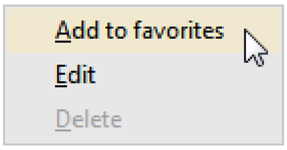
4.4 Selection Dialog for Systems and Components

The database selections offer some features facilitating the selection:

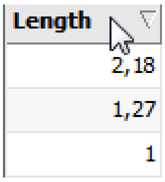
- Filter: Filter the table by using the checkboxes on top of the table.



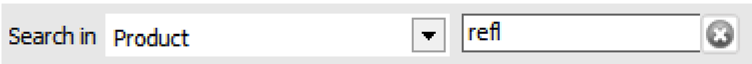
- List of your own favorites: right-click the component, context menu *Add to favorites*



- Sort table: by clicking into the table header



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



-> For editing and copying components see: Components

4.5 Open Dialogs, Enter Data

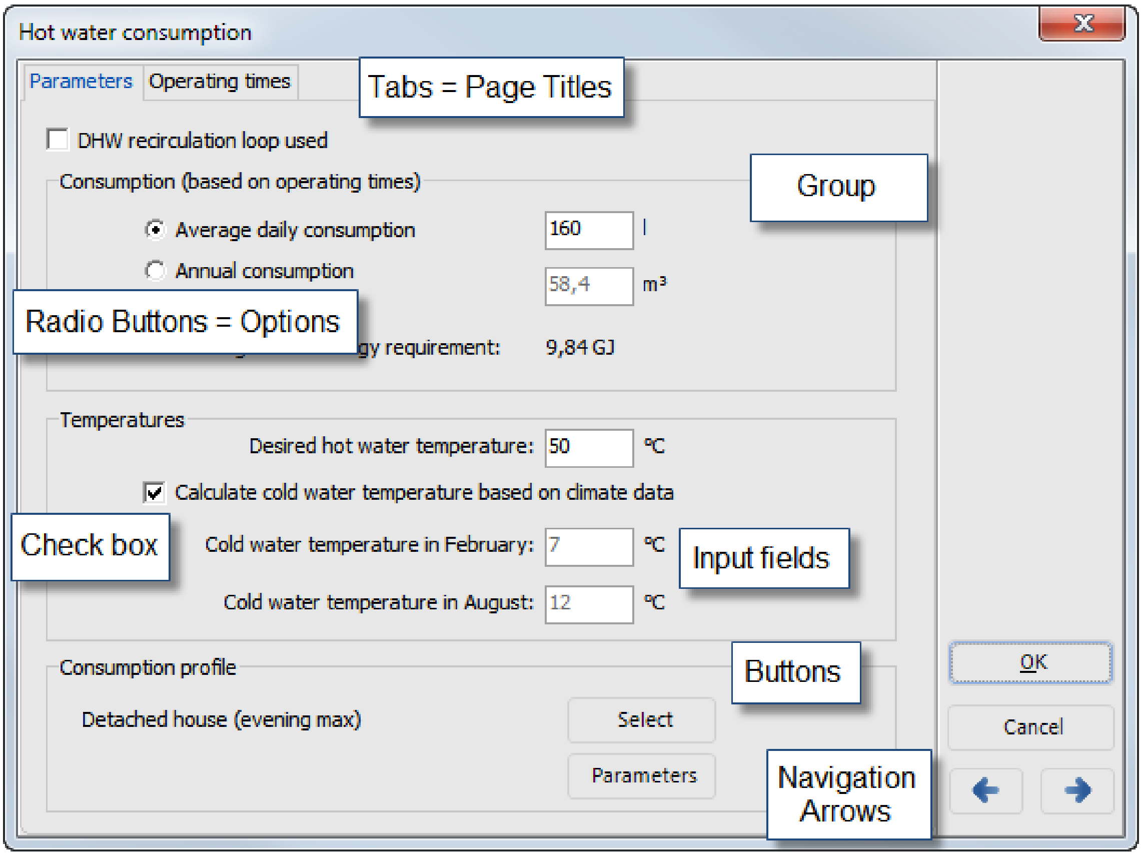


Image: Dialog window:entry and control elements

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).

4.6 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.

4.7 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 or new variant
2. Set Site Data
3. Select sytem
4. Define component parameters
5. Run simulation
6. Print project report

   or

   repeat steps 1 to 5
7. Compare variants (T*SOL Expert only) -> Choosing a variant

5 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 default list of the stored projects appears in the Projects folder C:\Users\‹User name›\Documents\Valentin EnergieSoftware\T*SOL Pro 5.5\Projects.

T*SOL projects can be saved with all variations in a file in any location.

A double click on the file starts T*SOL with the selected project.

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

Open last project

Menu *File › i*

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

Import project

Menu *File › Import*

Via this menu item, you can copy projects not located in the default Projects folder, for example on a removable drive, into the default Projects folder and open this copy.

The project format has been converted in T*SOL Pro 5.1.
You can load the T*SOL Pro 5.0 projects via the menu *File › Import*

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 › General 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.

Save Project as

Menu *File › Save as*

In the *File › Save as* menu, you can save projects in different folders or, for example, copy them to a removable drive.

This opens a file selection dialog that allows you to manage the files in the standard way.

Project Data

Menu *File › Project Data*

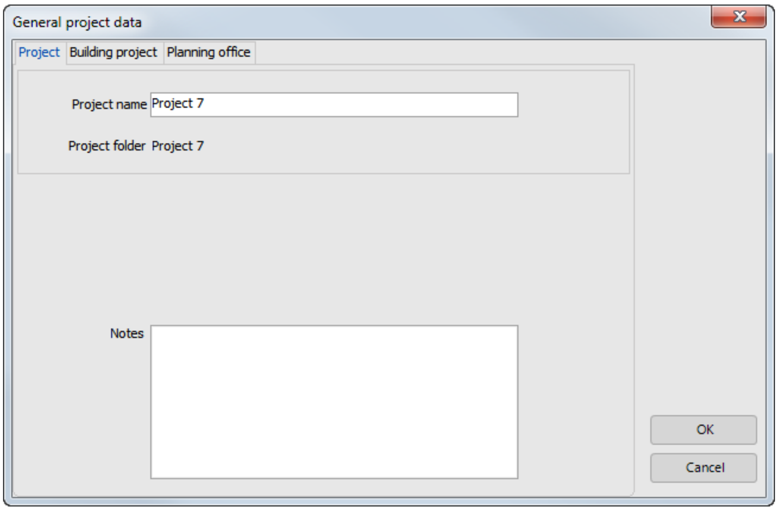
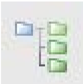


Image: Input dialog for general project data

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

-> 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*.



Project tree

Menu *File › Project Tree*

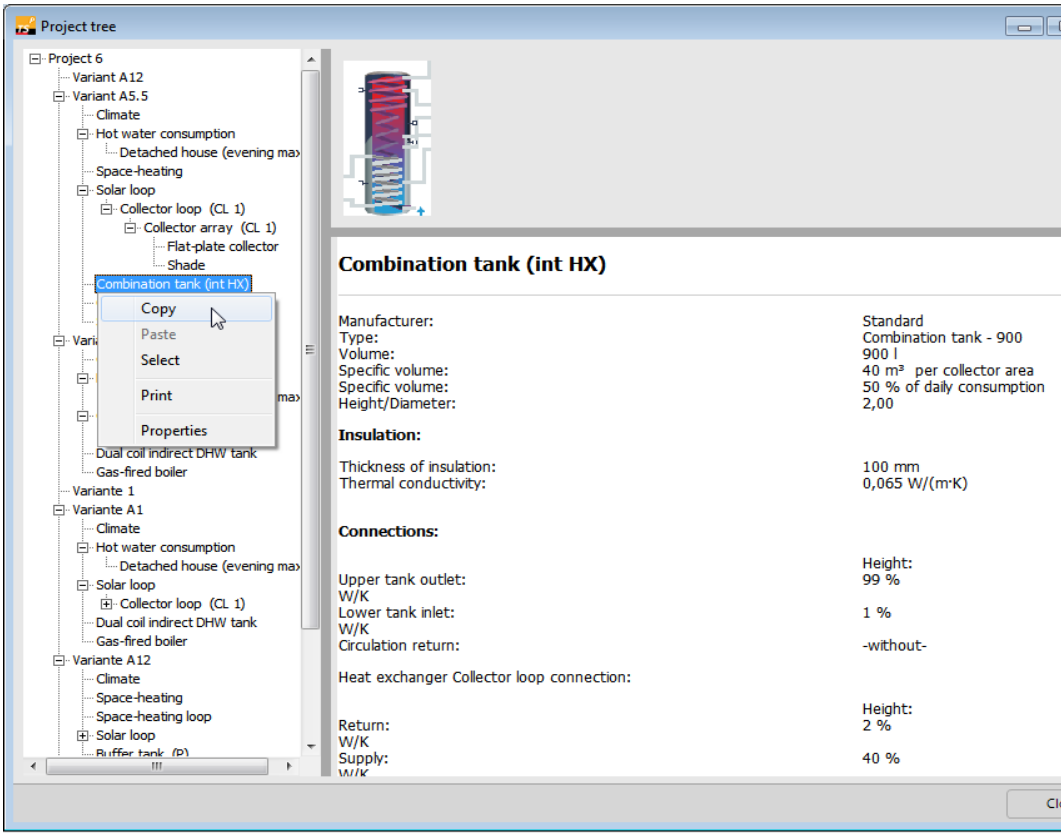


Image: *File › Project Tree*

The project tree presents for all variants an overview of it's components.

The components are listed in the left-hand area, their descriptions are given on the right.

You can also open the parameters dialog pertaining to each component and modify their parameters.

You can copy and paste components between variants and between projects. For this, use the *Copy* and *Paste* commands in the context menu, respectively.

Exit

Menu *File › Exit*

This command closes the program.

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

6 Variant Menu

Menu *Variant*

Within a project, you can create any number of system variants and edit up to eight of them at one time. All variants are saved in the project folder and take the file ending .var.

New variant

Menu *Variant › New*

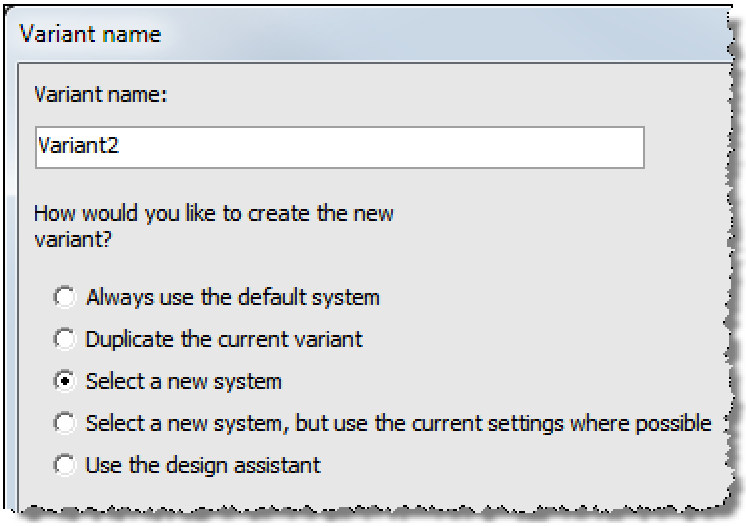


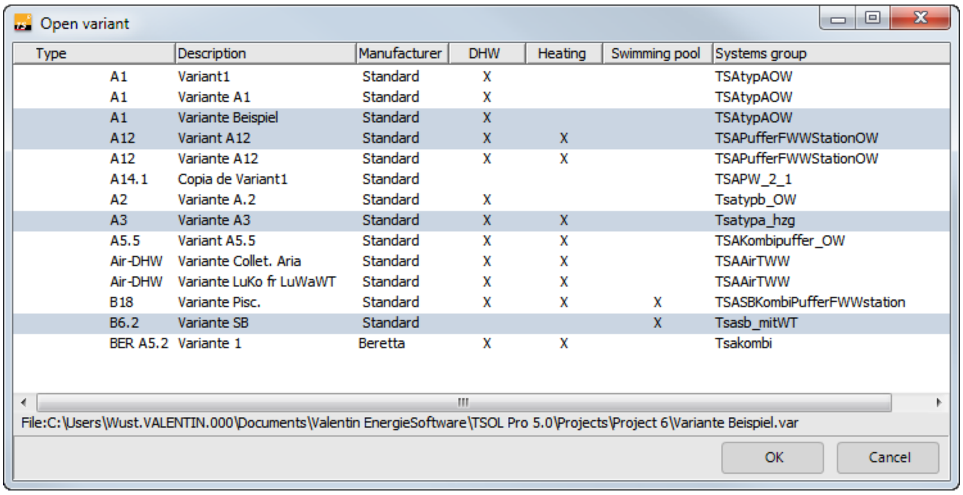
Image: Input dialog for creating a new variant

-› Proceed as follows:

1. Name the new variant.
   If you do not assign a name, one will be created automatically: "variant+consecutive number".
2. Various ways of creating a new variant are available:
   - with the default system,
   - by duplicating the open variant,
   - by selecting a new system for which you can choose to apply the values of the current variant,
   - or with the help of the assistant.
3. After clicking *OK*, the selected name appears in the header bar of the window.

Open variants

Menu *Variant › Open Variant*



Type	Description	Manufacturer	DHW	Heating	Swimming pool	Systems group
A1	Variant1	Standard	X			TSAtypAOW
A1	Variante A1	Standard	X			TSAtypAOW
A1	Variante Beispiel	Standard	X			TSAtypAOW
A12	Variant A12	Standard	X	X		TSAPufferFWWStationOW
A12	Variante A12	Standard	X	X		TSAPufferFWWStationOW
A14.1	Copia de Variant1	Standard				TSAPW_2_1
A2	Variante A.2	Standard	X			Tsatypb_OW
A3	Variante A3	Standard	X	X		Tsatypa_hzg
A5.5	Variant A5.5	Standard	X	X		TSAKombipuffer_OW
Air-DHW	Variante Collet. Aria	Standard	X	X		TSAAirTWW
Air-DHW	Variante LuKo fr LuWaWT	Standard	X	X		TSAAirTWW
B18	Variante Pisc.	Standard	X	X	X	TSASBKombiPufferFWWstation
B6.2	Variante SB	Standard			X	Tsasb_mitWT
BER A5.2	Variante 1	Beretta	X	X		Tsakombi

Image 6.2: Dialog for opening variants

All variants in this project are displayed in a list.

Open the variant(s) by selecting the relevant line(s) and clicking *OK*.

Duplicate variant

Menu *Variant › Duplicate Variant*

Copy the current variant to create a further variant. The copy then becomes the current (opened) variant.

Save variant

Menu *Variant › Save Variant*

Save the opened variant. Otherwise changes will only be saved when the variant or project is closed.

Close variant

Menu *Variant › Close Variant*

Close a variant by either entering CTRL+F4 or by clicking the button.

If you have made changes since last saving the variant, you will be given the option to save before it is closed.

If you close the variant without saving, changes will be discarded.

Delete variant

Menu *Variant › Delete Variant*

A list of all variants on the open project is displayed.

Select a variant and click *OK* or double-click the relevant line. Confirm that you wish to delete.

7 Site Data Menu

Menu *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 or sub-menus, respectively:

 Load climate data

 Set DHW requirements

 Define heating requirements

Process Heating Device

Building with Air Collectors

Swimming Pool

Project Data

Menu *File › Project Data*

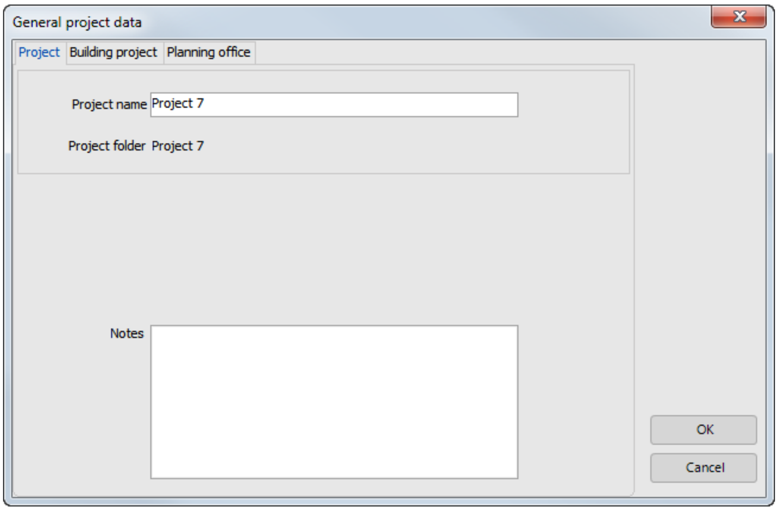


Image: Input dialog for general project data

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

-› 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*.

7.1 Climate

Climate

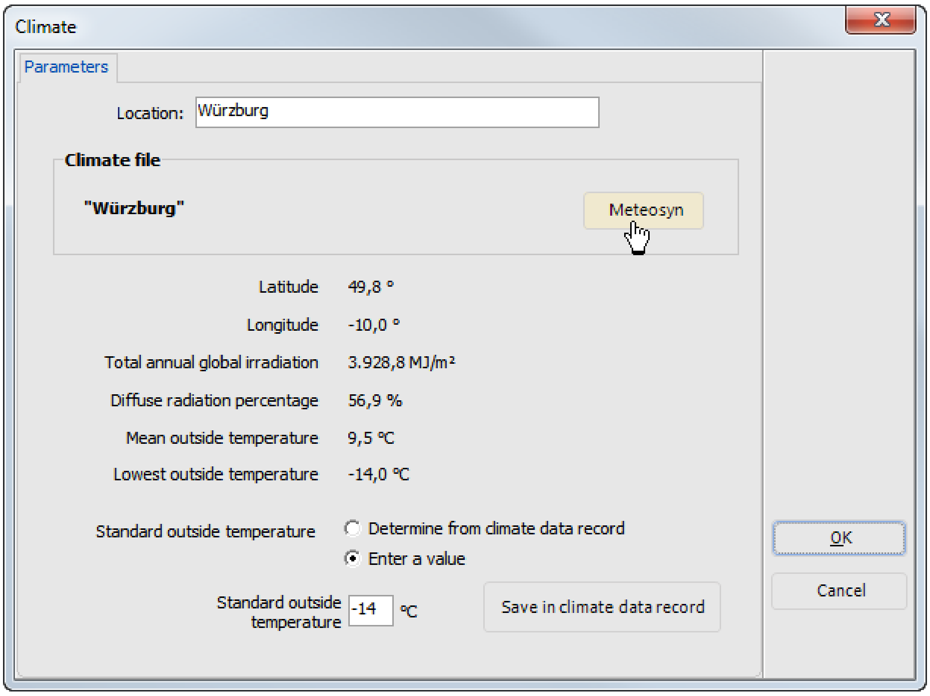


Image: Dialog for climate defaults

➔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.

➔How to proceed:

3. Select *Enter Temperature* in the *Standard Outside Temperature* box.
4. You can then enter the standard outside temperature.
5. 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

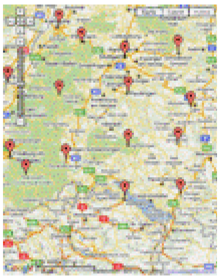
1	Norderney	-10	W
2	Hamburg	-12	W
3	Rostock	-10	W
4	Potsdam	-14	
5	Braunschweig	-14	W
6	Erfurt	-14	
7	Essen	-10	
8	Kassel	-12	
9	Chemnitz	-14	
10	Hof/Saale	-18	W
11	Würzburg	-12	
12	Mannheim	-12	
13	Freiburg i.Br.	-12	
14	Munich	-16	
15	Garmisch Partenkirchen	-18	

7.1.1 Climate Data

Menu *Databases › Climate Data*

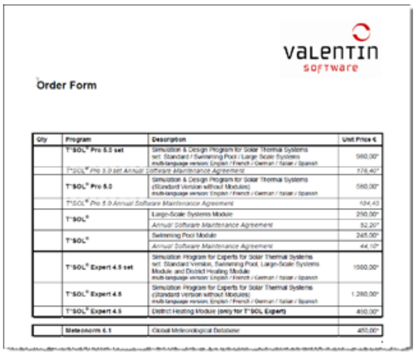
On our website at http://www.valentin.de/index_de_page=weather, you can

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



generate further climate data for Europe, or

order global climate data.



Order Form

Qty	Program	Description	Unit Price €
	T*SOL® Pro 5.0 set	Simulation & Design Program for Solar Thermal Systems set: Standard / Swimming Pool / Large Scale Systems multi-language version: English / French / German / Italian / Spanish	980,00*
	T*SOL® Pro 5.0 set Annual Software Maintenance Agreement		176,40*
	T*SOL® Pro 5.0	Simulation & Design Program for Solar Thermal Systems (Standard Version without Modules) multi-language version: English / French / German / Italian / Spanish	580,00*
	T*SOL® Pro 5.0 Annual Software Maintenance Agreement		104,40
	T*SOL®	Large-Scale Systems Module	290,00*
		Annual Software Maintenance Agreement	52,20*
	T*SOL®	Swimming Pool Module	245,00*
		Annual Software Maintenance Agreement	44,10*
	T*SOL® Expert 4.5 set	Simulation Program for Experts for Solar Thermal Systems set: Standard Version, Swimming Pool, Large-Scale Systems Module and District Heating Module multi-language version: English / French / German / Italian / Spanish	1500,00*
	T*SOL® Expert 4.5	Simulation Program for Experts for Solar Thermal Systems (Standard Version without Modules) multi-language version: English / French / German / Italian / Spanish	1.280,00*
	T*SOL® Expert 4.5	District Heating Module (only for T*SOL Expert)	400,00*
	Meteonorm 6.1	Global Meteorological Database	450,00*

7.2 Hot Water Consumption

Menu *Site data › Hot water consumption*

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

7.2.1 Parameters

Menu *Site data › Hot water consumption › Parameters*

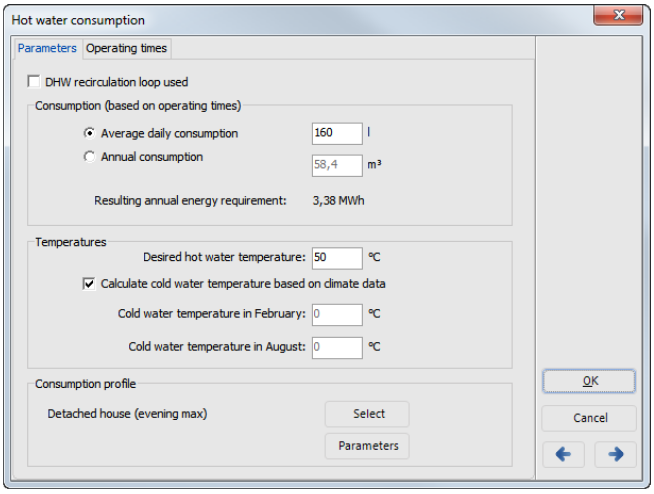


Image: Dialog for defining DHW requirement

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.

7.2.2 Consumption Profile

Menu *Site data › Hot water consumption › Parameters › Load Profile (Consumption Profile) › Select*

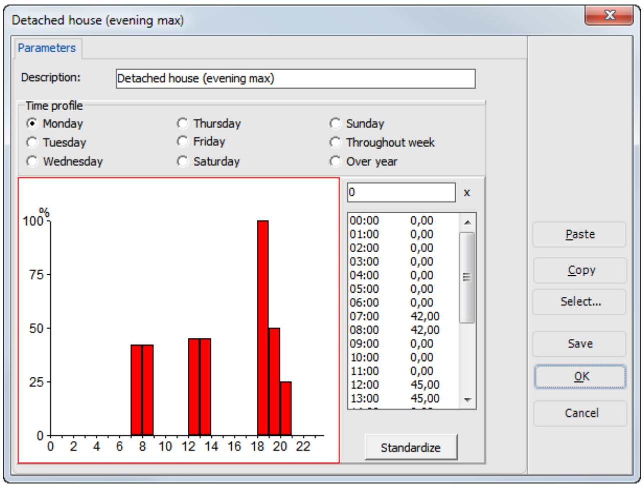


Image: Dialog for defining consumption profiles

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:

-> 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.

7.2.3 Circulation

Menu *Site data › 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.

7.2.4 Operating Times

Menu *Site data › 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.

7.2.5 Deactivate Hot Water Consumption

Menu *Site data › Hot water consumption*

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

- Site data dialog *Hot Water Consumption › Parameter*:
  switch off *DHW recirculation loop used*
  set the desired DHW temperature to 20 °C
  set both cold water temperatures to 20 °C
- System definition dialog *Hot Water Tank › Control* :
  set target tank temperature as *relative to DHW target temperature*
  in *Collector loop connection › Maximum temperature limit*, set the value to 20 °C

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

7.3 Space Heating Requirement

Menu *Site Data* › *Space Heating*

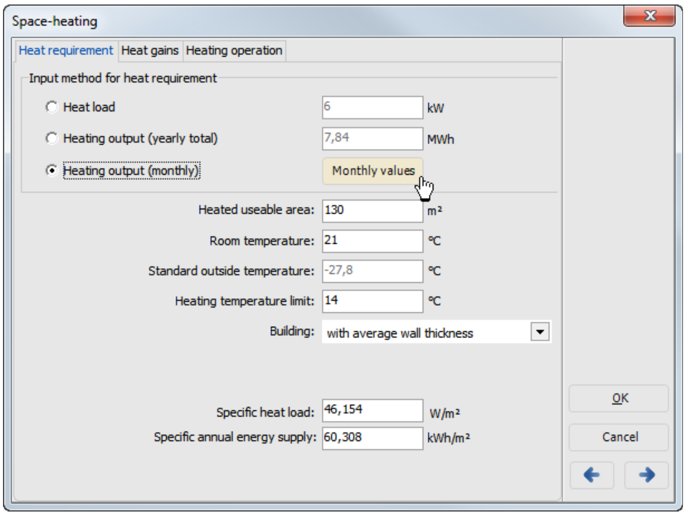


Image: Dialog *Site Data* › *pace Heating* Requirement

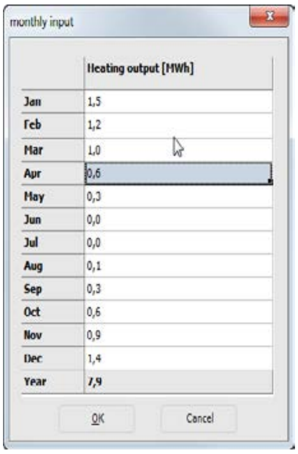


Image: Dialog *Site Data* › *Space Heating Requirement* › *Heating Output* - Monthly Values

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

Heat requirement

Menu *Site Data* › *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

Menu *Site Data* › *Space Heating* › *Heat Gains*

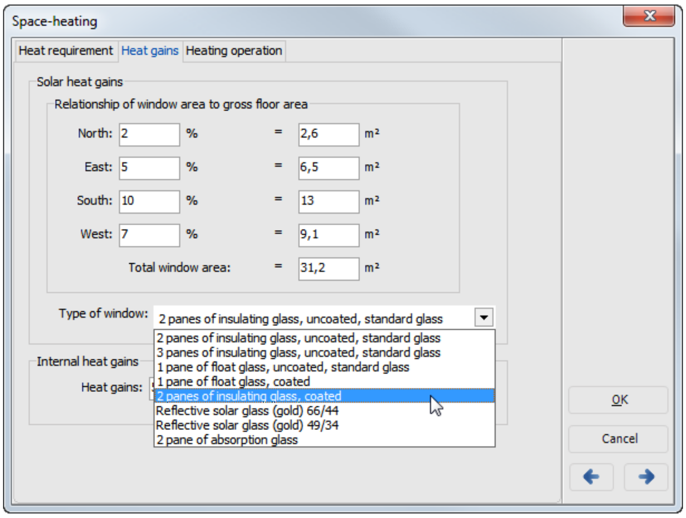


Image: Dialog *Site Data* › *Space Heating* › *Heat Gains*

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

Menu *Site Data* › *Space Heating* › *Heating Operation*

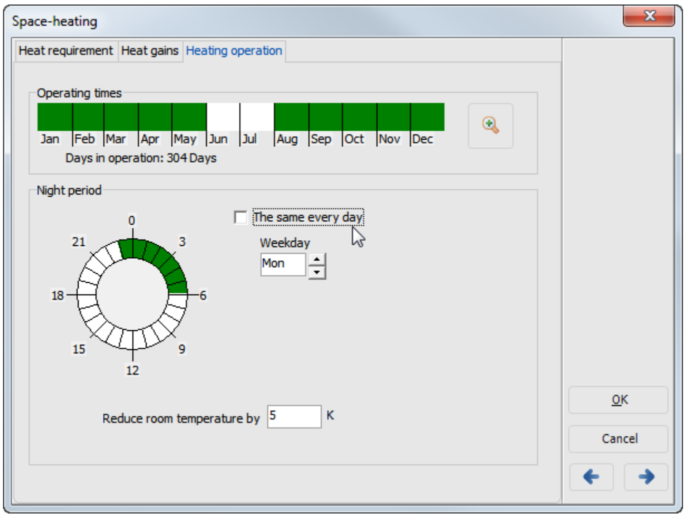


Image: Dialog *Site Data* › *Space Heating* › *Heating Operation*

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.

7.4 Process Heating Device

Menu *Site Data › Process Heating › Parameters* or variant menu *System Definition › Process Heating*

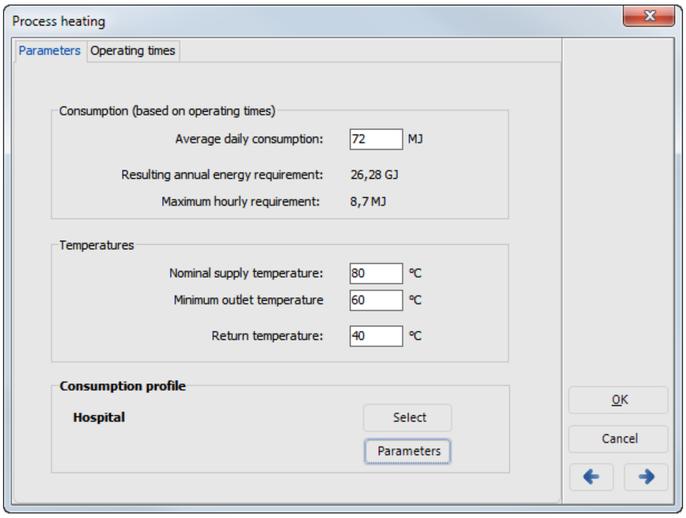


Image: Menu *Site Data › Process Heating › Parameters* or variant menu *System Definition › Process Heating*

The three systems A13, A14, and A15 include a process heating device. This is characterized by the fact that flow and return temperatures can be defined.

Auxiliary heating takes place in the buffer tank in system type A13, while system type A14 has auxiliary continuous-flow heating (in series).

Entering and operating the process heating is similar to DHW Consumption. Additional information here is the energy consumption and return temperature.

Enter an average daily energy requirement. The resulting annual requirement and the maximum expected hourly requirement are displayed.

Enter the desired outlet temperature ("nominal temperature") and return temperature. You can also provide a minimum outlet temperature at which the device starts up or to which the outlet temperature may drop below the desired temperature.

Annual process heating energy requirements are then determined via the qualitative consumption profiles. Use *Select* to choose a consumption profile.

Adjust the *Parameters* of the consumption profile to your needs.

Process heating with 100% solar fraction

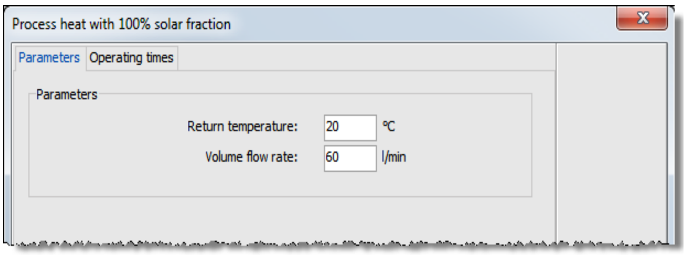


Image: System A15: Process heating without storage tank: variant menu *System definition › Process Heating with 100% Solar Fraction › Parameters*

In addition to the device with preset energy consumption, there is also the system type A15 without storage tank, in which you can only enter the return temperature and a constant flow rate. As soon as the outlet temperature rises above the return temperature, energy is extracted. This can be used to investigate how much energy the solar system could supply under these conditions.

è See chapter 9.1.11

7.5 Building with Air Collectors

Menu *Site Data › Building*

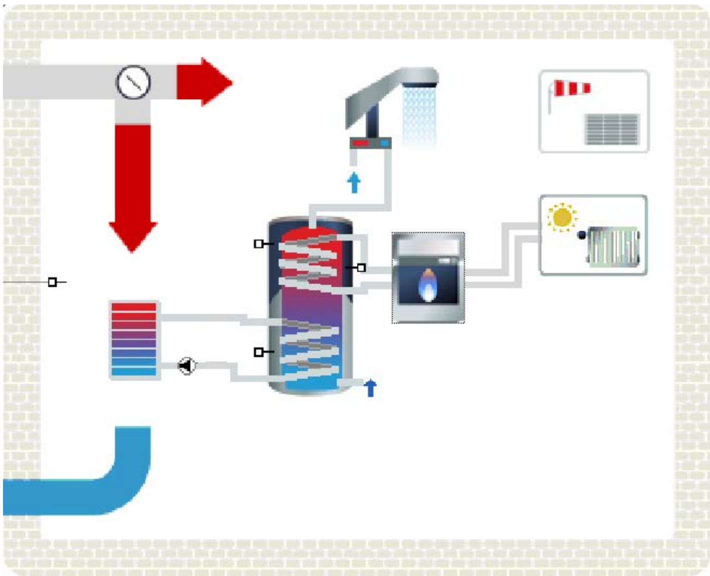


Image: Building display in the system schematic

The building model for air collector systems can not only highlight reactions between building elements and system technology but also simulate the building dynamics and ventilation losses / controlled ventilation.

The building is displayed as a cuboid which can consist of several floors. This cuboid has a flat roof and rests on a bottom slab (no basement possible). The building geometry is recorded. The building is symbolized in the system schematic by the surrounding building wall.

The building capacity and insulation is collected on the basis of the building geometry and information on the type of construction. The full capacity of the internal walls or the furnishings can be preset. In the model, these are distributed equally to all rooms.

7.5.1 Geometry

Menu *Site Data › Building › Geometry*

Only buildings with a rectangular floor plan, a flat roof, and no basement can be calculated.

The external walls are designated 1 to 4 and numbered consecutively clockwise. The wall numbers are used on the Construction Type page.

On the Site Data › Geometry page, enter the dimensions of your building:

- Inside length (wall 1 and 3)
- Inside width (wall 2 and 4)
- Ceiling height:
  The ceiling height is the same for all floors. The product of length, width, and number of floors defines the area to be heated. The product of area and ceiling height defines the volume to be heated.
- Number of floors (maximum=20 floors)

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

7.5.2 Construction Type

Menu *Site Data › Building › Construction Type*

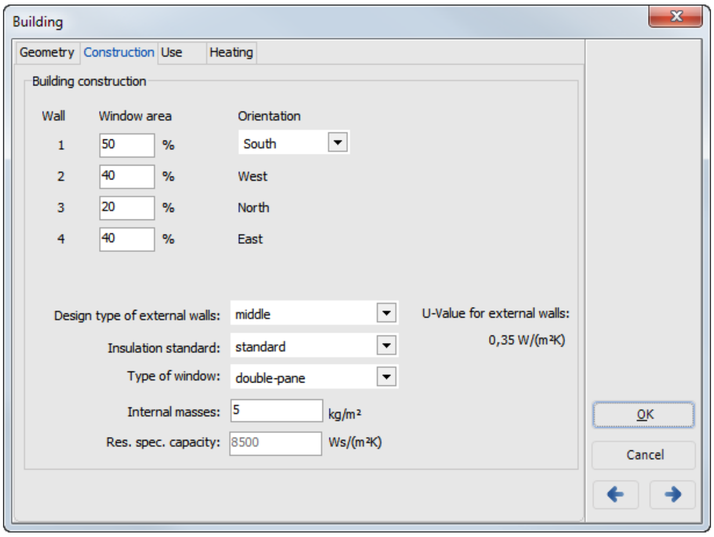


Image:
Dialog *Site Data › Building › Construction Type*

The external walls are designated 1 to 4 and numbered consecutively clockwise.

è Define the construction type of your building:

1. Enter the orientation of wall 1. The remaining walls are automatically displayed.
2. Enter the construction type of the external walls:

light	medium	heavy
wood post-and-beam structure	brick building	concrete composition
à increasing heat capacity.		

3.
4. Enter the insulation standard of the external walls:

uninsulated	standard	high
without any insulation (garden house)	standard 2010 insulation	doubling of all insulation layers

5. According to design and insulation chosen, the respective heat transfer coefficient (U value, acc. to DIN V 18599 / 2007) is taken and will be used for further calculation. The higher the U value, the higher the transmission losses of the building, which make up for a part of the heat requirement. This table gives an overview on the used U values.

Used U-values, according to construction type and insulation

Construction Type	Design type	Insulation	U value [W/K]
External Wall	light	high	0,13
External Wall	light	standard	0,17
External Wall	light	uninsulated	0,22

External Wall	medium	high	0,23
External Wall	medium	standard	0,43
External Wall	medium	uninsulated	3,05
External Wall	heavy	high	0,22
External Wall	heavy	standard	0,39
External Wall	heavy	uninsulated	1,70
Ground	light/medium/heavy	high	0,58
Ground	light/medium/heavy	standard	1,09
Ground	light/medium/heavy	uninsulated	8,42
Ground floor heating	light/medium/heavy	high	0,30
Ground floor heating	light/medium/heavy	standard	0,58
Ground floor heating	light/medium/heavy	uninsulated	8,42
Roof	light/medium	high	0,13
Roof	light/medium	standard	0,18
Roof	light/medium	uninsulated	3,16
Roof	heavy	high	0,16
Roof	heavy	standard	0,24
Roof	heavy	uninsulated	4,32
Roof with cooling	light/medium	high	0,13
Roof with cooling	light/medium	standard	0,18
Roof with cooling	light/medium	uninsulated	3,16
Roof with cooling	heavy	high	0,16
Roof with cooling	heavy	standard	0,24
Roof with cooling	heavy	uninsulated	4,32

6.

7. Enter the types of window: single / double / triple glazing. The percentage of frame is calculated as 10% for all windows. The windows differ from one another in the total transmissivity of the glazing. It is assumed that there is no shade.

8. Enter the furnishings mass in order to simulate additional heat capacity in the building, e.g. heavy furnishings. The specific heat capacity is calculated and displayed.

7.5.3 Use

Menu *Site Data › Building › Use*

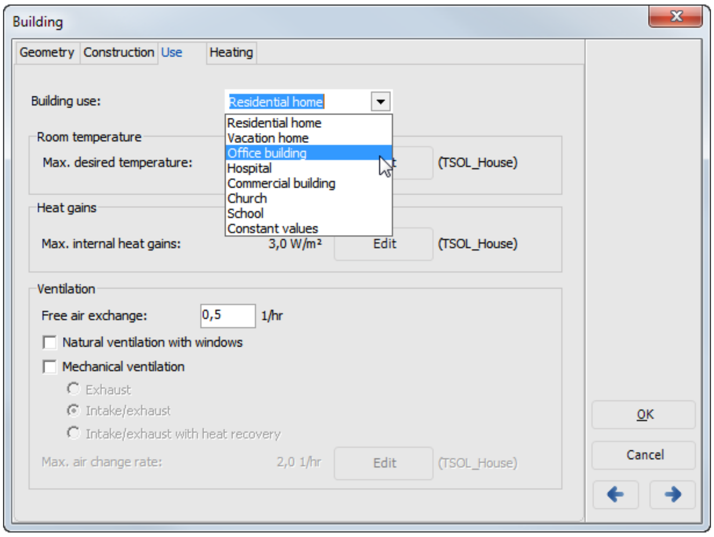


Image: Dialog *Site Data › Building › Use*

The parameters for building use arising from user behavior and the resulting control settings for heating and ventilation are collected on the *Use* page. DHW consumption is defined in the Site Data › DHW Consumption dialog.

Specify user behavior by choosing the most suitable use profile. Target temperature, internal heat sources, and ventilation are combined in the use profile:

- Residential building
- Vacation house
- Office building
- Hospital
- Store
- Church
- School
- Constant values, i.e. the same parameters for all hours in the year

Set the following use parameters:

- Target temperature for the room temperature control. The target temperature is the same for all rooms and is taken hourly from the temperature use profile.
  Value range 0 °C–30 °C.
- Heat from *internal heat sources*, e.g. from lighting, body warmth, computers, and other machines and equipment in the building. The heat is the same for all rooms and is taken hourly from the internal heat sources use profile.
  Value range 0–100 W/m²
- Ventilation
  - Even if there is no ventilation system, every building has ventilation resulting from the permeability of the building and the ventilation habits of the users. This so-called free ventilation is applied as a constant over the

year.
Value range: 0–4 1/h

- o Tick the "*Natural Ventilation with Windows*" checkbox to set the inclusion of another open window with correspondingly increased ventilation for cooling in the event of overheated rooms (e.g. in summer).
- o Select the "*Mechanical Ventilation*" checkbox to activate the calculation of mechanically operated ventilation systems.
  Hourly values 0 .. 8 1/h
  Two options are then available:
  - § *Exhaust air*: usually only in kitchens or toilets. However, the ventilation defined in the profile relates to the entire volume of the building. The system image adjusts to this setting.

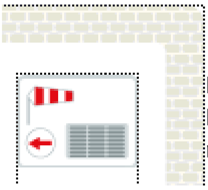


Image:
Building with mechanical exhaust air system. The red arrow represents the warm exhaust air.

  - § Ventilation and air-conditioning system *with heat recovery:* This features supply and exhaust air ventilators and heat recovery only activated during the heating period. The "exhaust air" option should be used for a building with a ventilation and air-conditioning system but without heat recovery. The system image adjusts to this setting.

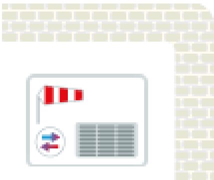


Image:
Building with mechanical ventilation and air-conditioning system and heat recovery. The two arrows represent the cooling of warm exhaust air and the heating of cold external air.

- § Define profile for mechanical ventilation with hourly values. Click *Edit* to open and edit the use profile for mechanical ventilation.
- § If you have set mechanical ventilation, you can set no partial areas in the supply area of the air collectors on the heating page, as it is assumed that the mechanical ventilation covers the entire building. (See chapter 7.5.5 Heating)

7.5.4 Edit Use Profiles

Menu *Site Data › Building › Use › Edit*

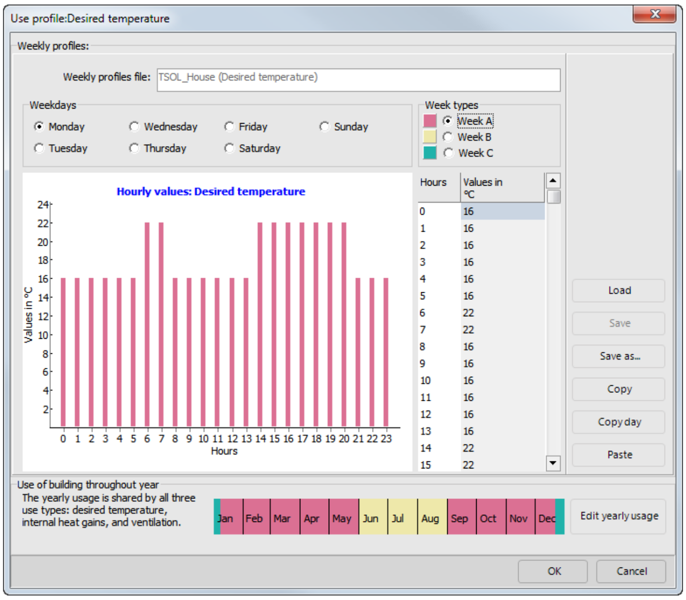


Image: Dialog *Site Data › Building › Use › Temperature Use Profile*

The *Site Data › Building › Use* page contains three *Edit* buttons, one for the target room temperature, one for the internal heat sources, and one for the mechanical ventilation. An edit dialog structured in the same way for all three cases opens:

You can save three different *Week Types* (A, B, and C) in a week profile. These week types include the three areas of target room temperature, internal heat sources, and mechanical ventilation, which must all be edited separately. Define *Day Profiles* for every *Weekday* for each week type.

The *Building Usage Times* over the year apply for all three usage areas.

è How to proceed:

1. Load a week profile file.
2. Select a week type for editing. The hourly values for Monday are shown in the table and the graph.
3. Select a week day for editing. Its hourly values for Monday are shown in the table and the graph.
4. Click on any value and overwrite it. The maximum value is 30 °C / 86 °F, larger values will be cut to these. The graph is adjusted as soon as you place the cursor in another field. You cannot modify the X-axis (hours).
5. Use the *Copy Week* or *Copy Day* buttons to paste complete weeks or days into another week type or day.
6. Click on *Edit Annual Use* and specify which of the three week types will be applied to which week or if the building will not be used. To do so, repeatedly click on the month or week until the desired week type color is shown. If you select *No Usage*, the target temperature will be set to 5 °C / 41 °F, i.e. frost protection, the internal heat sources and mechanical ventilation will be set at zero.

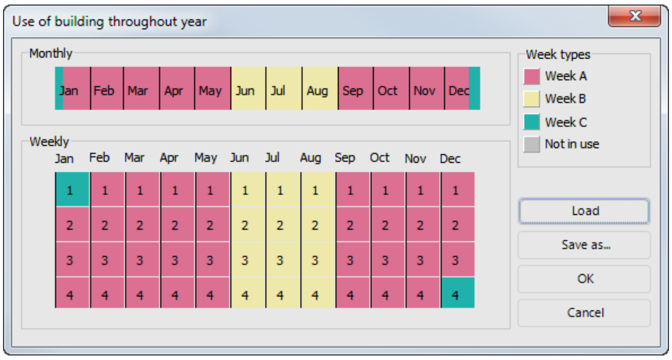


Image :
Dialog *Site Data › Building › Use › Use Profile › Edit Annual Use*

7.

8. If you want to save the entered data in a new use profile, use the *Save As* button, as you will overwrite the present use profile if you just click *Save*. The supplied use profiles are write-protected, so you can restore them to their original state at any time.

7.5.5 Heating / Preheating

Menu *Site Data › Building › Heating*

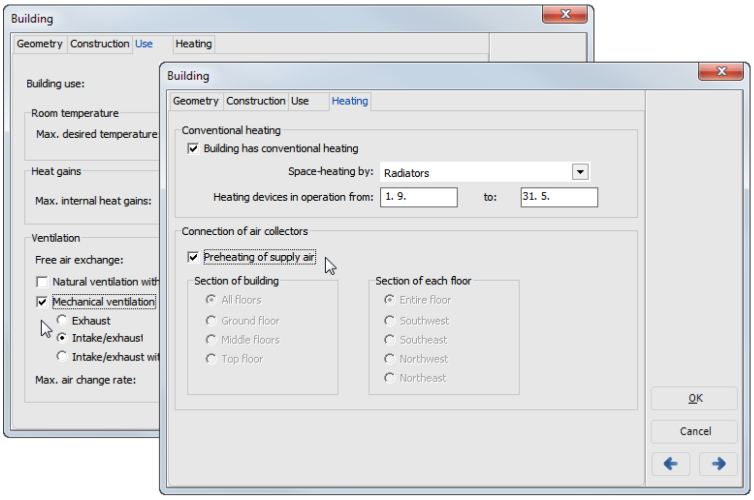
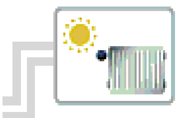


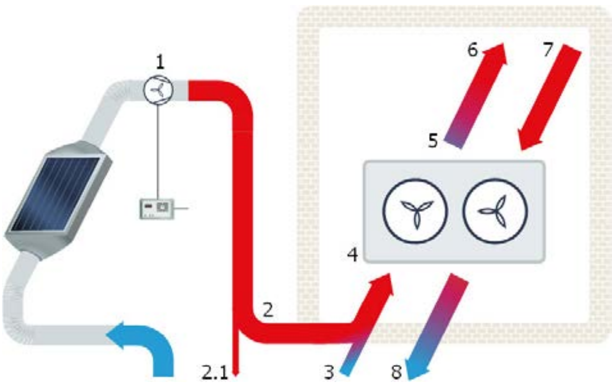
Image:
Dialog *Site Data › Building › Heating*



On the *Heating* page, specify the conventional heating and the supply area for the air collector heating.

In the *Conventional Heating* section, set the presence of a conventional heating system. If one is present, choose the type of hot water heating system (underfloor or radiator) and define the heating period.
If there is none present, the conventional heating is not displayed in the system schematic.

In the *Connection of air collectors* section, the options depend on the settings on the page *Use*.



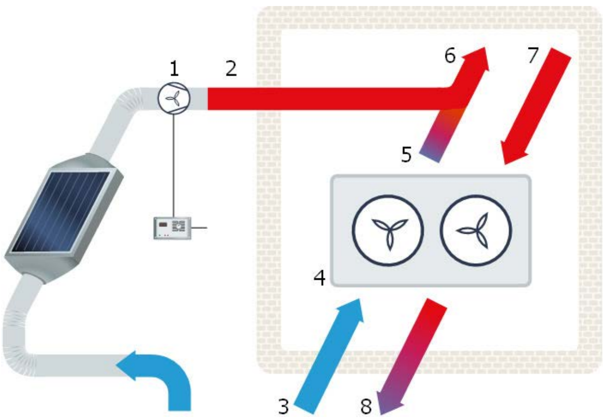
In case of a mechanically vented building with intake, the ventilation can receive air, preheated by the air collectors. This *Preheating of the intake air* has two results:

- In preheating mode, the air collectors will run so long as they can produce air that is warmer than the outside air temperature. Normally, in “heating support” mode, the air collectors will only run if they can produce air that is warmer than the building temperature.

- If the air collectors supply a greater volume of air than the mechanical ventilation is set to use, then the excess air of the air collectors is bypassed, and will not enter the building. This means that if the mechanical ventilation is turned off, no heated air from the collectors will be able to enter the building.

Legend:

1. Output of air collector circuit
2. Solar air heating to building
3. Outside air
4. Heat recovery - in
5. Supply air
6. Air in by forced ventilation
7. Return air
8. Heat recovery - out



For buildings without mechanical ventilation set whether the entire building or partial areas are to be supplied with heating from the air collectors. This section is only accessible if you have set no mechanical ventilation on the *Use* page. Define the partial areas across the supplied floors or compass direction:

- All floors or only first floor, central floor(s), or roof floor
- Full floors or south-west, south-east, north-west, or north-east floor area. For a building with a 45° orientation (e.g. north-east) (see chapter Type of Construction), the floor areas of south, north, east, and west are available. This means that the building is divided into four equally-sized, rectangular supply areas. Example:

Roof floor and south: only the south quadrant of the top floor is supplied.

7.6 Swimming Pool

Variantenmenü *System Definition › Swimming pool* or system layout

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.

-> See also:

Calculation of the Swimming Pool

Swimming Pool Systems

Swimming pool in collector loop

7.6.1 Swimming Pool Parameters

Menu *Site data › Swimming pool › Parameters*

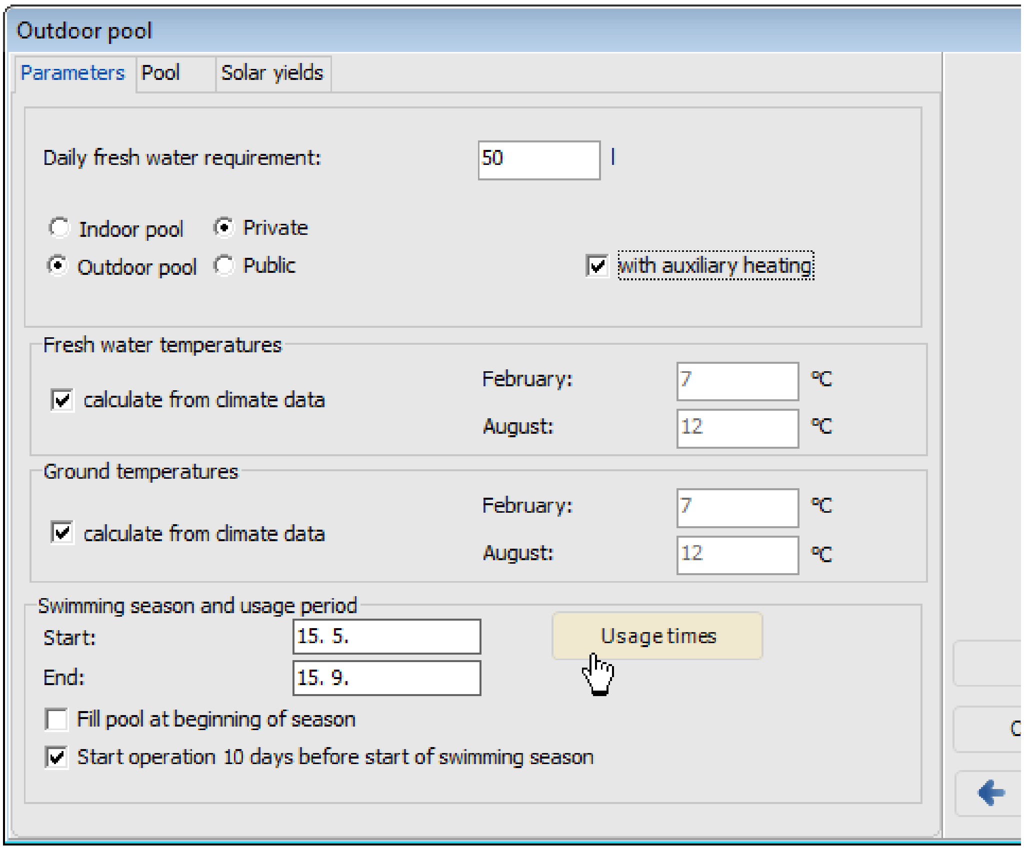


Image: Input dialog for swimming pool parameters

On the *Parameters* page, you can define the *daily fresh water requirement*.

When choosing between an indoor pool or an outdoor pool, please note that these are fundamentally subject to different conditions and therefore also differ with regard to the parameters which must be defined.

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 and usage period* 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.

7.6.2 Swimming Pool: the Pool

Menu *Site data › Swimming pool › Pool*

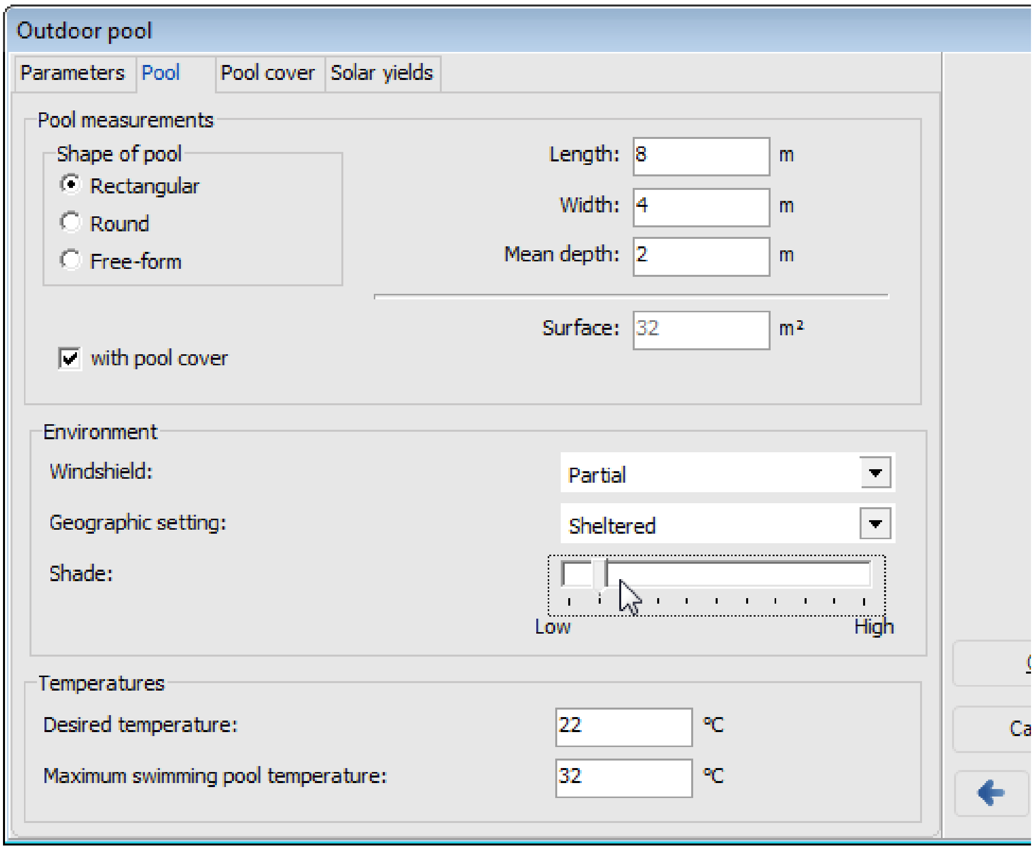


Image: Input dialog for swimming pool, Pool page; example: outdoor pool

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.

Pool measurements

Enter the *surface* size or - in case of for rectangular pools - the *length* and *width*.

Enter the *mean depth* of the water. The volume is calculated.

Define whether or not the pool comes ☑ *with pool cover*.

Environment

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

Enter whether any *windshield* is available at the pool which can reduce convection and evaporation losses.

Define the *geographic setting* of the swimming pool such as

- totally unsheltered, in the open
- unsheltered
- sheltered, e.g. in a residential estate,
- well sheltered, e.g. in a wooded area

Define the *shade* level.

Temperatures

Enter the *desired temperatur* and the *maximum swimming pool temperature*.

The maximum swimming pool temperature defines the temperature up to which the pool can be heated by solar power. It 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.

7.6.3 Swimming Pool: Cover

Menu *Site data › Swimming pool › Pool Cover*

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

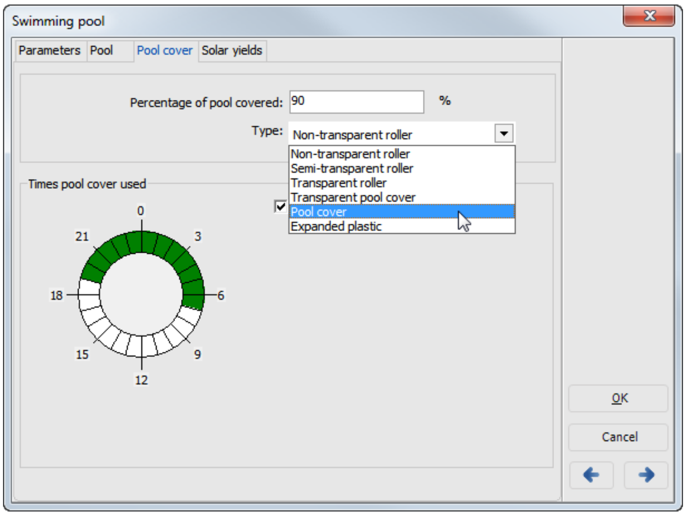


Image: Input dialog for swimming pool, Pool Cover page; example: outdoor pool

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.

In indoor pools, the evaporation losses are comparatively low on account of the relatively high ambient humidity and, because of the higher indoor temperature, no convective losses occur. For this reason, covers on indoor pools only make sense in special cases.

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.

7.6.4 Swimming Pool: Room Climate

Menu *Site data* › *Swimming pool* › *Room Climate*

If you select an indoor pool on the *Parameters* page, the additional *Room Climate*page appears. The values for room temperature and relative humidity are only required for indoor pools. The room temperature should be 3 °C above the desired temperature and the humidity should be 60%, as these conditions are recommended for structural reasons (e.g. protection against corrosion) and the demands of human comfort.

The calculation assumes that these values are maintained at a constant level by an air-conditioning system for the entire simulation period.

The maximum swimming pool temperature (see Pool) should be set to the value of the room temperature for indoor pools, as solar yields may otherwise heat the pool above the room temperature, leading to increased pool losses which would have to be eliminated with increased energy consumption by the air-conditioning.

7.6.5 Swimming Pool: Solar Yields

Menu *Site data › 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.

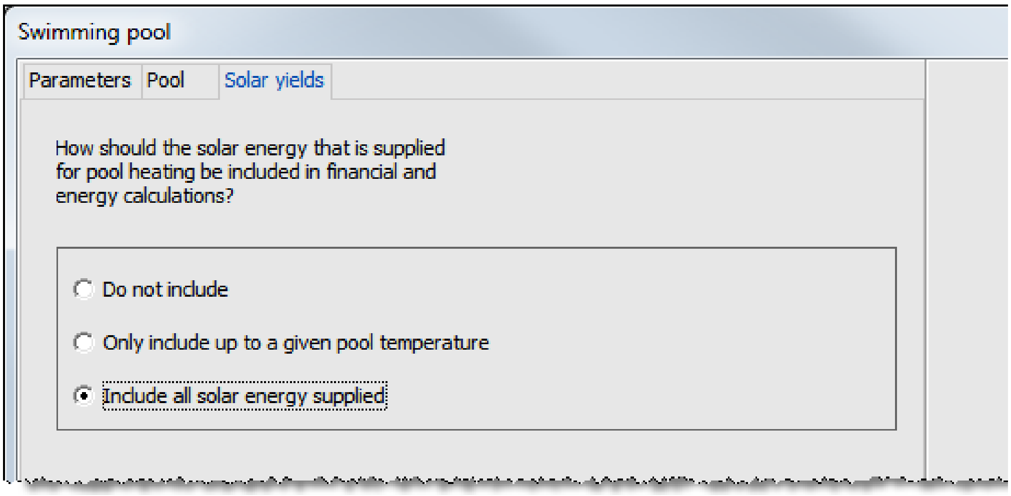


Image: Input dialog for swimming pool components, *Solar Yields* page

8 Databases Menu

Menu *Databases*

You can define your own system components and load profiles via this menu item. In T*SOL Pro, you can save collectors, air collectors and auxiliary heatings, in T*SOL Expert also tanks.

! These databases are maintained and updated by the manufacturers of the components (e.g. PV modules), themselves, and we make them available to you as biweekly database update.

! Do you miss any equipment ? Send an email to info@valentin.de, we refer your request to the right contact of the manufacturer, who is in charge of their database entries.

è See also:

- Consumption Profiles
- *Components*
- *Primary energy*

8.1 Consumption Profiles

Symbol or Menu *Site Data › Hot water consumption › Consumption Profile*; menu *Databases › Profiles*

Here, you can modify the current consumption profile or define your own consumption profiles.

Load a profile which approximates your requirements and then modify it.

You can select a consumption profile from the *Site Data > Hot water consumption* menu or via the symbol, only.

-> You find a detailed explanation on editing the consumption profiles under *Site Data › DHW Consumption › Consumption Profile › Parameters*

8.2 Components

Menu *Databases › Components*

The database selections for components offer some features facilitating the selection This is valid for:

- Collectors
- Boilers

! These databases are maintained and updated by the manufacturers of the components (e.g. PV modules), themselves, and we make them available to you as biweekly database update.

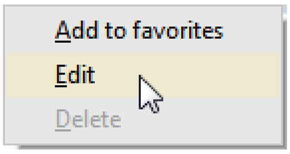
! Do you miss any equipment ? Send an email to info@valentin.de, we refer your request to the right contact of the manufacturer, who is in charge of their database entries.

-> For selection of components, please refer to

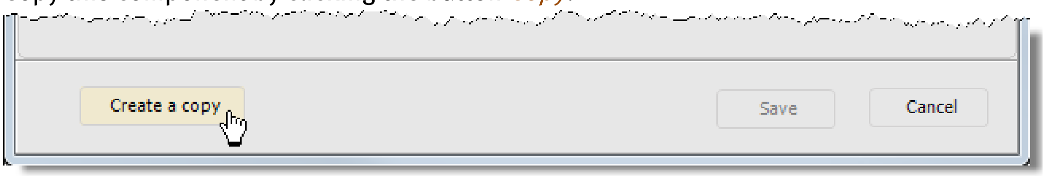
[Selection Dialogs for Systems and Components]

-> How to edit or enter your own components:

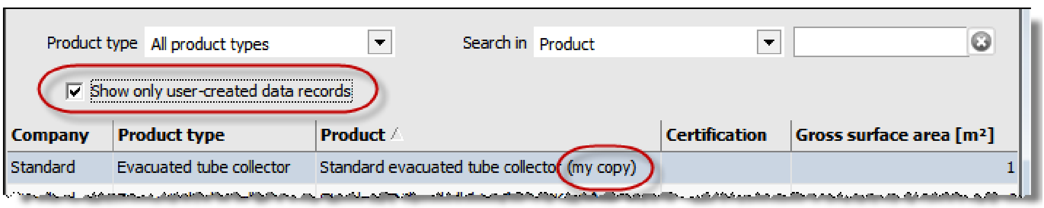
1. Open the components database by clicking *Select*.
2. Choose a component (left mouse).
3. Right-click for the context menu Edit. The component's data sheet is dis-played.



4. Copy this component by clicking the button *Copy*.



5. The component's name is changed to "Component name (Copy)", provisorily. Change the name and make your parameter entries.
6. Save the new component. The database table is displayed.
7. Filter your own components from the table by using the checkbox Show only user-created data records.



-> How to share user-created collectors with colleagues:

1. In the collectors database, click the button Export, to copy all user-created collectors to a file (.tcomp).
2. Send this file, e.g. MyCollectors_export.tcomp to your colleague.
3. Integrate collectors, which have been sent to you als .tcomp-file by using the button Import.

Import/Export works in T*SOL Pro for:

- Collectors

In T*SOL Expert, you can add/edit:

- Buffer tanks
- Combination tanks
- DHW stratified tanks
- External heat exchangers
- Boilers

Certified Components

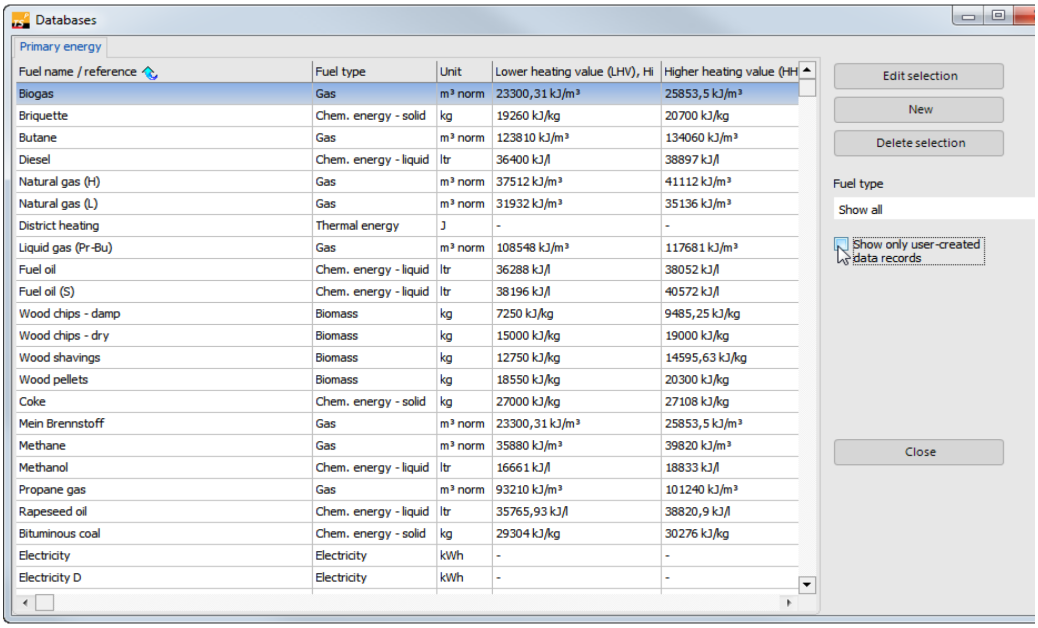
To help differentiate between standard components, certified components and "personal" components, the following icons are used:

Standard	Certified	Proof of Conformity Mark	Keymark	SRCC
				yes
T*SOL library	Components certified by independent institutes	Proof of conformity available	Collectors, which have been tested according to DINCERTCO	Collectors, which have been tested according to SRCC

Collectors, that were tested according to the 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".

8.3 Primary Energy

Menu *Databases › Primary Energy*



Fuel name / reference	Fuel type	Unit	Lower heating value (LHV), Hi	Higher heating value (HH
Biogas	Gas	m³ norm	23300,31 kJ/m³	25853,5 kJ/m³
Briquette	Chem. energy - solid	kg	19260 kJ/kg	20700 kJ/kg
Butane	Gas	m³ norm	123810 kJ/m³	134060 kJ/m³
Diesel	Chem. energy - liquid	ltr	36400 kJ/l	38897 kJ/l
Natural gas (H)	Gas	m³ norm	37512 kJ/m³	41112 kJ/m³
Natural gas (L)	Gas	m³ norm	31932 kJ/m³	35136 kJ/m³
District heating	Thermal energy	J	-	-
Liquid gas (Pr-Bu)	Gas	m³ norm	108548 kJ/m³	117681 kJ/m³
Fuel oil	Chem. energy - liquid	ltr	36288 kJ/l	38052 kJ/l
Fuel oil (S)	Chem. energy - liquid	ltr	38196 kJ/l	40572 kJ/l
Wood chips - damp	Biomass	kg	7250 kJ/kg	9485,25 kJ/kg
Wood chips - dry	Biomass	kg	15000 kJ/kg	19000 kJ/kg
Wood shavings	Biomass	kg	12750 kJ/kg	14595,63 kJ/kg
Wood pellets	Biomass	kg	18550 kJ/kg	20300 kJ/kg
Coke	Chem. energy - solid	kg	27000 kJ/kg	27108 kJ/kg
Mein Brennstoff	Gas	m³ norm	23300,31 kJ/m³	25853,5 kJ/m³
Methane	Gas	m³ norm	35880 kJ/m³	39820 kJ/m³
Methanol	Chem. energy - liquid	ltr	16661 kJ/l	18833 kJ/l
Propane gas	Gas	m³ norm	93210 kJ/m³	101240 kJ/m³
Rapeseed oil	Chem. energy - liquid	ltr	35765,93 kJ/l	38820,9 kJ/l
Bituminous coal	Chem. energy - solid	kg	29304 kJ/kg	30276 kJ/kg
Electricity	Electricity	kWh	-	-
Electricity D	Electricity	kWh	-	-

Image 8.4.1: Dialog for the primary energy database

T*SOL includes all typical fuels with the following properties in a database:

- *Fuel Type*: all fuels are classified in groups for easier sorting.
- *Unit*: this is the unit in which fuel amounts are usually stated.
- *Heating Value Hu*: this expresses the energy content. The lower heating value is stated on the assumption that the water of consumption is present in vaporous form.
- *CO2 emissions*: this value states the specific CO2 emissions on fuel combustion. The fuels can be directly compared here, as the emissions are related to the energy content and not the mass.
- *Price*: the prices are subject to heavy fluctuation and are not suitable for precise calculations.

You can also add your own fuels by clicking on the *New* button and even delete and edit created fuels.

The primary energy database can be accessed by all users of a PC. It is saved in the following directory: C:\Documents and Settings\All Users\Application Data\Valentin EnergieSoftware\.

9 System Selection

Variant Menu *System Selection*

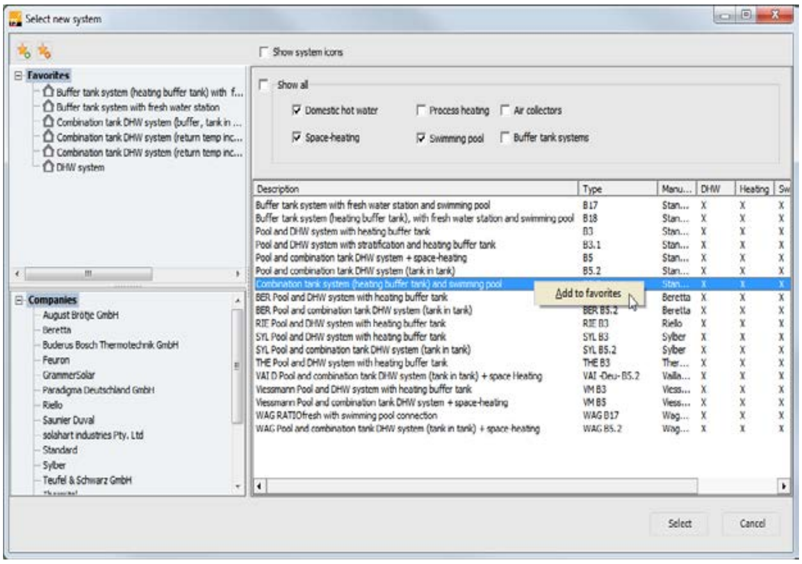


Image: System selection with system icons and filters

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* variant menu.
2. You can choose to display the systems as schematic diagrams or as lists.
3. Select a system. (See Selection Dialog for Systems and Components for details.)
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*.

You can either directly select the applicable system schematic or run through the steps of the design assistant. This is highly recommended for familiarizing yourself with the program.

9.1 Standard Systems

Variant menu *System Selection*

System	Dual coil indirect hot water tank	Solar tank / buffer tank	Single coil heating buffer tanks	Combination tank / internal heat exchanger	Auxiliary heating	Heating loop	External heat exchanger	DHW standby tank	DHW heating	Fresh water station	Process heating device	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							
A8 - Space heating		x			x	x						
A10 - System with continuous flow heater	x				C							x
A12 - System with external heat exchang-er and fresh water station					o	o	x			x		x
A13 - Systems w. process heating device and auxiliary heating in buffer tank		x			x	o	x				x	x
A10 - Systems with process heating de-vice and continuous flow heater		x			C	o	x				x	
A15 - Systems with process heating de-vice and heat exchanger							x				x	
A16 - Systems with distributed DHW sta-tions in multiple dwellings	x				C							x
A17 - System with buffer tank and fresh-water station	x	x			o	o				x		x
A18 - System with buffer tank and fresh-water 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, contains
        - Collector

9.1.1 A1 - DHW Systems with Dual Coil Tank

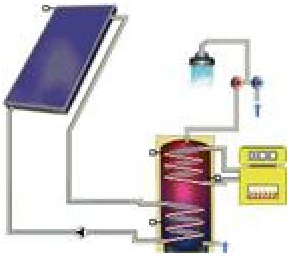


Image: A1 - DHW system

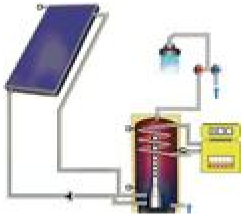


Image A1.1 DHW system with stratification

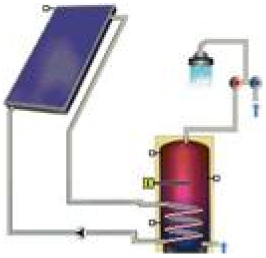


Image: A1.2 - DHW system with electric heating element

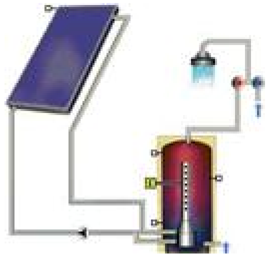


Image: A1.3 - DHW system with electric heating ele

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 (see chapter 10.3)
    - Shading
- Dual coil DHW tank
- Auxiliary heating

9.1.2 A2 - DHW Systems (2 Tanks)

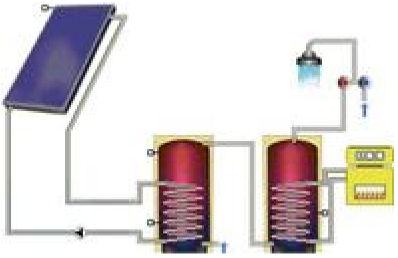


Image: A2 - DHW system with two tanks, without stratification

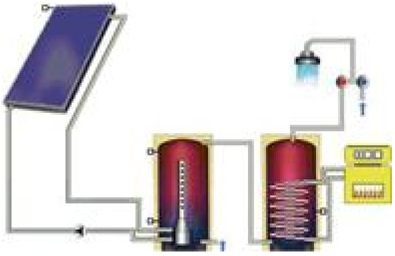


Image: A2.1 - DHW system with two tanks, with stratification

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

9.1.3 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

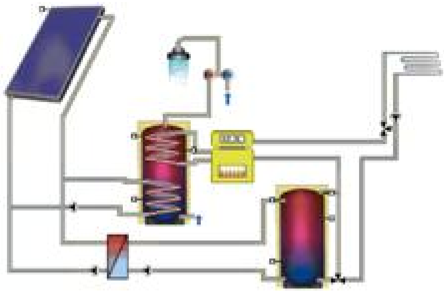


Image: A3.2 - DHW system with heating buffer tank and external heat exchanger

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. On the *System Definition ›* (System name), tab *Control*, the setting ☑ *DHW-circuit has priority* 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

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

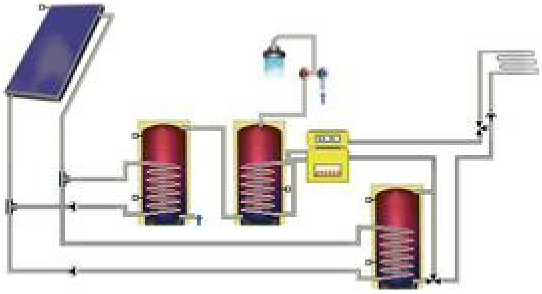


Image0: A4 - Two tank systems with heating buffer tank, without stratification

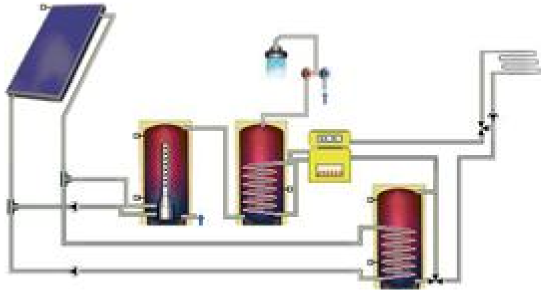


Image1: A4.1 - Two tank systems with heating buffer tank, with stratification

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
- Solar tank
- Auxiliary heating
- Heating loop
- Single coil heating buffer tank

9.1.5 A5 - Combination Tank Systems

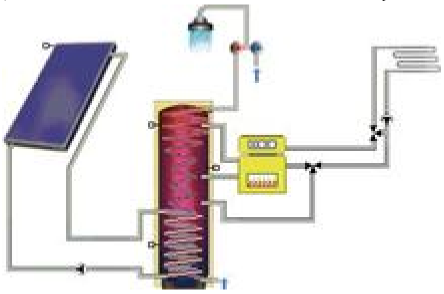


Image: A5 - Combination tank system for hot water and heating

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

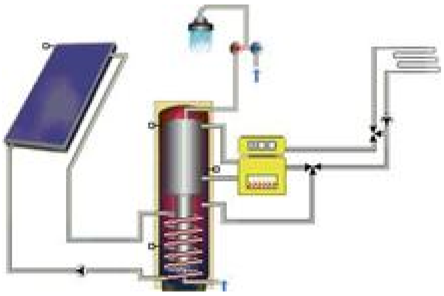


Image: A5.2 - Combination tank system (tank in tank) for hot water and heating

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

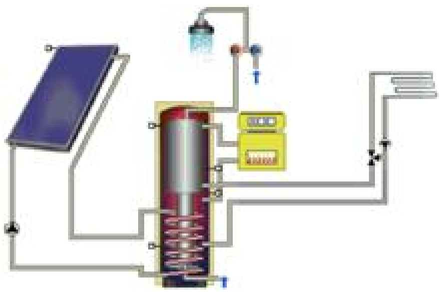


Image: A5.4 - Combination tank system (tank in tank) for hot water and heating

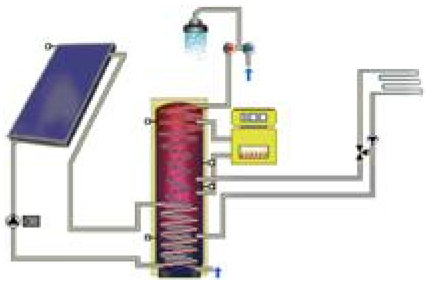


Image: A5.5. - Combination tank system for hot water and heating

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 ›* (System name), tab *Control*, the setting ☑ *DHW-circuit has priority* over the auxiliary heating can be made.

The system consists of the following components:

- Collector loop connection, contains
    - Collector array, contains
        - Collector
        - Shading
- Combination tank (tank in tank or internal heat exchanger)
- Auxiliary heating
- where required, heating loop

9.1.6 A6 - Buffer Tank Systems

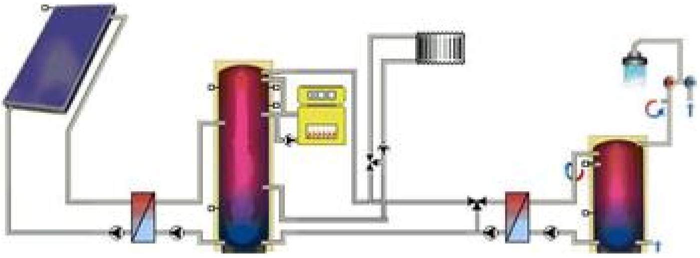


Image8: A6 - Buffer tank system for hot water and heating

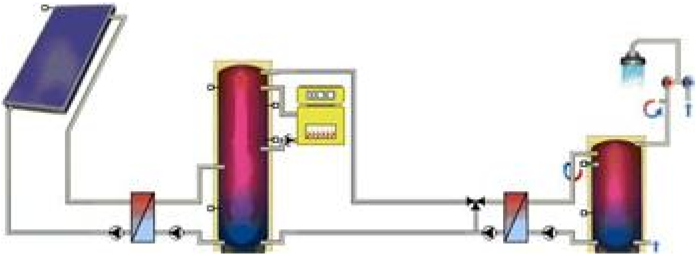


Image9: A6.1 - Buffer tank system for DHW only

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 ›* (System name), tab *Control*, the setting ☑ *DHW-circuit has priority* over the auxiliary heating can be made. 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, contains
    - External heat exchanger
    - DHW standby tank

9.1.7 A7 - Thermosyphon Systems

Image0: A7 - Thermosyphon system with continuous flow heater, stand-alone

Image1: 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.

9.1.8 A8 - Space Heating

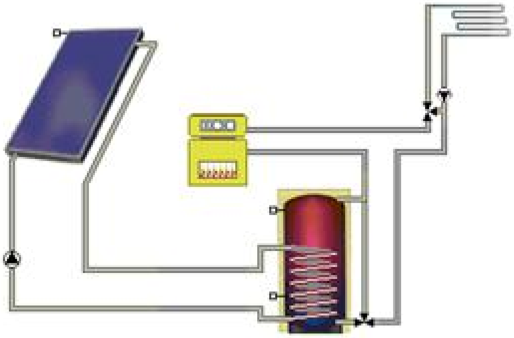


Image2: A8 - Space heating-only system

This system serves exclusively for space heating. The auxiliary heating is controlled via the thermostatic valve.

Solar loading of the heating buffer tank takes place via an internal heat exchanger. The temperature of the buffer tank energy is increased by the auxiliary heating for the space heating.

9.1.9 A10 - System with Solar Tank and Continuous Flow Heater

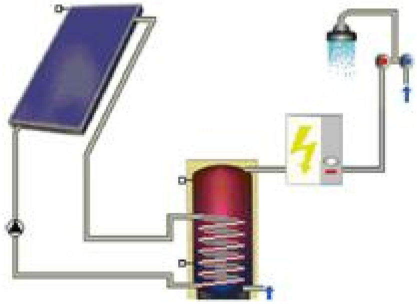


Image3: A10 - System with continuous flow heater

Single coil tank with solar loading. This system uses a continuous 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* › (selected heating type name) › *Parameters*, you can select the auxiliary heating type and enter the power and fuel (electricity, oil, natural gas) for the auxiliary heating.

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

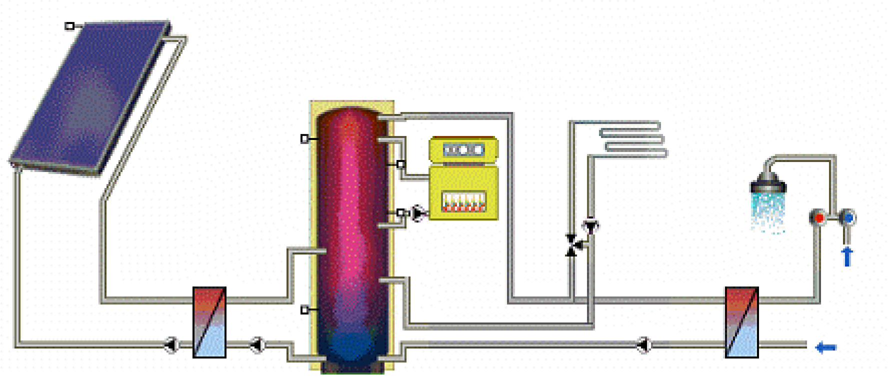


Image4: A12 - System with external heat exchanger and fresh water station

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.

9.1.11 A13/A14/A15 - Systems with Process Heating Device

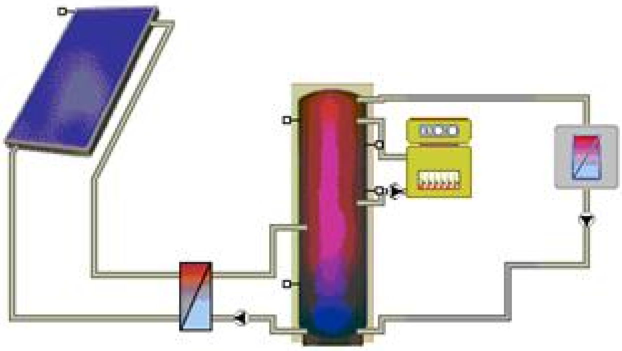


Image5: System A13: auxiliary heating in buffer tank as in system A12.

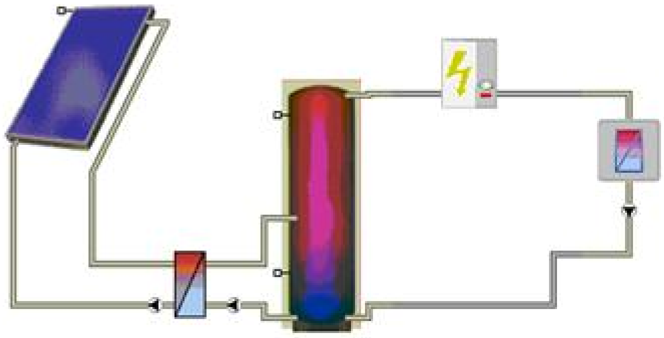


Image6: System A14: missing energy is supplied with the help of a continuous flow heater.

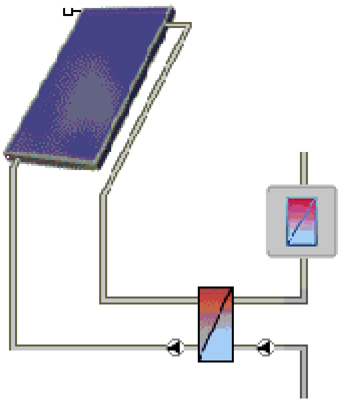


Image7: System A15: the device is connected with a heat exchanger directly at the collector loop. As a result, all the energy supplied from a certain outlet temperature can be taken from the collector array.

The three systems A 13/A 14/A 15 use two different process heating devices . In contrast to DHW consumption, these have a defined return temperature.

Open the *System Definition* of the Process Heating Device by double-clicking the process heating symbol  in the system schematic.

9.1.12 A16 - Systems with Distributed DHW Stations in Multiple Dwellings

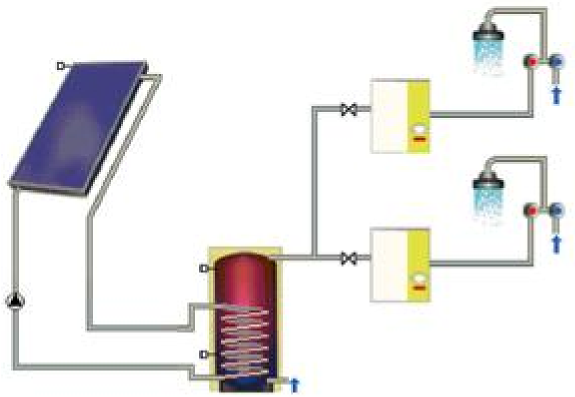


Image8: A16 - Systems for distributed supply in multiple dwellings

In this system, the DHW is exclusively preheated in a solar tank (compare A 10./

The preheated domestic hot water is then distributed to the separate apartment transfer stations. Up to 10 stations are possible. In these stations, the water is heated to the desired temperature with the help of a continuous flow heater.

9.1.13 A17/A18 - Systems with Buffer Tank

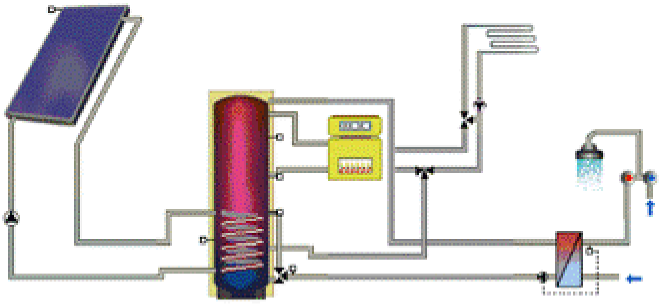


Image9: A17 - System with buffer tank and fresh water station

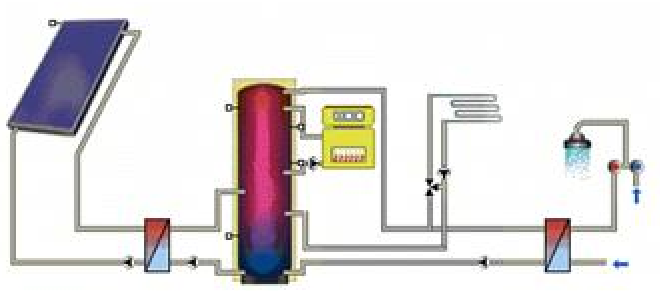


Image0: A18 - System with buffer tank and fresh water station

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.

9.2 Air Collectors

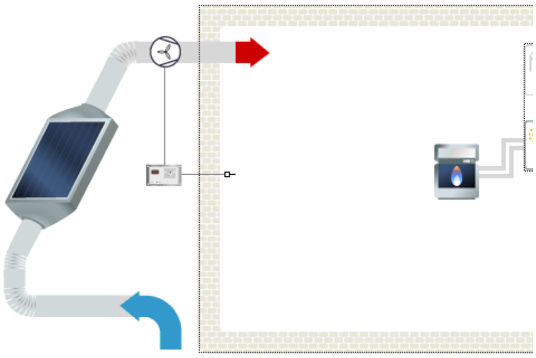


Image: Air collector system with heating

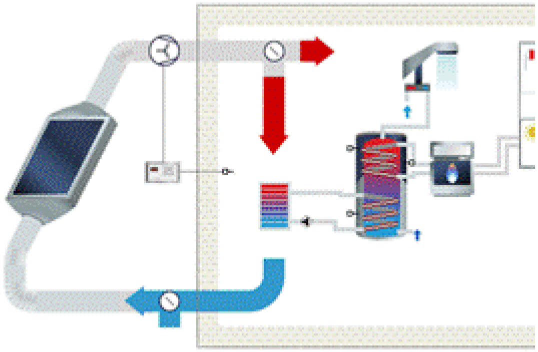


Image: Air collector system with heating and DHW

There are two systems with which the building is supplied with solar heated air. They differ from one another with regard to their solar DHW supply.

The systems consist of the following components:

- Air collector loop with air collectors, air intakes, and air-water heat exchangers
- Building (building definition, ventilation, heating)
- Air-water heat exchanger
- Auxiliary heating
- DHW tank
- DHW consumption

➔See also System Definition › Solar Loop with Air Collectors

9.3 Swimming Pool Systems

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

Using T*SOL, an indoor or 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

Solar fraction for swimming pool systems:

The swimming pool is not reheated in this system. The solar energy is first used for DHW and heating, and then the swimming pool with lowest priority. During the calculation of the solar fraction, only the energy that is supplied to the DHW and the heating is taken into account, however not that which the solar system supplies to the swimming pool.

This prevents the solar system from being parameterized so that the swimming pool is supplied with solar energy first, and the heating and DHW are not supplied at all. This would result in enormous solar coverage for the swimming pool, but no energy savings in the boiler.

9.3.1 B1 - Swimming Pool and DHW Systems

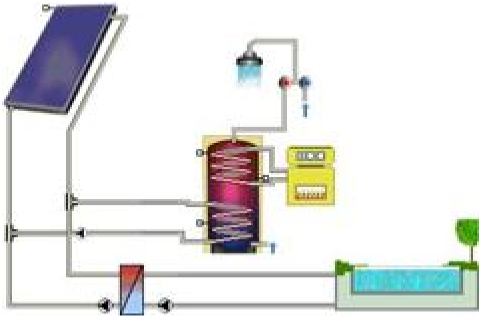


Image: B1 - Swimming pool and DHW system without stratification

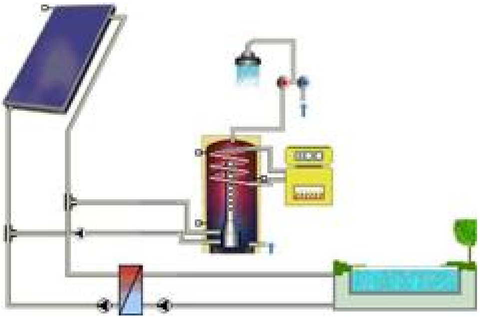


Image: B1.1 - Swimming pool and DHW system with stratification

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

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

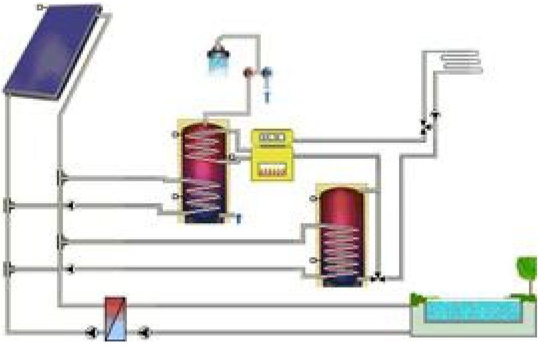


Image: B3 - Swimming pool and DHW system with heating buffer tank

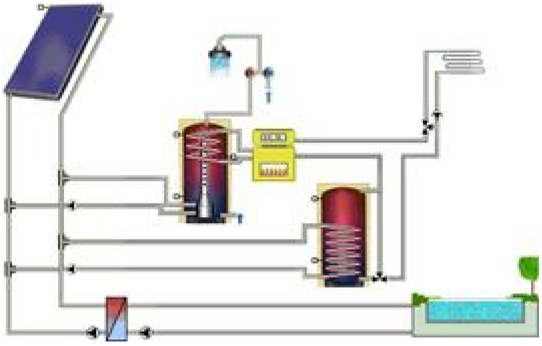


Image: B3.1 - Swimming pool and DHW system with heating buffer tank and stratification

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

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

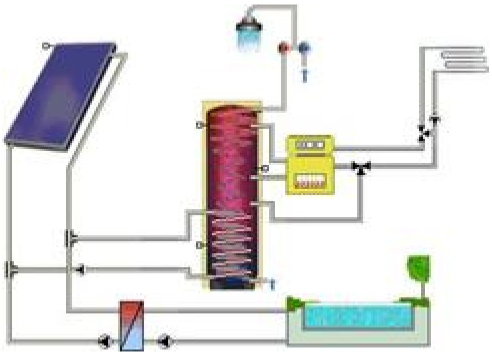


Image: B5 - Swimming pool and combination tank DHW system + space heating

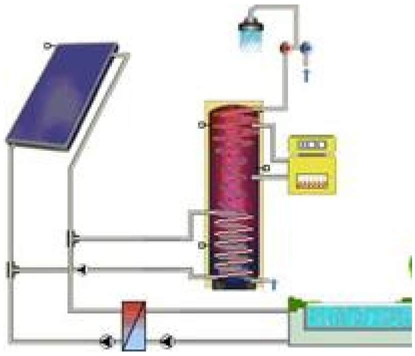


Image: B5.1 - Swimming pool and combination tank DHW system

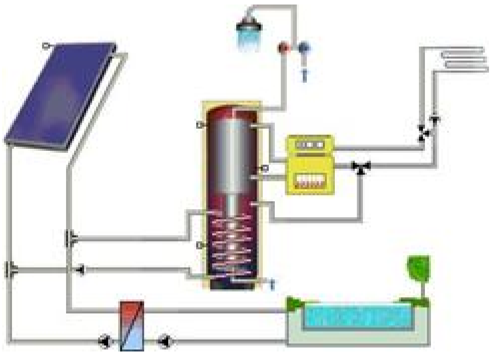


Image: B5.2 - Swimming pool and combination tank system (tank in tank) for DHW and heating

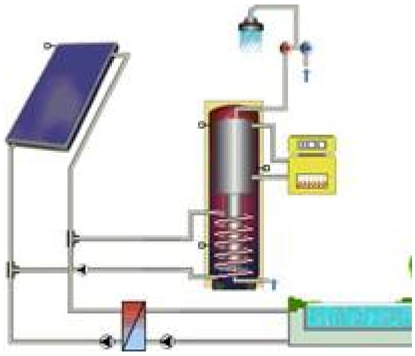


Image: B5.3 - Swimming pool and combination tank system (tank in tank) for DHW only

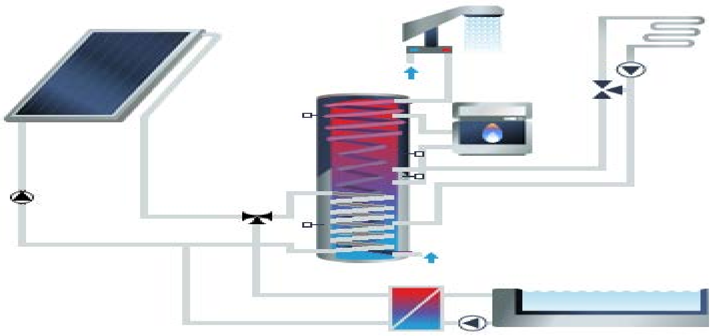


Image : B5.5 - Swimming pool system with buffer tank (heating buffer), DHW, and space heating

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 internal heat exchanger)
- Auxiliary heating
- where required, heating loop
- where required, external heat exchanger

9.3.4 B6 - Simple Swimming Pool Systems

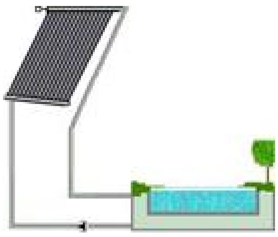


Image: B6 - Swimming pool without heat exchanger or auxiliary heating

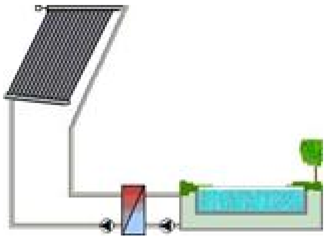


Image: B6.1 - Swimming pool with heat exchanger and without auxiliary heating

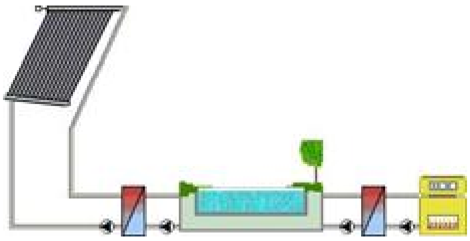


Image: B6.2 - Swimming pool with heat exchanger and auxiliary heating

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

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

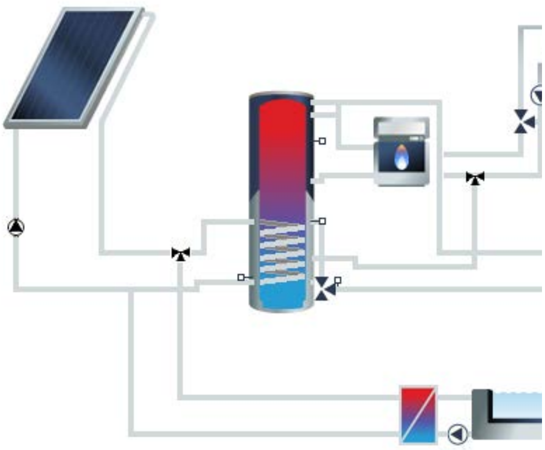


Image: B17 - Swimming pool system with buffer tank and fresh water station

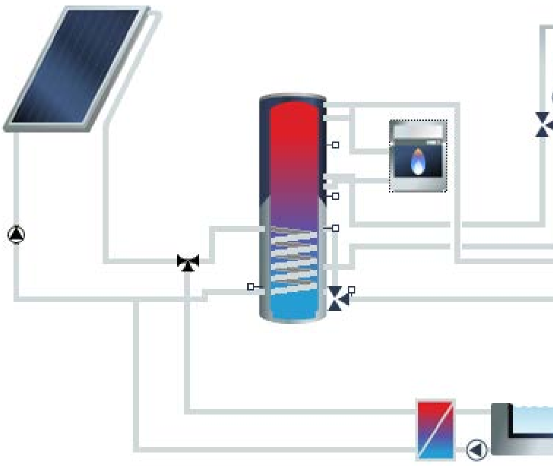


Image: B18 - Swimming pool system with buffer tank (heating buffer) and fresh water station

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

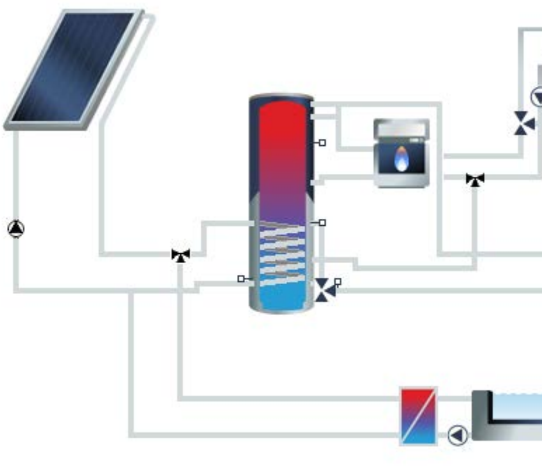


Image: B17 - Swimming pool system with buffer tank and fresh water station

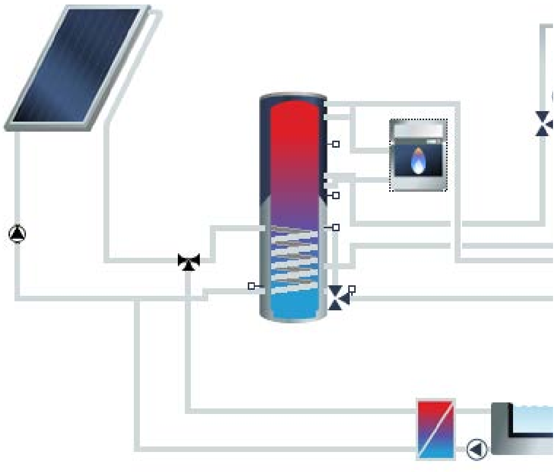


Image: B18 - Swimming pool system with buffer tank (heating buffer) and fresh water station

9.4 Large-Scale Systems

System	Dual coil indirect hot water tank	Solar tank / buffer tank	Auxiliary heating	Heating loop	Single coil heating buffer tank	DHW standby tank	Combination tank / internal heat exchanger	External heat exchanger	DHW heating	Fresh water station	Swimming pool
C1 - Large-scale DHW system with solar and standby tank		x	x			2x		x	x		
C2 - Large-scale DHW system with standby tank		x	x			x		x	x		
C3 - Large-scale DHW system with standby tank and heat exchanger		x	x			x		x	x		

C4 - Large-scale DHW and space heating system with auxiliary heating in flow		x	x	o		x		x	x		
C6 - Large-scale DHW system with solar and standby storage tank		x / x	x	x						x	

x = available, o = optional

The use of large solar buffer tanks, external heat exchangers, and anti-Legionnaire's switches is typical for large-scale systems.

9.4.1 C1 - Large-scale DHW system with solar and standby tank

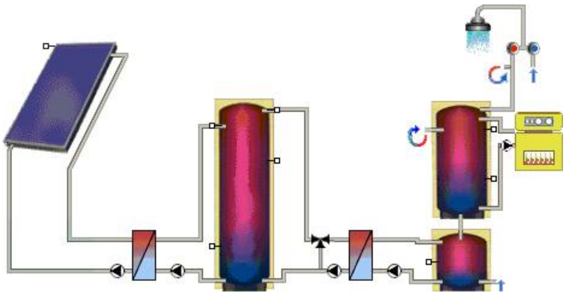


Image: C1 - Large-scale DHW system with solar and standby tank

Description of hydraulic configuration:

the collector array heats the buffer tank. If the temperature level in the buffer tank is high enough to heat up the preheating tank, the discharge pump of the buffer tank (primary loop) and the loading pump of the DHW standby tank (secondary loop) are started up. Consequently, the solar energy from the buffer tank is delivered to the preheating tank via the external heat exchanger. The domestic hot water first flows through the preheating tank and then the series-connected standby tank. If the temperature in the standby tank is not higher than the desired temperature, the tank is heated to the desired temperature by the auxiliary heating.

The system consists of the following components:

- Collector loop connection, contains
    - Collector array, contains
        - Collector
        - Shading
    - External heat exchanger
- Buffer tank
- DHW supply, contains
    - External heat exchanger
    - 2x DHW standby tank
    - Auxiliary heating

9.4.2 C2 - Large-scale DHW system with standby tank

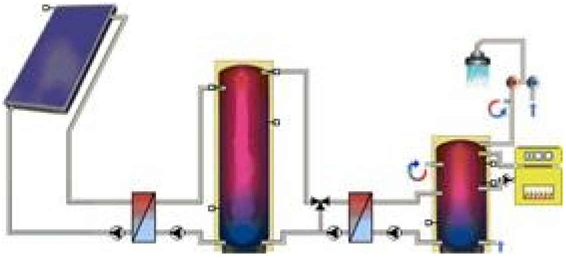


Image: C2 - Large-scale DHW system with standby tank

Description of hydraulic configuration:

The collector array heats the buffer tank. If the temperature level in the buffer tank is high enough to heat up the lower part of the dual coil DHW standby tank, the discharge pump of the buffer tank (primary loop) and the loading pump of the DHW standby tank (secondary loop) are started up. Consequently, the solar energy from the buffer tank is delivered to the DHW standby tank via the external heat exchanger. If the temperature in the upper part of the standby tank is not higher than its desired temperature, the tank is heated to the desired temperature by the auxiliary heating.

The system consists of the following components:

- Collector loop connection, contains
    - Collector array, contains
        - Collector (see chapter 10.1.1)
        - Shading
    - External heat exchanger
- Buffer tank
- DHW supply (see chapter 10.12.3), contains
    - External heat exchanger
    - DHW standby tank (see chapter 10.6.9)
    - Auxiliary heating

9.4.3 C3 - Large-scale DHW system with standby tank and heat exchanger

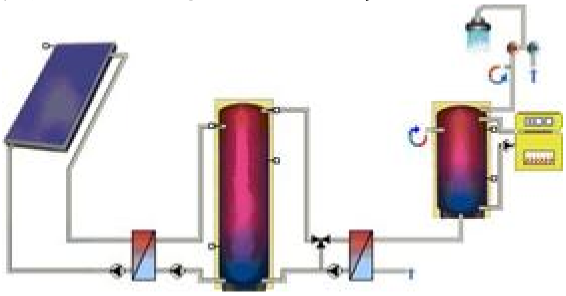


Image: C3 - Large-scale DHW system with standby tank and heat exchanger

Description of hydraulic configuration:

The collector array heats the buffer tank. If the draw-off flow rate rises above a limit value, the discharge pump of the buffer tank (primary loop) is started up. The solar energy from the buffer tank is delivered to the standby tank via the external heat exchanger. If the temperature in the standby tank is not higher than its desired temperature, the tank is heated to the desired temperature by the auxiliary heating.

The system consists of the following components:

- Collector loop connection, contains
    - Collector array, contains
        - Collector (see chapter 10.1.1)
        - Shading
    - External heat exchanger
- Buffer tank
- DHW supply (see chapter 10.12.2), contains
    - External heat exchanger
    - DHW standby tank (see chapter 10.6.9)
    - Auxiliary heating

9.4.4 C4 - Large-scale DHW and space heating system with auxiliary heating in flow

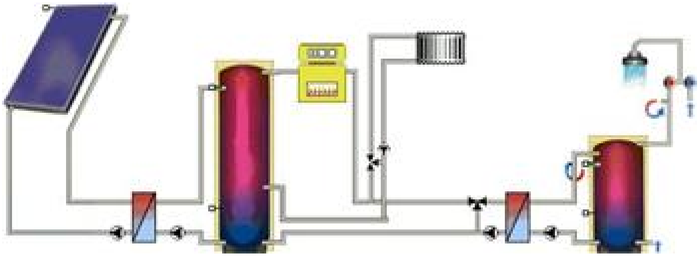


Image: C4 - Large-scale DHW and space heating system with auxiliary heating in flow

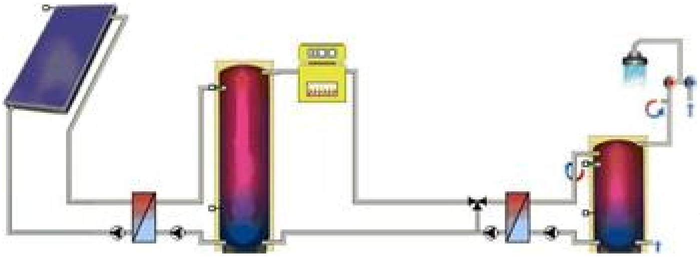


Image: C4.1 - Large-scale DHW system with auxiliary heating in flow

The system consists of the following components:

- where required, heating loop
- Collector loop connection, contains
  - Collector array, contains
    - Collector
    - Shading
  - External heat exchanger
- Buffer tank
- Auxiliary heating
- DHW supply, contains
  - External heat exchanger
  - DHW standby tank

9.4.5 C6 - Large-scale DHW system with solar and standby storage tank

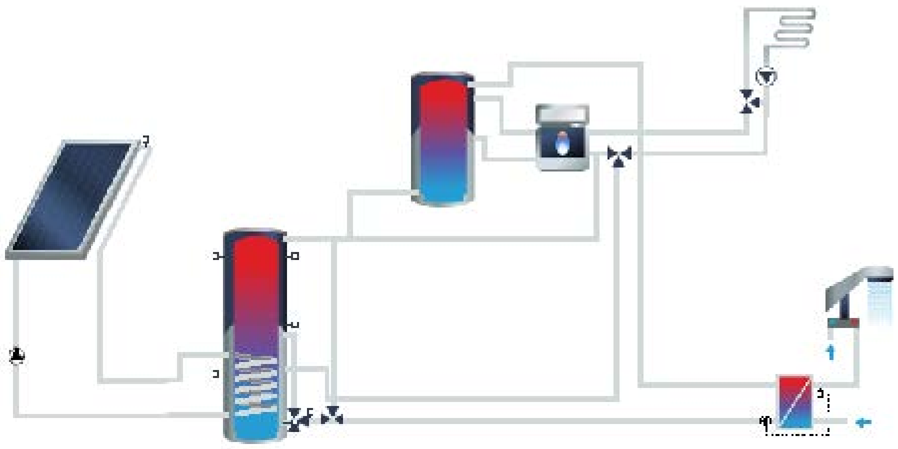


Figure: C6 - Large-scale DHW system with solar and standby storage tank

Description of hydraulic configuration:

The C6 buffer tank system consists of a solar buffer tank and a serial boiler buffer tank.

DHW consumers are supplied with hot water through a DHW station, which is supplied by the boiler buffer tank.

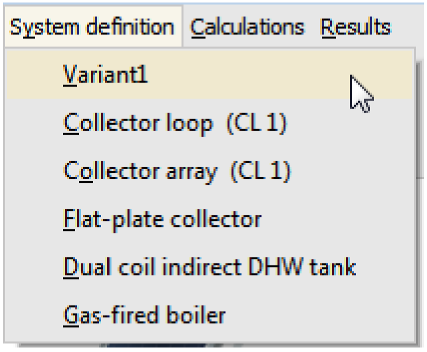
The solar heating is supported by a return increase control.

The system consists of the following components:

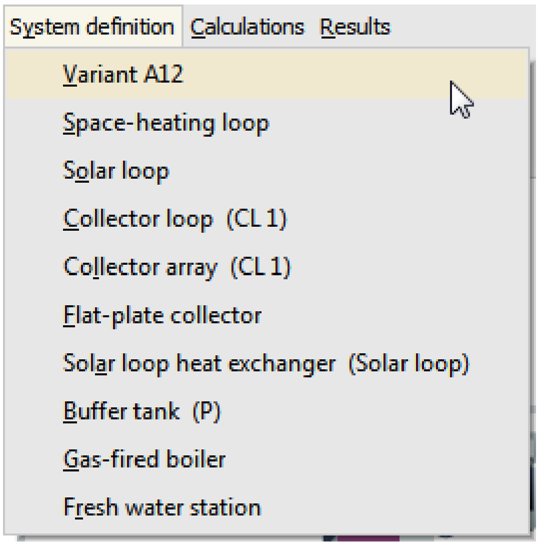
- One or two collector loops
- Connection to the energy center is made with the internal heat exchanger in the buffer tank.
- Solar buffer tank
  The solar buffer tank is then loaded by the solar system. If the temperature in the storage tank in high enough, the heating return is raised by discharging the tank.
  The return from the DHW station is layered over a 3-way reversing valve and dependent on the storage temperature in the solar buffer tank.
  If the return temperature is too high to discharge the buffer tank, the solar buffer tank is circumvented with a bypass switch and the return from the DHW station is sent directly to the boiler buffer tank.
- Boiler buffer tank
  The boiler buffer tank is heated by the boiler only.
  The consistent temperatures in the boiler buffer tank enable more simple and safer operation of the boiler as well as the drinking water station.
  The boiler buffer tank is discharged through the drinking water station only.
- Auxiliary heating
  The auxiliary heating defined in the system maintains the temperature setting in the boiler buffer tank and supplies the heating loop with the required energy.

10 System Definition

Variant Menu *System definition*



Variant menu for an A1 system



Variant menu for an A12 system

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

- via the variant menu *System Definition › ‹Your_Component›* ,
- 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 submenus 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. If you change site data (see chapter Site Data Menu) in the *System Definition* variant menu, these changes only apply to this variant.
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 or in graphic / tabular form.

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.

10.1 Definition of the Variant and its Components

Variant menu *System Definition › Variant*

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

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

You can only change the variant name on the *Variant › Site Data* page. You can also define the *Climate*, *Hot Water*, and *Heating Requirement* defaults specifically for this variant. This does not change the project defaults.

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.

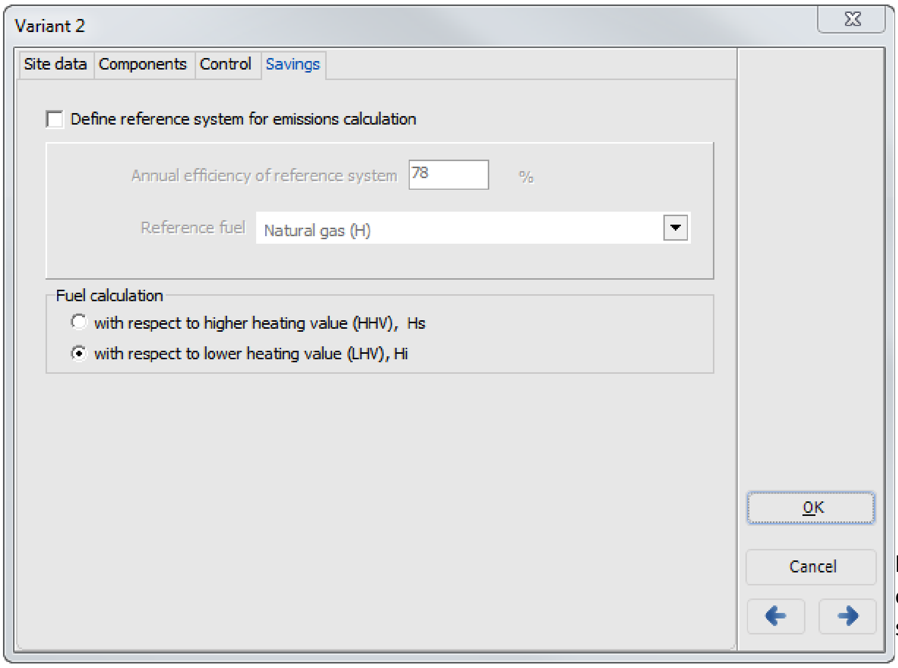


Image: System definition of standard systems, Savings page

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.

10.1.1 Two Collector Loops

Variant menu *System Definitions › Variant X› 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.

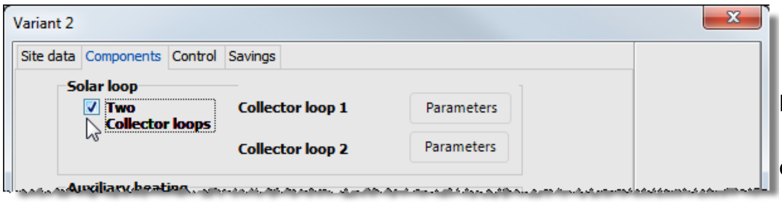


Image: *System Definition › Variants › Components* with option "*Two Collector loops*"

è How to proceed:

1. Select a suitable system (A1, A2, or A5)
2. Go to *System Definition › Variant X › 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*.

10.2 Collector Loop

Variant menu *System Definition › Collector Loop › Collector Loop* or system schematic

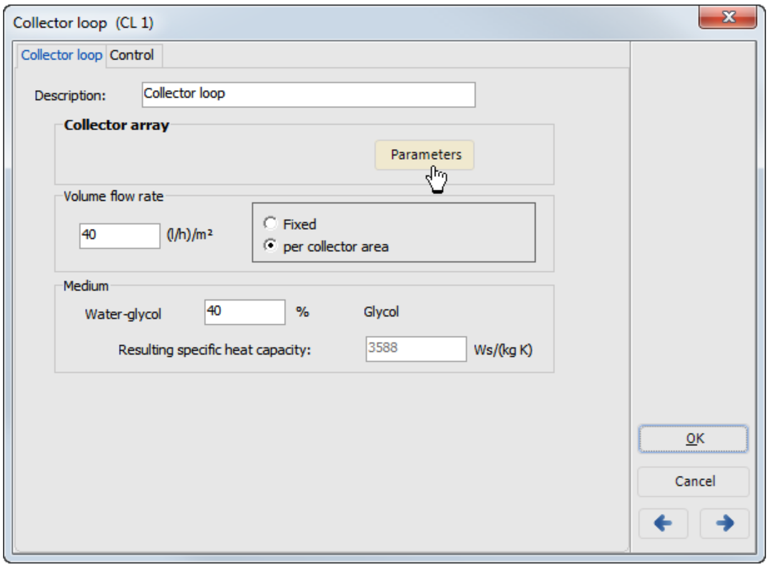


Image: Dialog for connecting the collector loop

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

The volumetric flow rate states 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 capacity is then displayed.

10.2.1 Tank Connection / External Heat Exchanger

System Definition › Collector Loop › Tank Connection

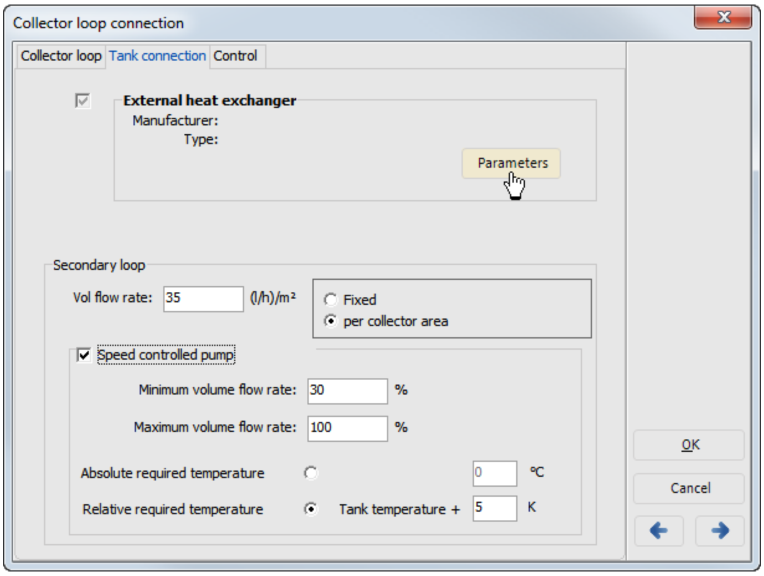


Image: Dialog *Connection › Collector Loop › Tank Connection* for systems with external heat exchanger, e.g. system A3.2

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.

10.2.2 DHW Tank / Space heating buffer tank

System Definition › Collector Loop › DHW Tank / Space heating buffer tank

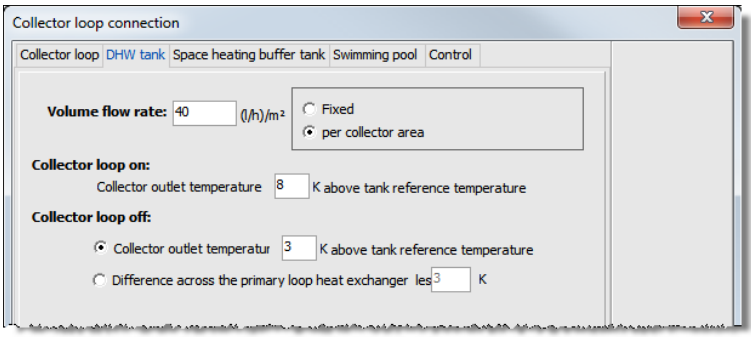


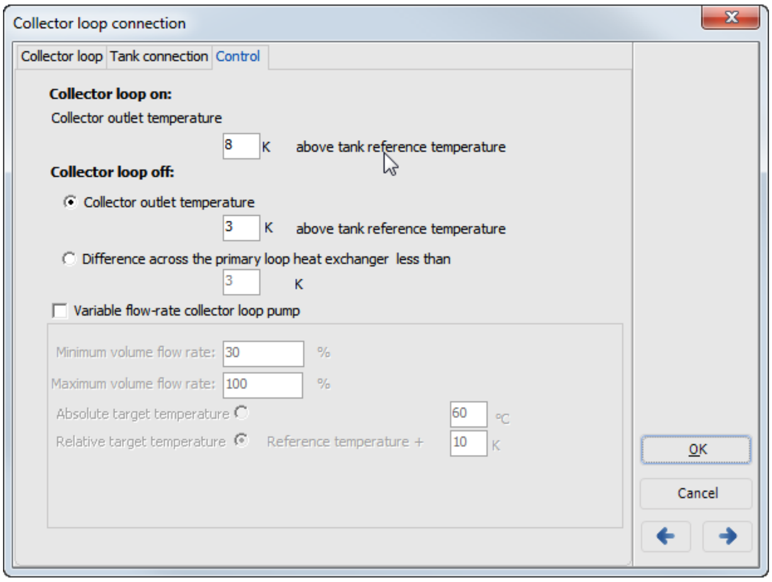
Image: Dialog *Connection › Collector Loop*, connection of a dual coil DHW tank, e.g system B3.1

You can enter the volumetric flow rate as an absolute value or per m² of collector surface area.

Define different conditions for switching on or off of the collector loop, relative to
- the collector outlet temperature,
- the tank reference temperature, and
- the temperature spread across the primary loop heat exchanger.

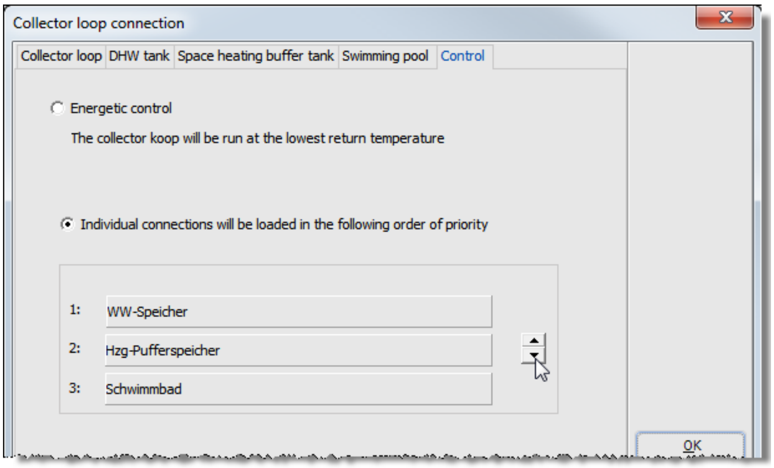
10.2.3 Control

Variant menu *System Definition › Collector Loop › Control*



-> Input dialog for *Collector loop connection › Control* page

Example: system A6, A6.1, similar, but without heat exchanger: A5, A10,



-> Requisites: System B3, B3.1,

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

10.2.4 Swimming Pool in Collector Loop

Variant menu *System Definition › Collector Loop Connection › Swimming Pool or Control*

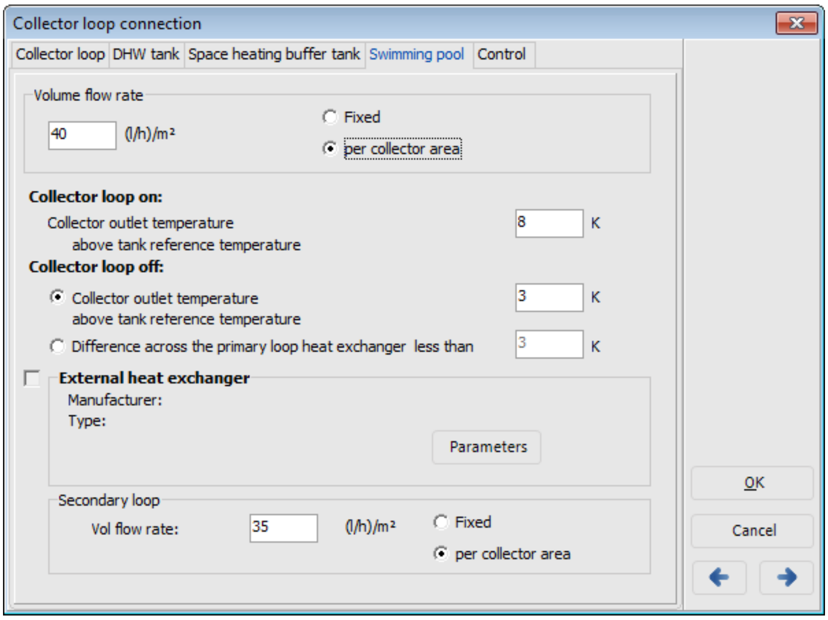


Image: Collector loop connection dialog for swimming pool systems

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.

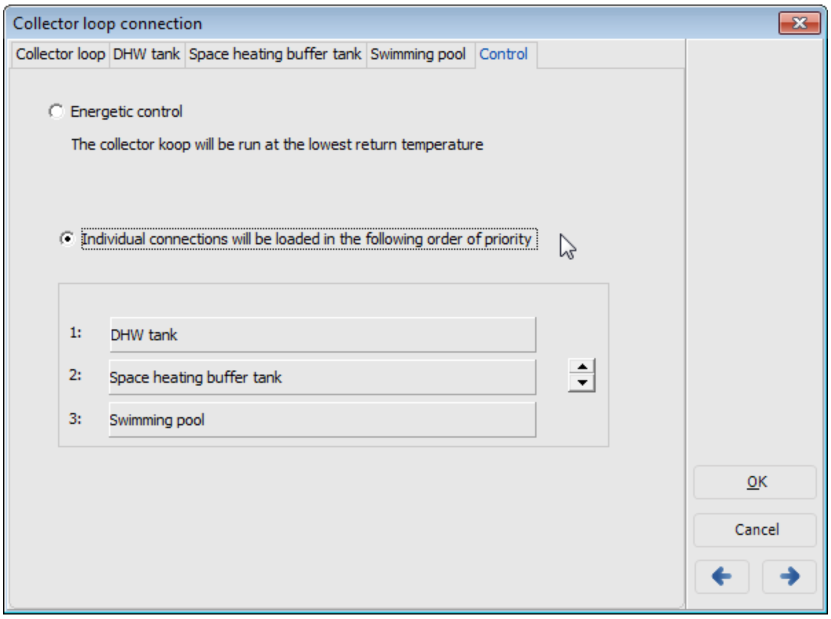


Image: Input dialog for connection to *collector loop › Control* page

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.

10.3 Collector Array

Variant menu *System Definition › Collector Array* or system schematic

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

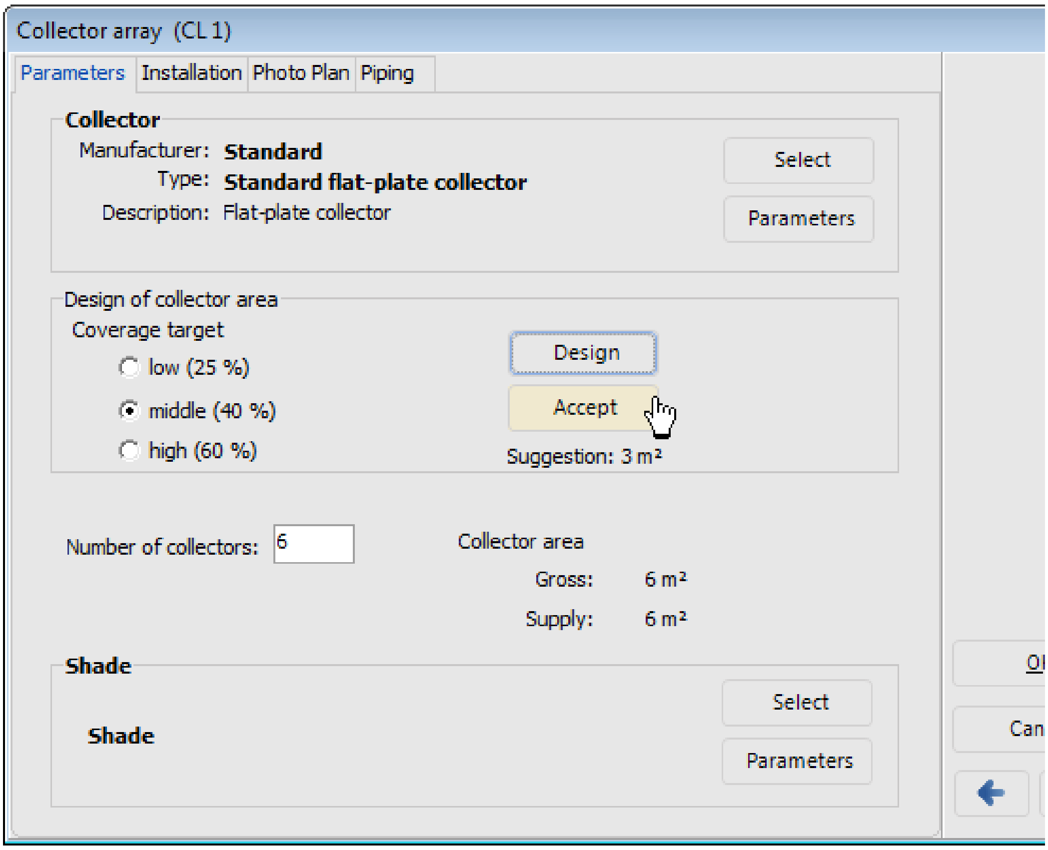


Image: Dialog for defining the collector array

10.3.1 Collector Array Parameters

Variant menu *System Definition › Collector Array › Parameters*

-> Proceed as follows:

1. Click on the *Select* button to access the collectors database, select one.
   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 *Design*. 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 Shading.
6. Define the geometric arrangement of the collectors on the *Installation* page.
7. On the page *PhotoPlan* you can calculate the roof mounting with the help of imported photos and the visualization program "PhotoPlan".
8. Define properties for calculating piping losses on the *Piping* page, see chapter Piping.
9. Save all entries by clicking *OK* or go to the next dialog using the arrow button .

10.4 Collector

Variant menu *System Definition › Collector Array › Collector › Select* or system schematic

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

10.4.1 Collector Parameters

Variant menu *System Definition › Collector Array › Collector › Parameters*

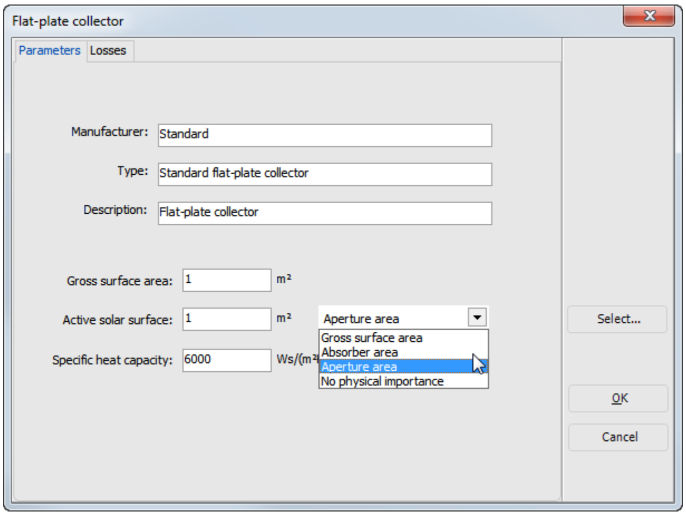


Image: Entering the collector areas and specific heat capacity.

The gross surface area is 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 surface taken 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.

10.4.2 Collector – Thermal Losses

Variant menu *System Definitions › Flat-Plate / Tube Collector › Losses / Thermal Losses*

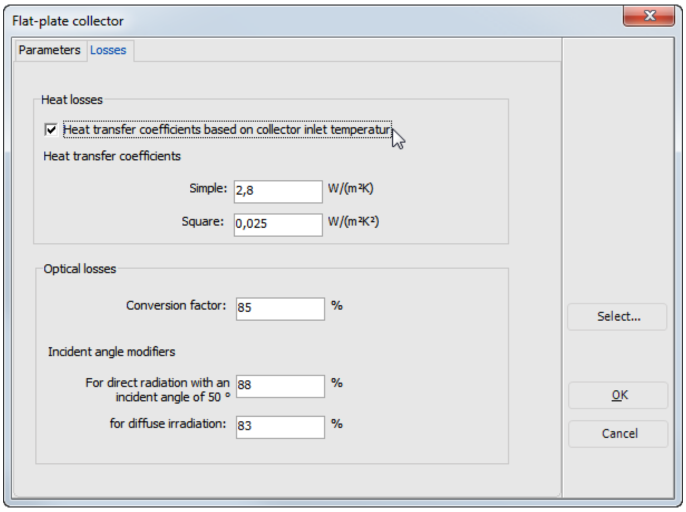


Image : Calculation of thermal and optical collector losses

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

$$P = G_{dir} \cdot \eta_0 \cdot f_{IAM} + f_{IAM_{diff}} \cdot G_{diff} \cdot \eta_0 - k_0 \cdot (T_{Cm} - T_A) - k_q \cdot (T_{Cm} - T_A)^2$$

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_0 (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.

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.

Collectors, which have been tested by Solar Collector Certification Program (SRCC) can be found either by sorting the (most right) column SRCC or by using the search applied to the column SRCC searching for "yes".

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

10.4.3 Collector – Optical Losses

Variant menu *System Definitions › Flat-Plate / Tube Collector › Losses / Optical Losses*

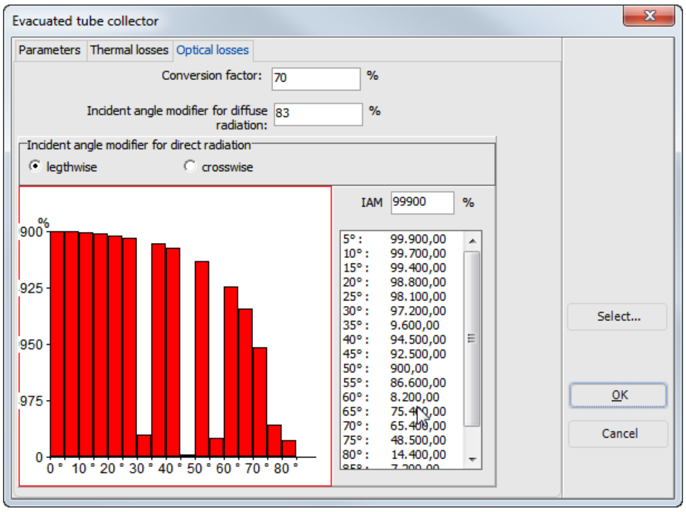


Image : Calculation of optical collector losses of a tube collector

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.

10.4.4 Shading

Variant menu *System Definition › Collector Array › Parameters › Shading*

Define the general parameters of shading.

10.4.4.1 Shading parameters

Variant menu *System Definition › Collector Array › Parameters › Shading › Parameters*

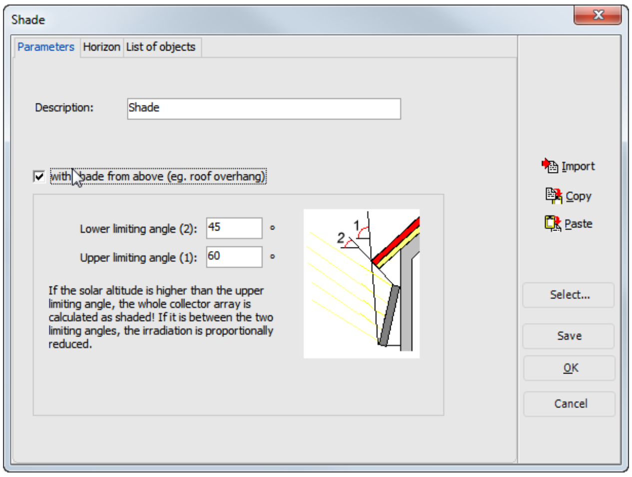


Image: Dialog for defining the shading of the collector array

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

You can also select *With Shade from Above*, if the collectors, for example, are mounted on a facade with roof overhangs or similar.

Upper limiting angle: If the solar altitude is higher than the upper limiting angle, the whole collector array is shaded.

Lower limiting angle: If the solar altitude is lower than the upper limiting angle, the collector array is not shaded.

If the solar altitude is higher than the lower limiting angle and lower than the upper limiting angle, irradiation to the collector array is reduced proportionally.

The angle entries for the azimuth relate to the south. East is entered as -90° and West as +90°.

10.4.4.2 Shading: Horizon

Variant menu *System Definition › Shading › Horizon*

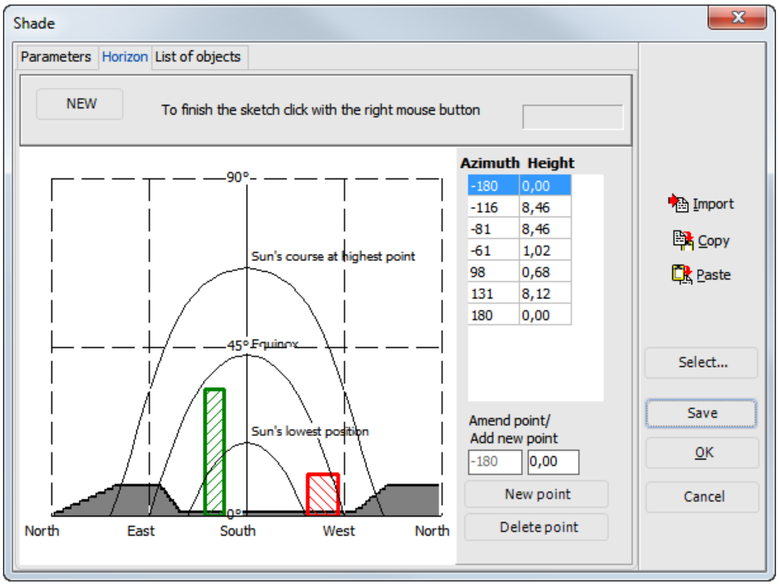


Image: Definition of shading via horizon and individual objects

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: Installation

-> 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 copy the table to the clipboard and from there into spreadsheets such as Excel.
5. You can paste a table from the clipboard.
6. 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.
3. *Save* this horizon and it's objects for further use in other variants.

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.

10.4.4.3 Shading: Individual Objects

Variant menu *System Definition › Shading › List of Objects*

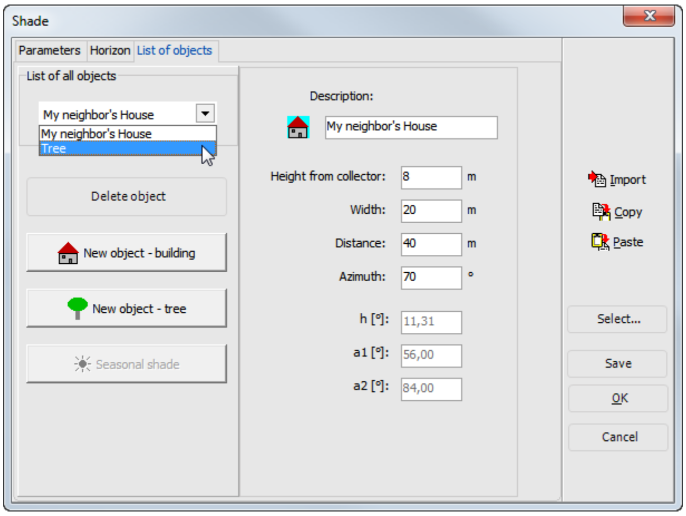


Image: Input field for individual shading objects

On the *List of Objects* page, you define shade from individual objects.

In addition to horizon shading, individual objects which shade the collector can be defined in the program. This is done on the *List of Objects* page of the Shading dialog.

The objects you have defined can be found in the *List of All Objects* drop-down box. Here, you can select the object whose value you can see or wish to change in the right part of the window.

In addition to the object description in the left part of the window, you can see an image corresponding to the object type (tree or building). If no object has been defined, the list is empty.

è How to define a new object:

1. Depending on the object type, click on the *New Object - Building* or *New Object - Tree* button. A new object (e.g. with reference Object No. 1) is created and its standard values entered in the right part of the window.
2. To better differentiate among objects, give each object its own reference.
3. Enter the values (for objects in the medium distance): height, width, distance, and azimuth.
   The measuring point for defining these values is the center of the collector surface looking south. In other words, an azimuth of 0° means that the object is in the south (-90° = East; +90° = West), irrespective of the collector azimuth. The height angle can be defined from the information on height and distance. Width and azimuth set the angle for the vertices of the object.
4. The difference between tree and building resides in the light permeability of the objects. For a tree object, the *Seasonal Shade* button is activated. Enter a percentage of shade for every month of the year. In summer, shade will be greater than in winter due to leaves.
5. On the *Horizon* page, the building objects appear as red-hatched rectangles, the tree objects as green-hatched rectangles. Double-click on one of the objects to select it on the *List of Objects* page and modify it.
6. Existing objects can be deleted by clicking the *Delete Object* button.

10.4.5 Installation

Variant menu *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	Azimuth angle	
		Northern Hemisphere	Southern Hemisphere
North	0	180	0
East	90	-90	90
South	180	0	180
West	270	90	-90

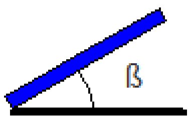


Image: The *inclination* or *tilt angle* ß describes the angle between the horizontal and the collector surface area.

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

ß = 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.

10.4.5.1 Minimum distance between mounted collectors

Variant menu *System Definition › Collector Array › Installation › Calculation*

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 pr 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.

10.4.6 Roof layout with Photo Plan

Variant menu *System definition › Collector array › Photo Plan*

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

-> 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

10.4.7 Piping

Variant menu *System Definition › Collector Array › Piping*

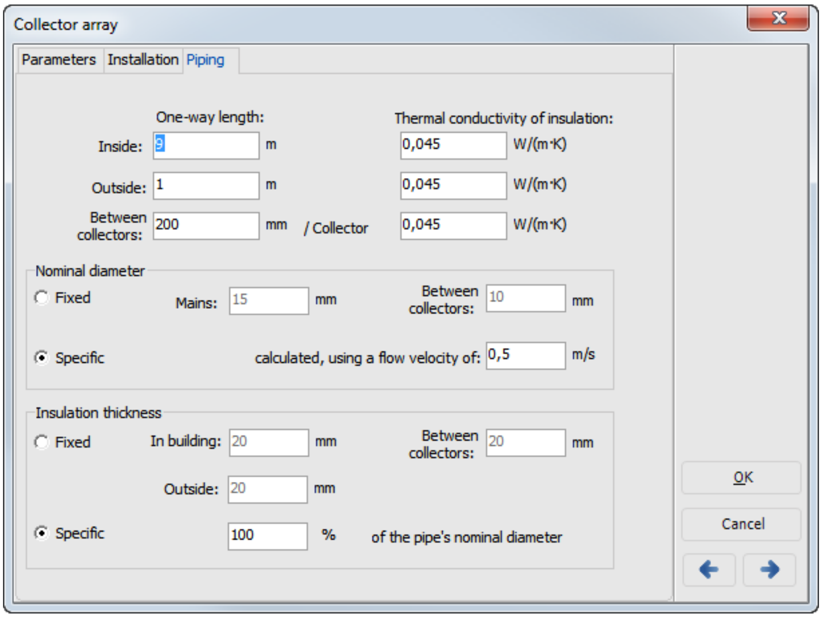


Image: Dialog for the piping of the collector array

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.

10.5 Solar Loop with Air Collectors

Variant menu *System Definition › Solar Loop with Air Collectors*

è Prerequisites: System with air collector: *Select New System* › ☑ *Air collectors*

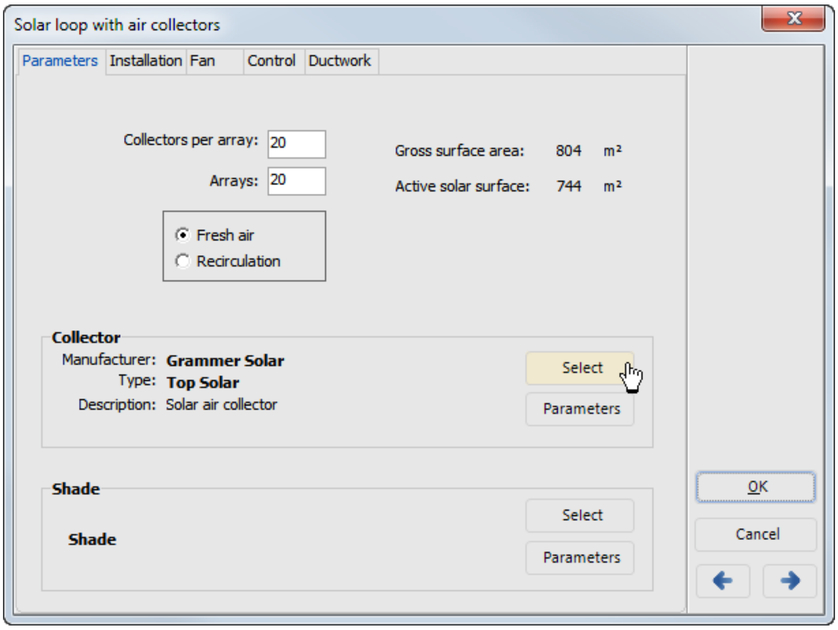


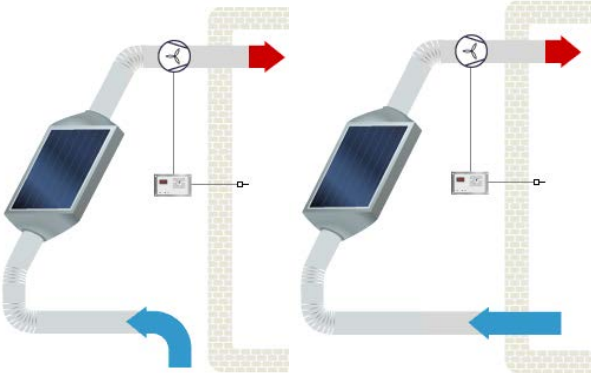
Image 10.6.1: Dialog *System Definition › Solar Loop with Air Collectors › Parameters*

The values of the solar air collector array are recorded over several pages. Wherever the data collection is the same as for other collectors, please read the corresponding chapter: Shading, Installation

è How to define a solar loop with air collectors

10.5.1 Parameters

1. Go to the *System Definition › Solar Loop with Air Collectors* dialog. This opens the *Parameters* page, which can also be accessed by double-clicking the air collector in the system schematic. The definition dialog is opened.
2. Click on the *Selection* button and choose an air collector from the table. Confirm by clicking *OK*. The collector is now shown in the *Collectors* section.
   è See chapter Air Collectors.
3. Set the *Number of Air Collectors per Row* (0–20, normally 1–6) and the *Number of Rows* (1–50, normally 1–3). The gross surface area and the active solar surface are calculated and displayed.
4. Choose from fresh air and circulated air operation. If you choose circulated air operation, the system schematic is adjusted. Fresh air is the usual setting.



Solar loop with air collectors: fresh air (left) and circulated air (right)

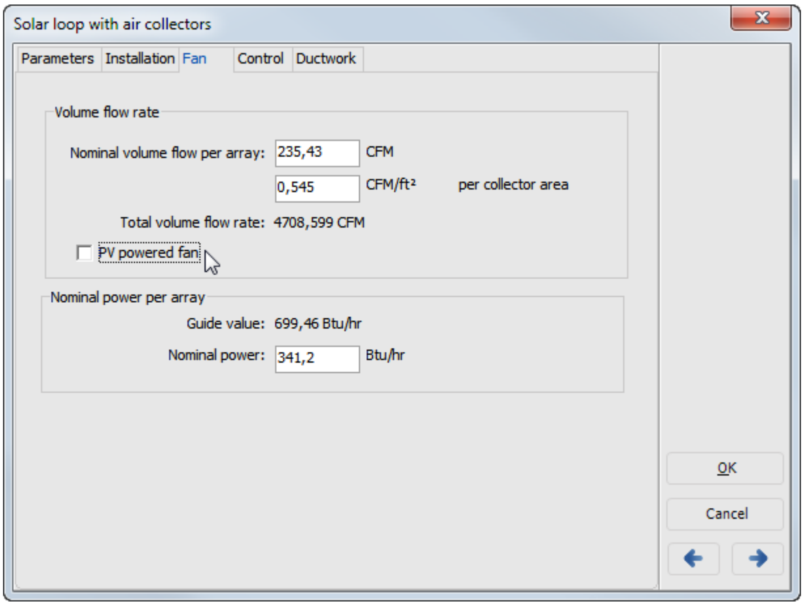
5.

6. Click the *Parameters* button to specify the air collector in greater detail.

7. è The *Installation* page is the same as for the other collectors

10.5.2 Fan

Variant menu *System Definition › Solar Loop with Air Collectors › Fan*



Dialog *System Definition › Solar Loop with Air Collectors › Fan*

8. Go to the *Fan* page. Define the volume flow rate of the fan, either as an absolute value per row or as a specific value in relation to the gross collector surface area. (normally 30 m³/h , maximum flow of the air collector.)
   The total volume flow rate is calculated by multiplying with the number of arrays as given on the page Parameters.

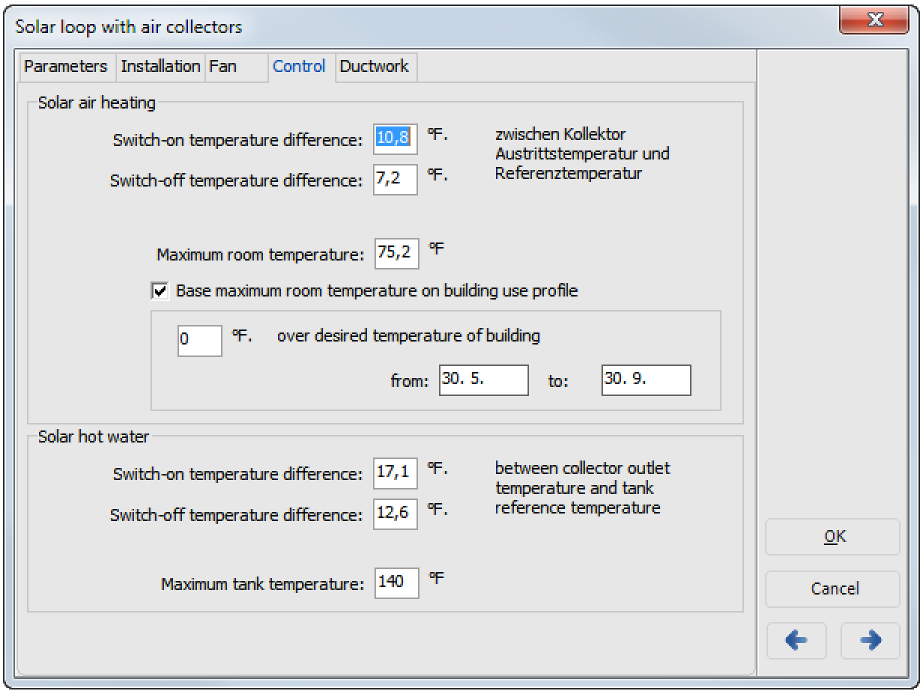
! ! In case, the nominal volume flow is higher than the maximum volume flow of the air collectors combined, you'll get a warning.

9. Specify whether the fan is operated with photovoltaic power or not. If not, *Nominal Power* section appears:

The recommended nominal power of the fan, the *Guide Value*, is calculated on the basis of the air collector, the volume flow rate of the fan, and the number of collectors per row. Enter the value for the nominal power used.

10.5.3 Control

Variant menu *System Definition › Solar Loop with Air Collectors › Control*



Dialog *System Definition › Solar Loop with Air Collectors › Control*: air collector loop control for solar room and DHW heating

10. Go to the *Control* page. In the *Solar Air Heating* section, you can set the switch-on and switch-off values for the solar air-room heating. Typical values have been pre-entered in all the editable fields.

Room heating always takes priority – hot water is only heated when room heating is not possible on account of temperature conditions.

Fan-Hysteresis Control

The fan switches on as soon as the outlet temperature of the air collector is higher than the calculated room temperature by the switch-on temperature difference in the part of the building whose heating is supported by solar air heating. (normally 5–10 °C).

The fan switches off when it is either too hot in the room or as soon as the air from the air collector is too cold, i.e.

a) if the outlet temperature of the air collector is lower than the building reference room temperature by the switch-off temperature difference (normally 2–5 °C, typically lower than the switch-on temperature difference), or

b) if it is too warm in the room,

b1) because the room temperature exceeds the maximum room temperature or b2) because the room temperature exceeds the maximum room temperature defined in the building use profile. Go to *System Definition › Building › Use* to edit use profiles.

b3) In addition, you can enter a period at which the building target temperature is used for this comparison. Outside this time, the maximum room temperature given here is used.

11. In the *Solar Hot Water* section, you can set the switch-on and switch-off values for the solar DHW heating. This section is only visible for applicable systems. Typical values have been pre-entered in all editable fields.

    The fan switches on as soon as the outlet temperature of the air collector is higher than the calculated tank temperature for the solar DHW heating by the switch-on temperature difference. (normally 9–13 °C).

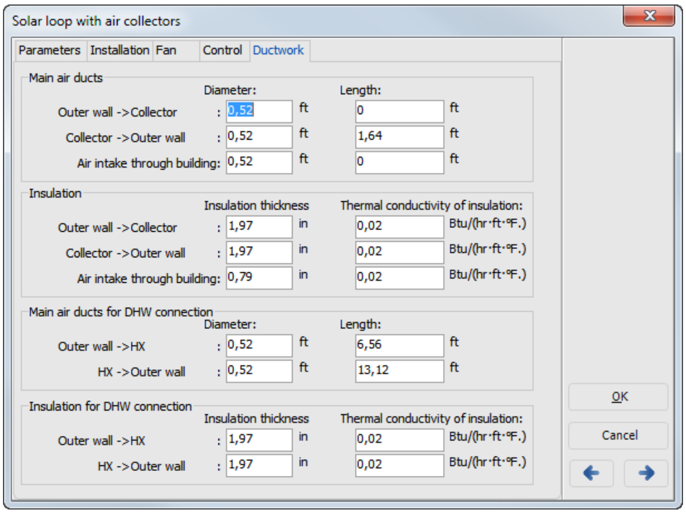
    The fan switches off as soon as the air from the air collector is too cold or if it is either too hot in the tank

    a) because the outlet temperature of the air collector is lower than the tank temperature by the switch-off temperature difference (normally 2–6 °C, typically lower than the switch-on temperature difference), or

    b) because the tank temperature is higher than the maximum tank temperature stated here (normally 50–70 °C).

10.5.4 Air Ducts

Variant menu *System Definition › Solar Loop with Air Collectors › Air Ducts*



Dialog *System Definition › Solar Loop with Air Collectors › Control*: air collector loop control for solar room and DHW heating

12. Go to the *System Definition › Solar Loop with Air Collectors › Air Ducts* dialog.

13. In the *Main Air Ducts* and *Insulation* sections, enter the Diameter, Length as well as the Thickness and Insulation Thermal Conductivity Coefficient of the inlet and outlet air ducts. In detail:

    - External wall -> Collector= Air duct from the external wall to the collector input
    - Collector -> External wall= Air duct from collector output to external wall

- Air intake through building = Fresh air duct passing through the building to the collector. A rare but efficient setup.

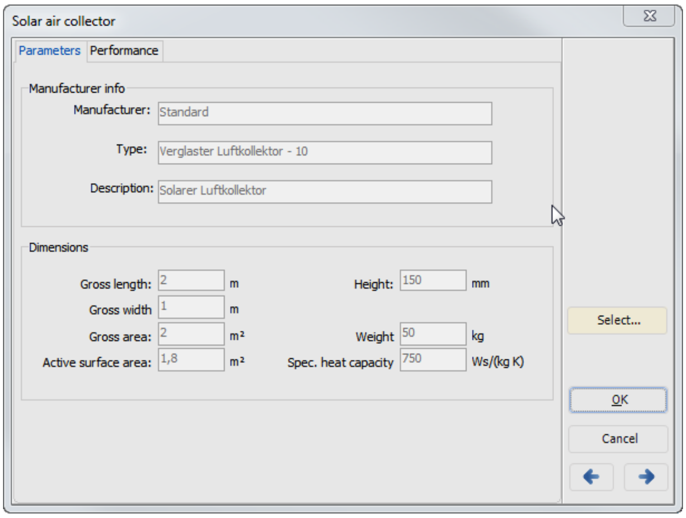
14. In the *Main Air Ducts for DHW Connection* and *Insulation for DHW Connection* sections, enter the Diameter, Length as well as the Thickness and Insulation Thermal Conductivity Coefficient of the inlet and outlet air ducts for DHW heating. In detail:
    - External wall -> HX= Air duct from building external wall to HX
    - HX -> Collector= Air duct from HX output to building external wall

    HX: Heat exchanger

10.6 Air Collector Parameters

Variant menu *System Definition › Solar Air Collector › Parameters*

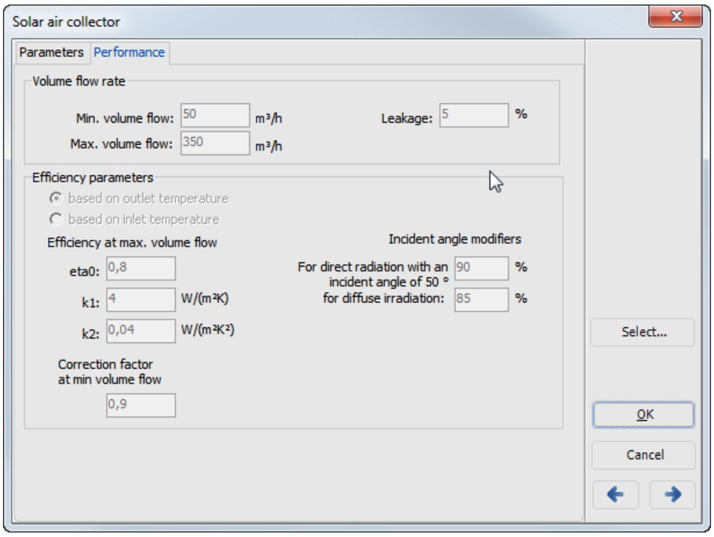
è Prerequisites: System with air collector: *Select New System* › ☑*Air collectors*



The collector geometry and specific heat capacity are retrieved from the collector database.

è How to define the solar air collector:

1. Go to the *System Definition › Solar Loop with Air Collectors* variant menu. The definition dialog is opened. You will see the *Parameters* page.
   Manufacturer data, geometry, and specific heat capacity are applied from the database and cannot be changed here.



Calculating collector power from volume flow rate and efficiency parameters

2. Enter the maximum and minimum volume flow rate.
3. Every air collector is porous; leakage must be less than 15%.
4. Enter the correction parameters □η_0, k_1, and k_2 for calculating the efficiency η. Using these, the efficiency η is calculated using the following formula:

$$\eta = \eta_0 - \frac{k_1(\Delta T) + k_2(\Delta T)^2}{G''}$$

with:

G" irradiation and $\Delta T = T_{\text{Air collector, out}} - T_{\text{Environment}}$

The correction parameters η_0, k_1, and k_2 can be found in the testing institute's records for this collector. However, they are only valid for the tested volume flow rate. In order to be able to simulate with other volume flow rates, you can adjust these correction parameters here. Air collectors usually show lower levels of efficiency with lower volume flow rates.

5. The efficiency η at minimum volume flow is multiplied by the *correction factor at minimum flow rate* following correction with the above formula. The correction factor is between 0 and 2.

! ! The incident angle modifiers are used in the same way as those of water (brine) collectors. See chapter Collector – Optical Losses.

! ! Values which are grayed-out come from the collector database.

! ! When you select a new collector, your values entered here are overwritten.

10.7 Tanks

Variant menu *System Definition › Tank* or system schematic

Different types of tanks are loaded depending on the system.

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

You can use either the company products from the database or standard values to make calculations.

Dynamic Simulation of Tank Losses

The tank losses that would arise also without the use of a solar system are calculated on the basis of the storage geometry and the target values. During calculation of the energy supplied by the solar loop, additional tank losses are set off, which are primarily those created in summer i.e. generated through operational availability and the solar buffer. The solar fraction contribution calculated in this way is lower, but better comparable with the fraction of solar systems in which tank losses can be definitely assigned to the solar system and have also already been deducted from the solar yield. Solar loop yields that are only used to generate tank losses are thus now a thing of the past.

10.7.1 Tank Parameters

Variant menu *System Definition › Tank › Parameters*

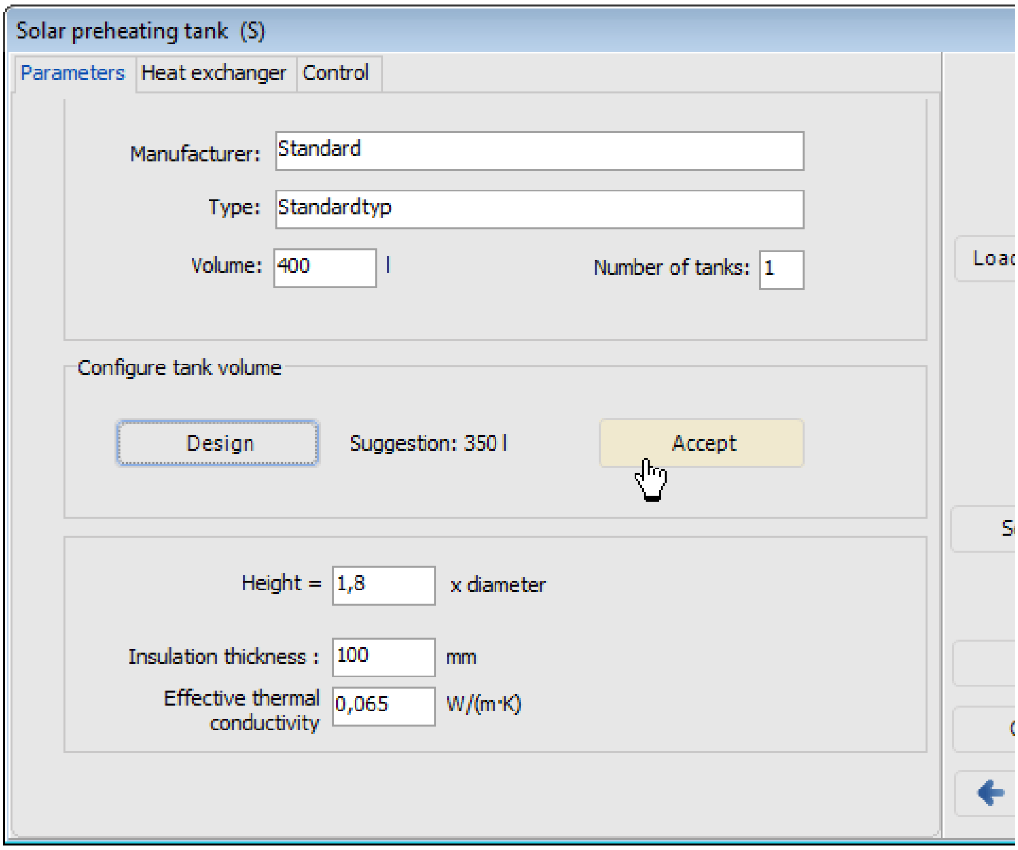


Image: Input dialog for tank parameters, example single coil tank

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 .

10.7.2 Tank Heat Exchanger

Variant menu *System Definition › Tank › Heat Exchanger*

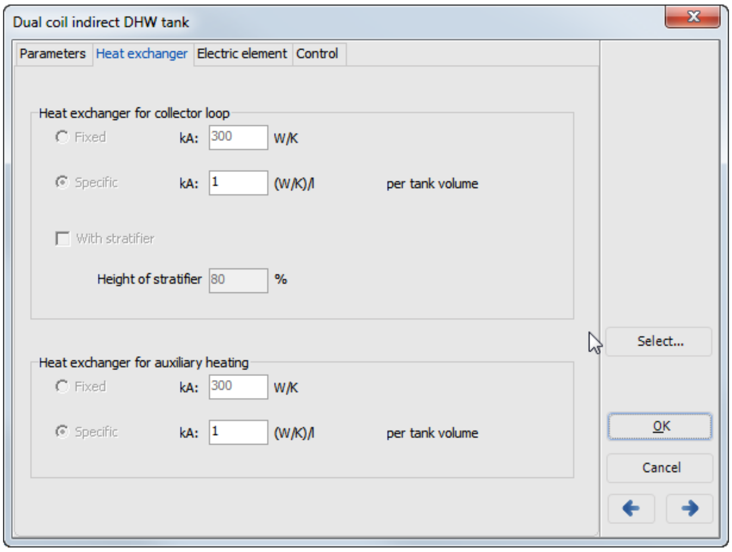


Image: Tank dialog, Heat Exchanger page: example dual coil tank

The values shown on the *Heat Exchanger* page of all tanks 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.

10.7.3 Tank Control

Variant menu *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.

10.7.4 Tank Types

Variant menu *System Definition › Tank* or system schematic

Different types of tanks are loaded depending on the system.

10.7.4.1 Single coil DHW tank

Variant menu *System Definition › Tank › Control* or system schematic

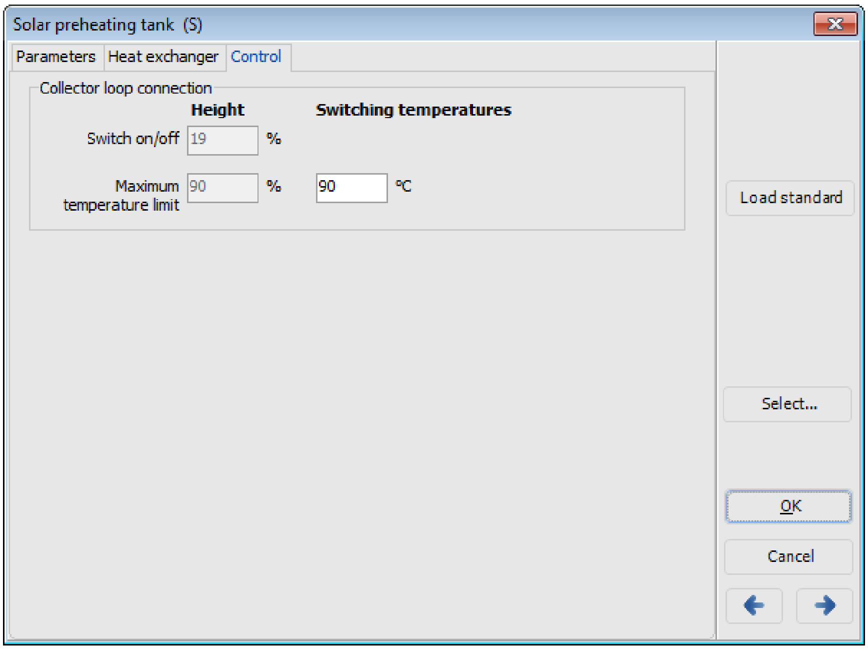


Image: Single coil DHW tank, used as standby tank, *Control* page

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.

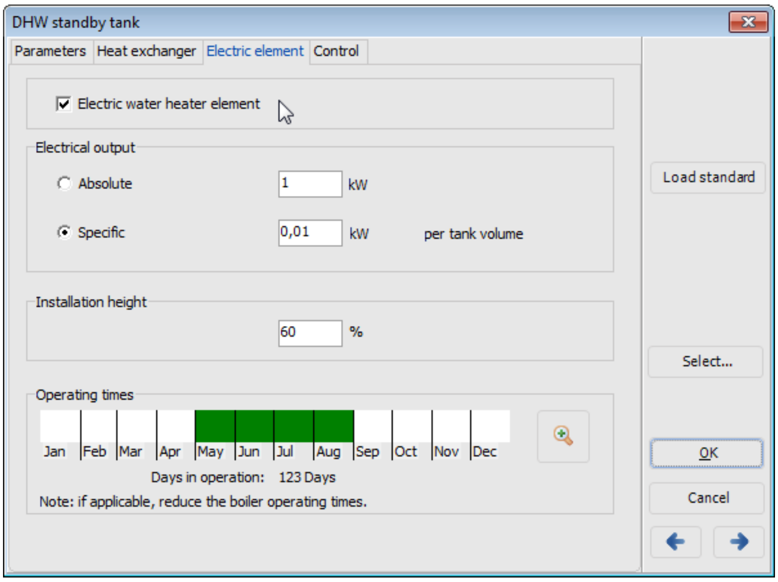


Image: A2 or A4 system: Single coil DHW tank, used as standby tank, page *Electric Element*

For the standby tank you can plan
- an ☑ *Electrical water heater 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.

10.7.4.2 Dual coil DHW tank

Variant menu *System Definition › Tank* or system schematic

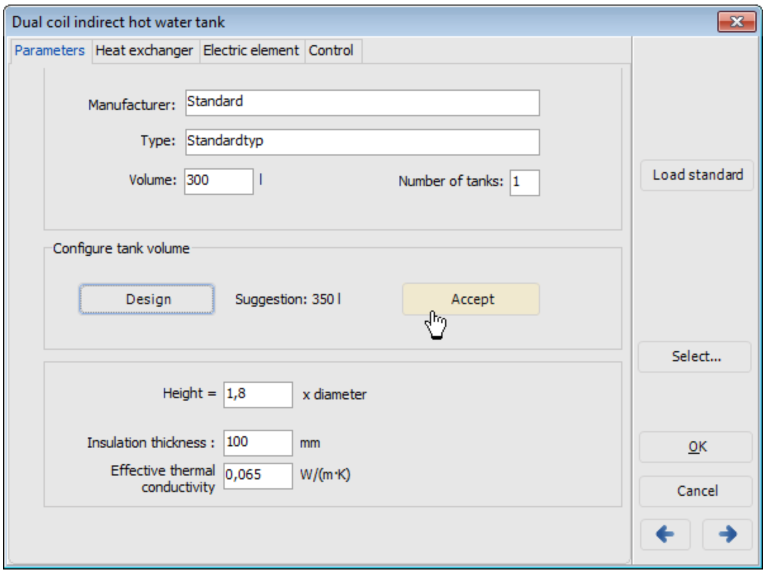


Image: Input dialog for dual coil DHW tank

The type of tank serves as a solar tank in the lower area and 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.

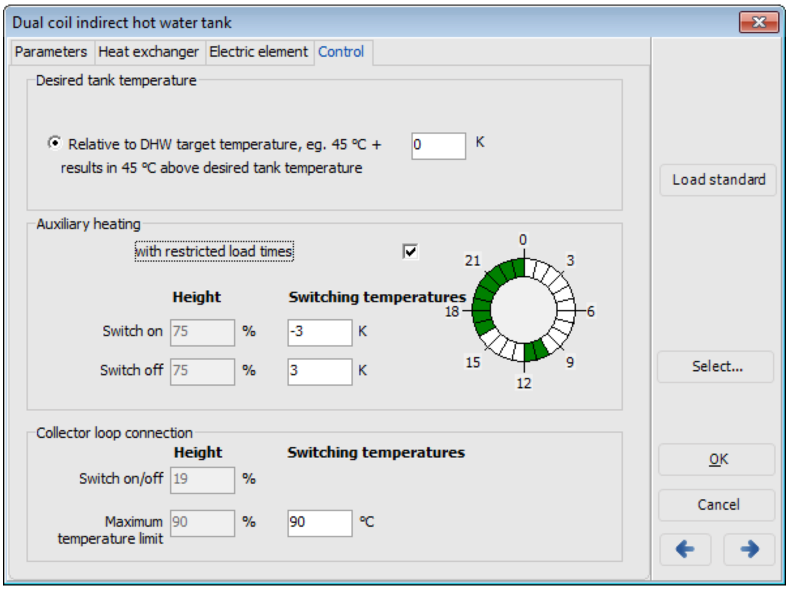


Image: Input dialog for dual coil DHW tank, *Control* page

-> 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.

10.7.4.3 Combination tank

Variant menu *System Definition › Tank* or system schematic

10.7.4.3.1 Combination tank in tank

Variant menu *System Definition › Tank › Heat Exchanger / Tank*

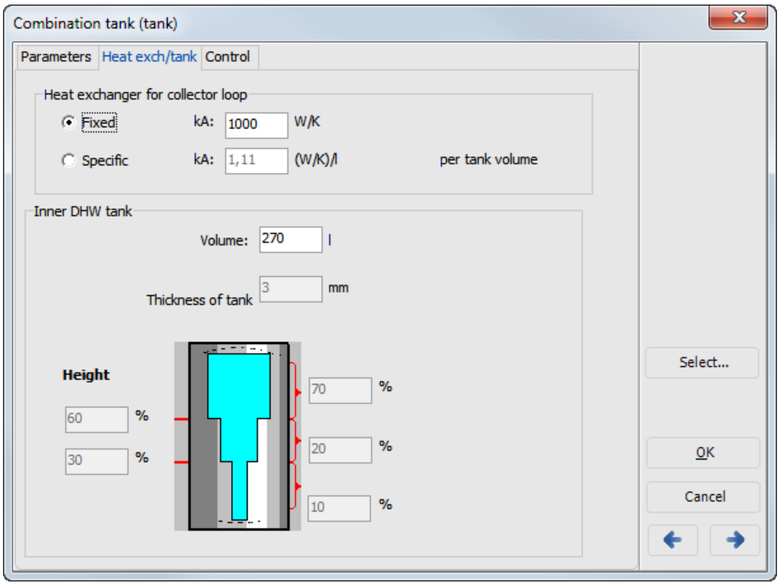


Image: System A5.4: Input dialog for tank in tank system, *Heat Exchanger / Tank* page

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.

10.7.4.3.2 Combination tank with internal heat exchanger

Variant menu *System Definition › Tank › Heat Exchanger*

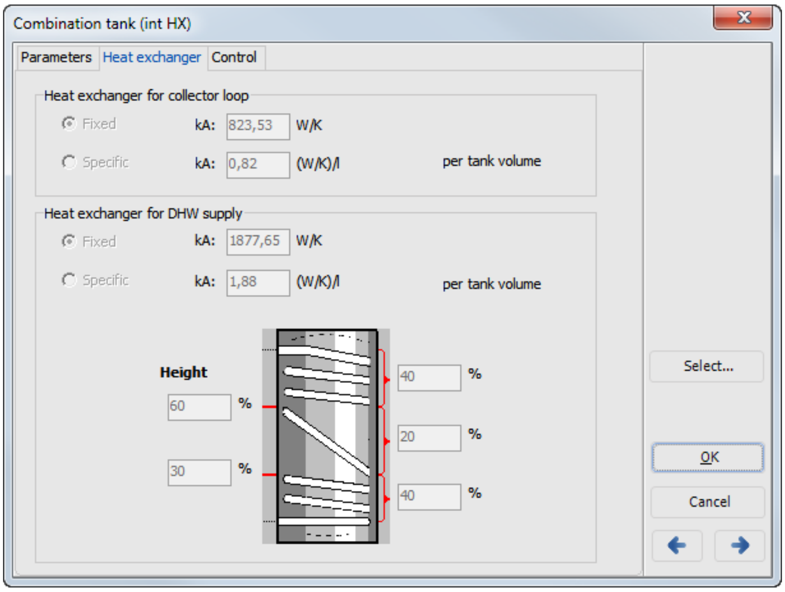


Image: System A5: Input dialog for combination tank with internal heat exchanger, *Heat Exchanger* page

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.

10.7.4.3.3 Combination tank control

Variant menu *System Definition › Tank › Control*

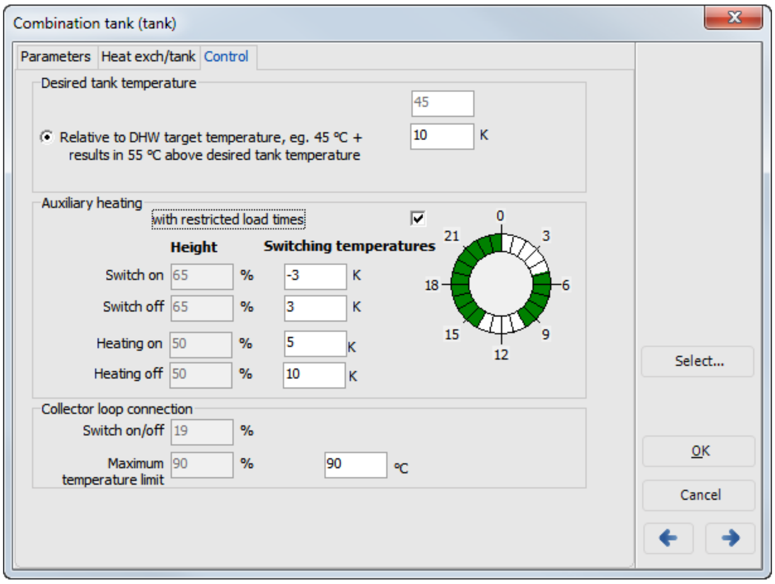


Image: System A5.X: Input dialog for combination tank, *Control* page

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.

10.7.4.3.4 Solar Fraction of Systems using Combination Tanks

For combination tank systems, the fraction (domestic hot water) and the heating fraction are determined in the dynamic simulation and displayed individually in the project report (previously: total solar fraction), as the fraction e.g. for funding applications must be separately given.
In every time increment, the T*SOL simulation balances if the yields contribute to the fraction of domestic hot water and thermal heat supply, the circulation losses and the tank losses or the heating of the storage tank content. Thus the origin (solar loop or supplementary heating) of the heat is known, meaning heat delivery can be distributed.

10.7.4.4 Heating buffer tank

Variant menu *System Definition › Tank › Control* or system schematic

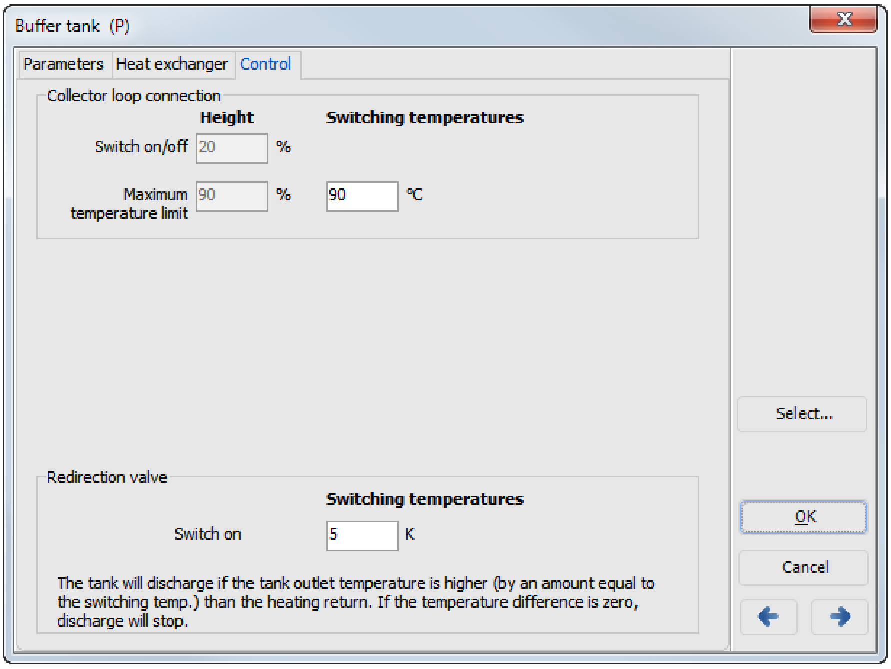


Image: System A3 or A4: Input dialog for heating buffer tank, *Control* page

On the *Control* page, the single coil heating buffer tanks have the same input parameters as the [single coil DHW tanks](#).

Additionally, you define in the *Redirection Valve* section, the switching temperature for switching the three-way valve in the heating return:
If the total of tank temperature in the boiler return and given switching temperature difference is higher than the temperature in the heating return, the heating return is redirected in the tank, which is therefore unloaded.

10.7.4.5 Bivalent Buffer Tank (P)

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

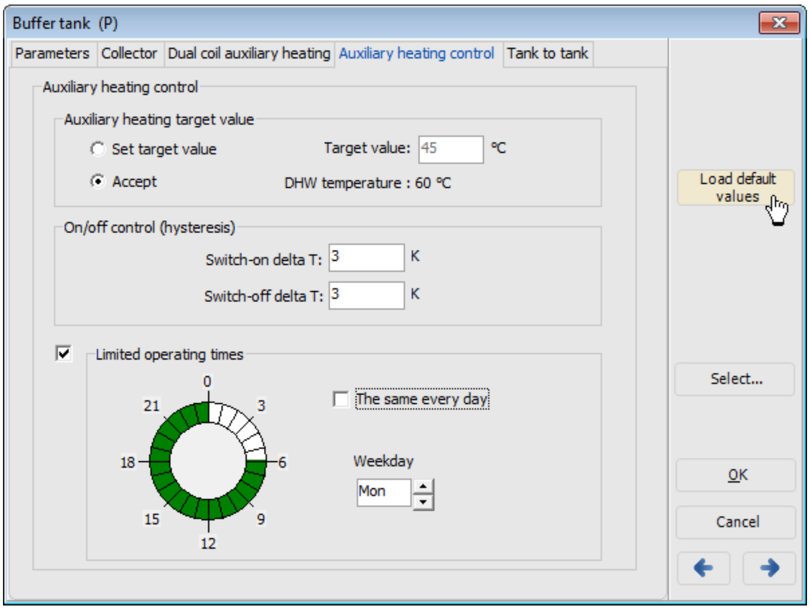


Image: Input dialog for buffer tank with external heat exchanger, *Auxiliary Heating Control* page

Systems A6, A12, A13, C1, C2, C3, C4 contain bivalent 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.

10.7.4.6 DHW tank with external heat exchanger

Variant menu *System Definition › Tank › DHW* or system schematic

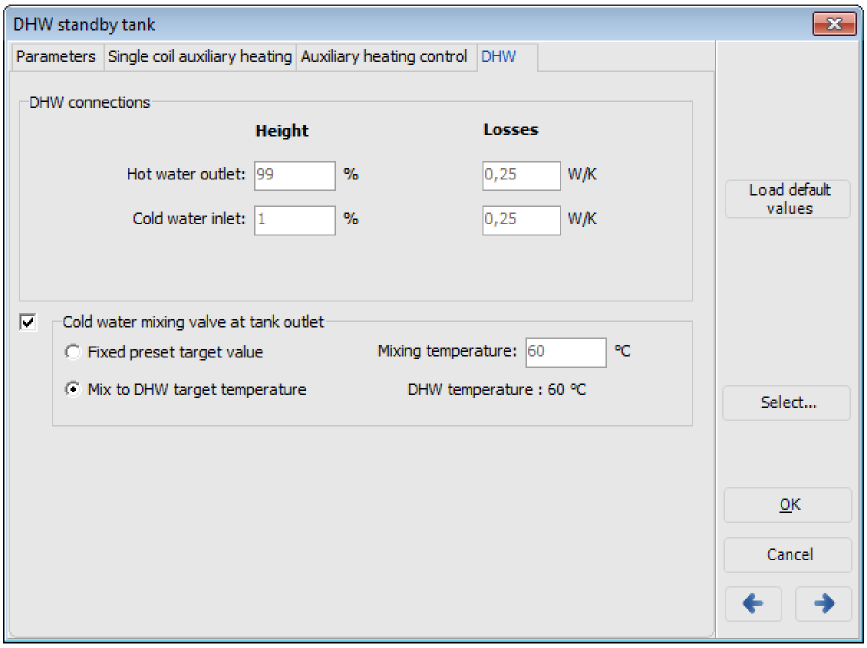


Image: Input dialog for *DHW tank* with internal heat exchanger, *DHW* page

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.

10.7.4.7 Solar buffer tank

Variant menu *System definition › Storage tank* or system layout

The solar buffer tank (P) is used in the A 17, B17, A18, B18, A14.1, Buderus SAT-VWS, Buderus SAT ZWE and Vaillant Allstor systems and is bivalent.
It includes, if needed, the tab *Auxiliary heating*.

The solar buffer tank (S) is used in the C6 system and is monovalent.

'Parameters' Page

Enter the manufacturer, type and geometry of the tank and its insulation or select a tank.

Tank loading page

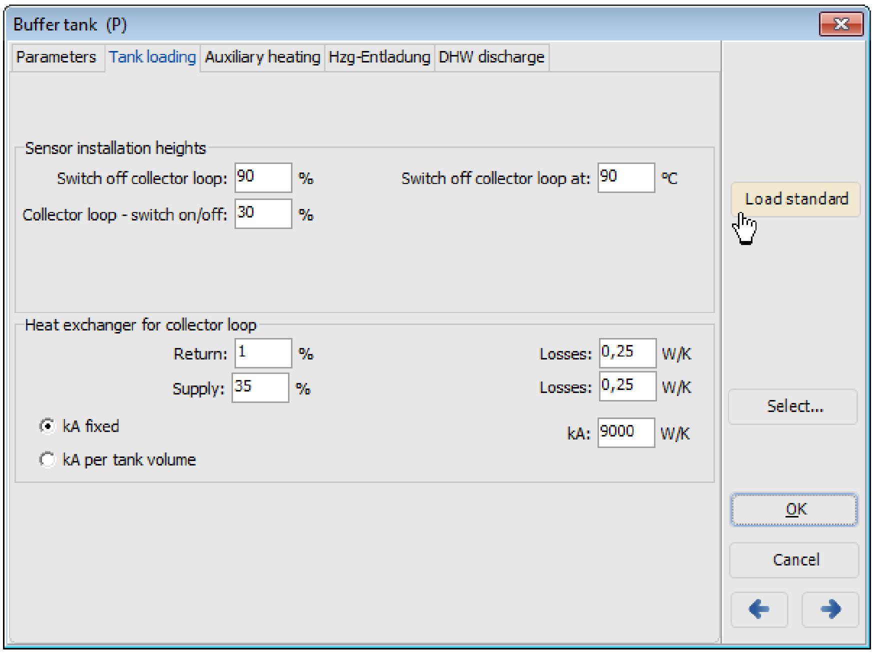


Image: Loading a solar buffer tank

The controller and connection of the collector loop to the buffer tank is described on the *Tank Loading* page.

Sensor mounting heights :
Enter the *sensor mounting heights* for the various tank sensors used to control the collector loop pumps.
Enter the maximum tank temperature. If the tank is hotter than this temperature, the collector loop pumps are deactivated.

Heat exchanger: connection to the collector loop :
Define the pipe connection heights and thermal loss of the tank connections for the loading circuit (flow and return)

If the tank has a heating lance, its height is defined here.

For the kA value, see the glossary.

Heat dissipation page

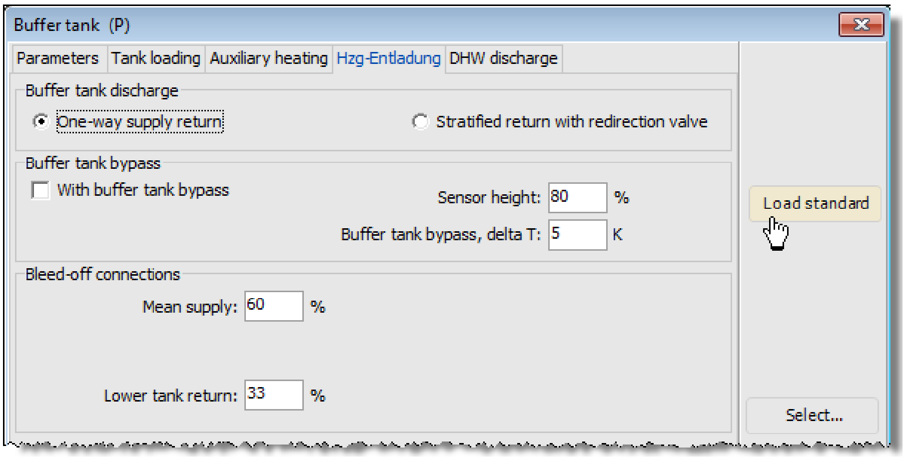


Image: Heat dissipation of a buffer tank (p) in system B18

On this page, define the controller and connection of the heating support to the buffer tank.

Buffer bypass for return increase:
In systems with heating support from the increasing of the heating return temperature, the mounting height of the sensors and the temperature difference (*buffer bypass delta T*) are defined here, which serve to activate the return increase to control the switching valves.

Bleed-off connections:
If the heating loop is completely supplied from the tank, as with system type B18 for example, the pipe connection heights from the heat flow and return can be defined. Otherwise, only the return height.

In addition, the return can be placed at two different heights in the tank. The corresponding valve switch is controlled using a sensor and temperature difference.

Here, a tank bypass can also be defined, complete with a corresponding control sensor. This switch can be used to avoid warming a cold tank with the return and thereby increasing the system loss.

DHW Discharge page

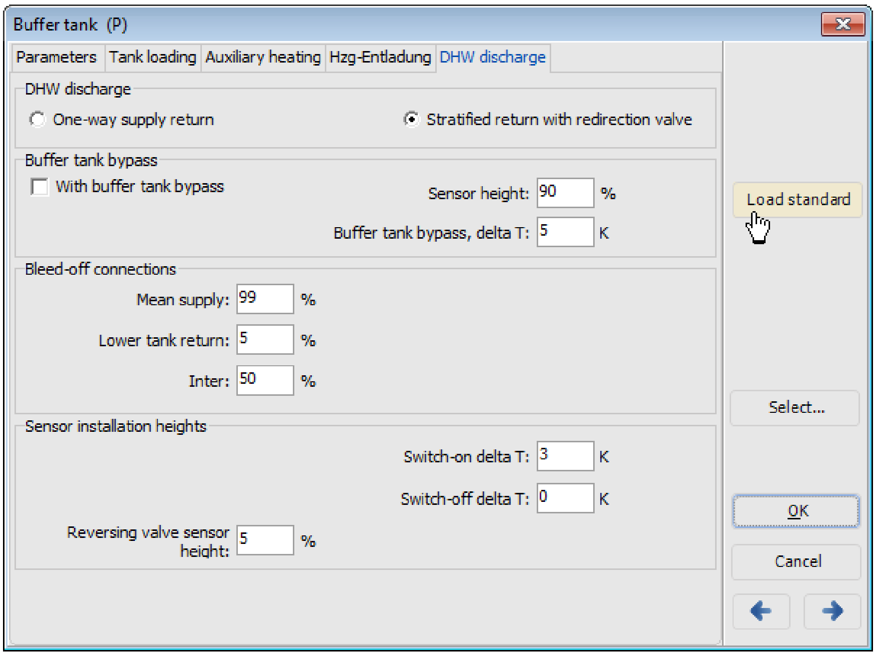


Image: DHW discharge of a solar buffer tank

Define the controller and the physical connection of the DHW stations to the the buffer tank.

Enter the pipe connection heights from the flow and return and their loss.

In addition, the return can be layered over two different heights in the tank. The corresponding valve switch

Here, a tank bypass can also be defined, complete with a corresponding control sensor. With this switch, warming a cold tank with the return and thereby increasing the system loss can be avoided.

Solar buffer tank The solar buffer tank is then loaded by the solar system. If the temperature in the storage tank in high enough, the heating return is raised by discharging the tank.

The return from the DHW station is layered over a 3-way reversing valve and dependent on the storage temperature in the solar buffer tank.

If the return increase temperature is too high to discharge the buffer tank, the solar buffer tank is circumvented with a bypass switch and the return from the DHW station is sent directly to the boiler buffer tank.

-> See also:

C6 - Large scale system for DHW with solar and boiler buffer tank, as well as heating controller

10.7.4.8 Boiler buffer tank (P)

Variant menu *System definition › Storage tank* or system layout

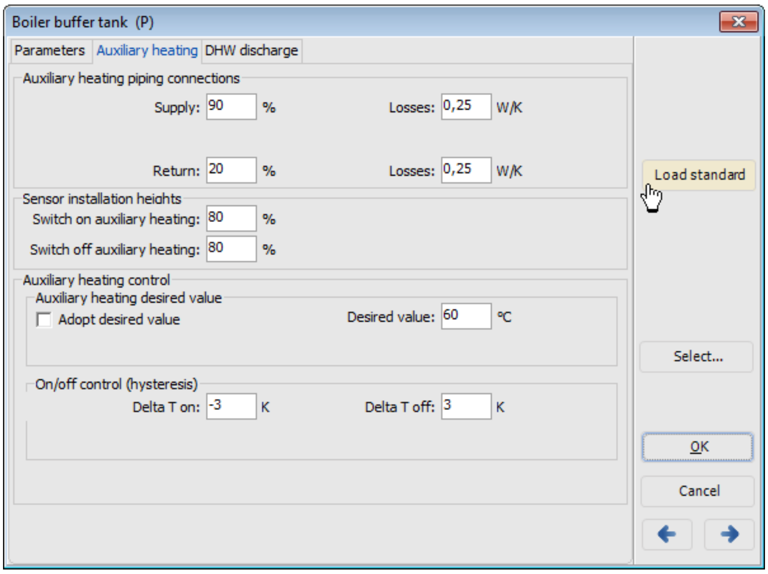


Image: C6 System: *System definition › Boiler buffer tank (P) › Auxiliary heating*

The boiler buffer tank is heated by the boiler only.

The consistent temperatures in the boiler buffer tank enable easier and safer operation of the boiler as well as the drinking water station.

The boiler buffer tank is discharged through the drinking water station only.

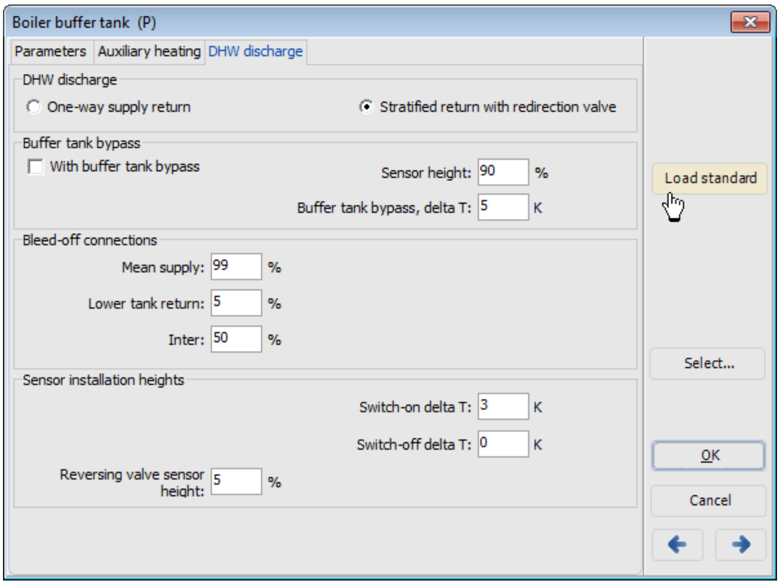


Image: C6 System: *System definition › Boiler buffer tank (P) › DHW Discharge*

-> See also:

[C6 - Large scale system for DHW with solar and boiler buffer tank, as well as heating controller]

10.8 Auxiliary Heating

Variant menu *System Definition › Gas Boiler › Parameters* or system schematic

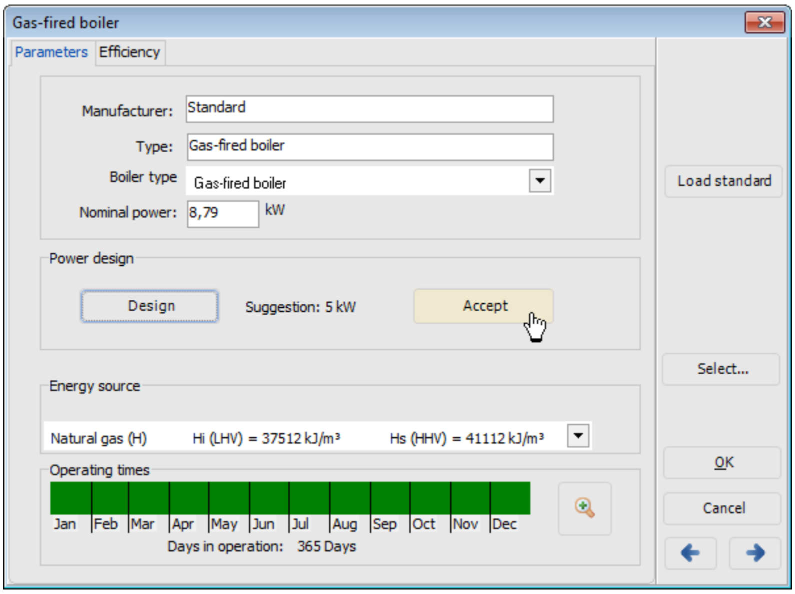


Image: Input dialog for auxiliary heating

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.

-> Proceed as follows:

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

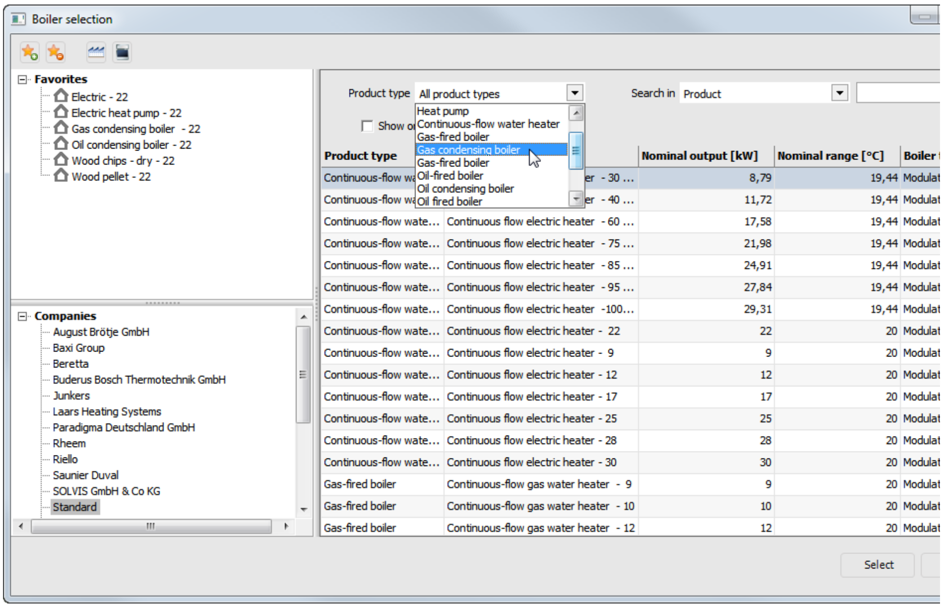


Image: Dialog for boiler selection

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

3. Select one of the auxiliary heating systems by clicking it in the list on the right side.
4. 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.
5. You can modify a range of parameters for the supplied auxiliary heating system. These changes are only applied to the current variant.
6. 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.
7. Save all entries by clicking *OK* or go to the next parameter dialog using the arrow button.

-> See also: Components

Efficiency

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

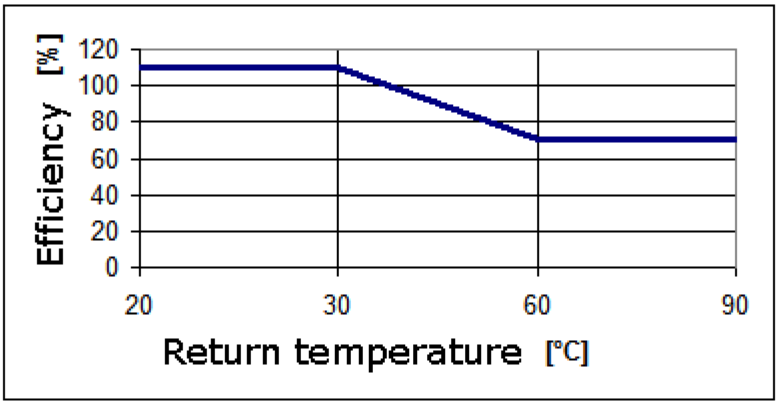


Image: Definition of efficiency curve in relation to the return temperature

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 › Variant X › 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.

10.9 Heating Loop

Variant menu *System Definition › Heating Loop*

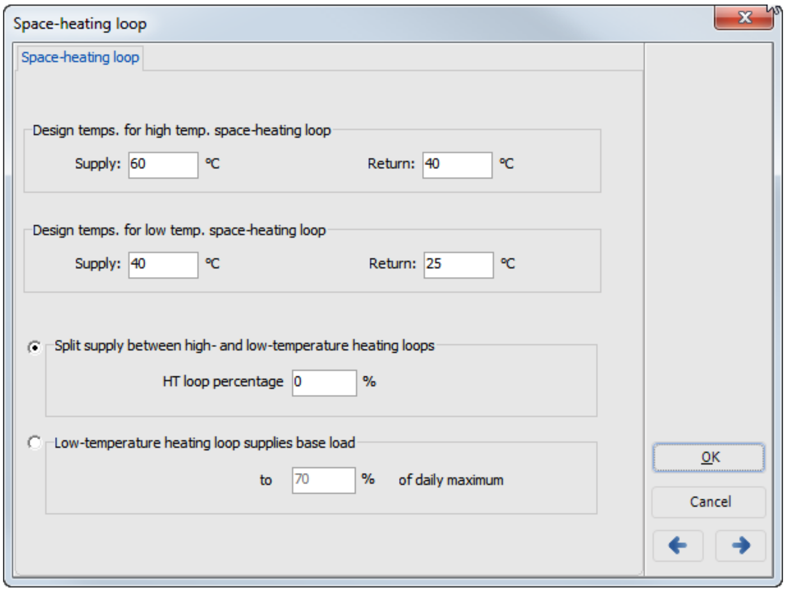


Image: Input dialog for the heating loop

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

-> 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*.

10.10 External Heat Exchanger

Variant menu *System Definition › External Heat Exchanger* or system schematic

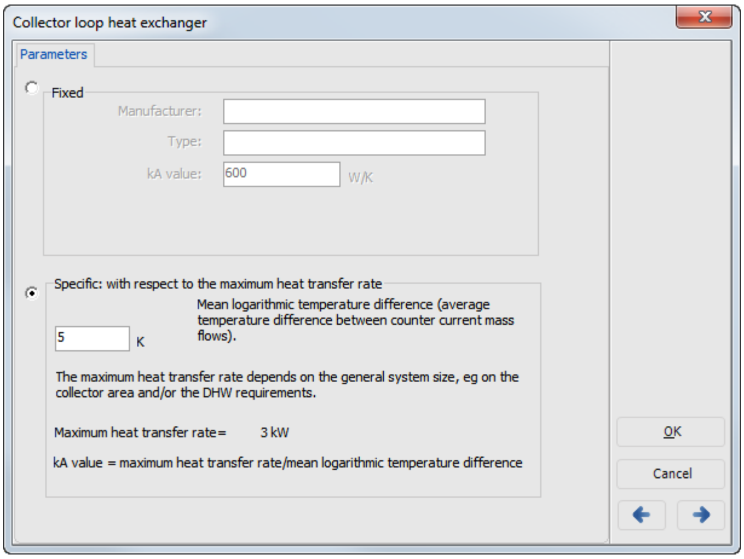


Image: Input dialog for the external heat exchanger

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, P_{max} 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.

10.11 DHW Supply (Large-Scale Systems)

This component primarily appears in large-scale systems, but is also found, for example, in solar heating networks.

This chapter describes the components which only occur in large-scale systems or otherwise differ from those in standard systems. The remaining components are explained in chapters 10.1 to 10.10.

The following types of DHW supply are simulated for large-scale systems:

- Single coil DHW supply
- Dual coil continuous flow DHW supply
- Dual coil DHW supply with a DHW tank
- Dual Coil DHW Supply with a Solar Preheating Tank and Auxiliary Heating in the DHW Standby Tank

In the first case, the DHW standby tank is connected to the heated buffer tank via an external heat exchanger, while in the other cases the buffer tank is only loaded by solar power and the auxiliary heating directly supplies the DHW tank.

10.11.1 Single Coil DHW Supply

Variant menu *System Definition › DHW Supply* or system schematic

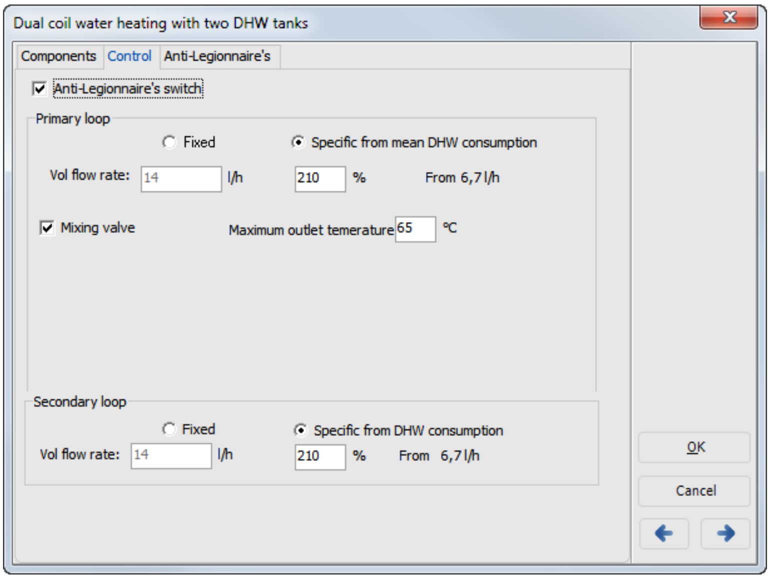


Image 10.11.1: Input dialog for DHW supply

The dialogs on the External Heat Exchanger and DHW Standby Tank can be accessed via the *System Definition › DHW Supply › Components* page.

On the *Control* page, the time it takes for the DHW standby tank to fully load is shown under *Load Time*. If the volumetric flow rate of the loading pumps is to be calculated from this value (i.e. the relevant radio button is selected), the load time can be modified.

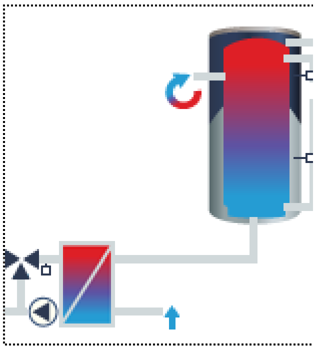
Alternatively, you can also enter the required *volumetric flow rate* of the primary and secondary loops directly. The supply temperature in the primary loop can be limited to the required temperature in the DHW standby tank to prevent calcification via the *mixing valve* field.

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 value for this target temperature. Click *Accept* to apply the respective desired tank temperature as the target temperature. This is recommended if you set different desired tank temperatures during operating times on account of the *anti-Legionnaire's switch*.

If you select the *Anti-Legionnaire's Switch* checkbox, the Anti-Legionnaire's Switch tab is activated.

10.11.2 Dual Coil DHW Supply with Solar Preheating of Fresh Water

Variant menu *System Definition › DHW Supply* or system schematic



in System C3

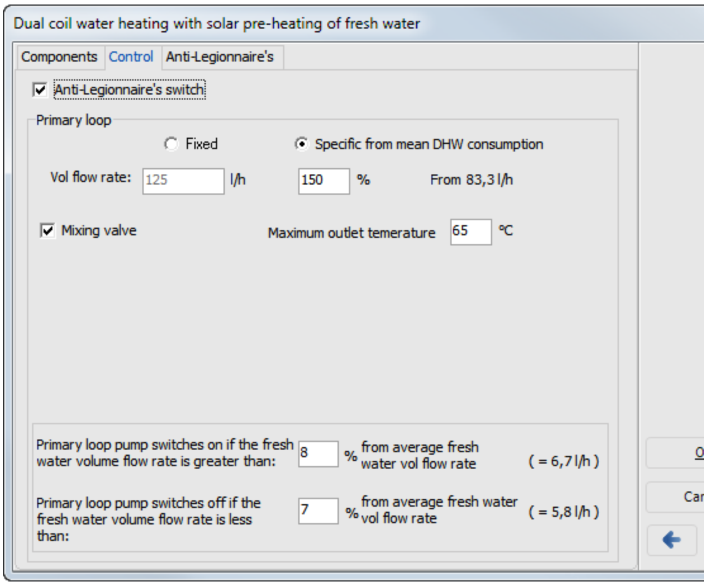


Image 10.11.2: Dialog for dual coil DHW supply with solar preheating of fresh water

The dialogs on the External Heat Exchanger, Auxiliary Heating, and DHW Standby Tanks can be accessed via the Components page.

On the *Control*page, the *volume flow rate*of the primary and secondary loop pump is either specified as relative to mean DHW consumption or entered as an absolute value in liters per hour.

The temperature in the heat exchanger can be limited to a maximum temperature via the *mixing valve*field.

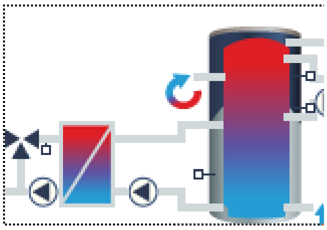
Whether the *pump in the primary loop*is started up or stopped is controlled by the draw-off flow rate for DHW consumption.

For example, you have defined 100 liters per day as hot water requirement in the DHW consumption section. In this case, the pump in the primary loop is activated on a draw-off flow rate of 10 liters per hour. Analogously, the pump is deactivated on a draw-off flow rate of less than 9 liters per hour.

If you select the Anti-Legionnaire's Switch checkbox, the Anti-Legionnaire's page appears.

10.11.3 Dual Coil DHW Supply with a DHW Tank

Variant menu *System Definition › DHW Supply* or system schematic



in installation C2

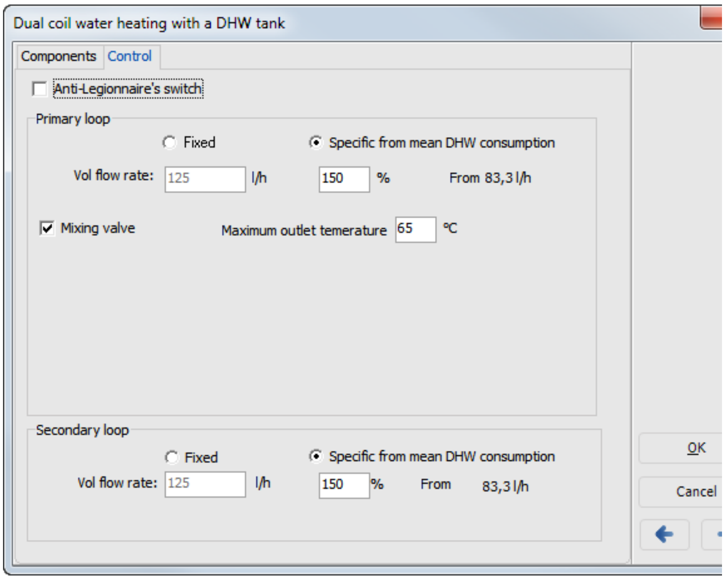


Image 10.11.3: Dialog for dual coil DHW supply with a DHW tank

This component is only used in large-scale systems.

The dialogs on the External Heat Exchanger, Auxiliary Heating, and DHW Standby Tanks can be accessed via the *Components* page.

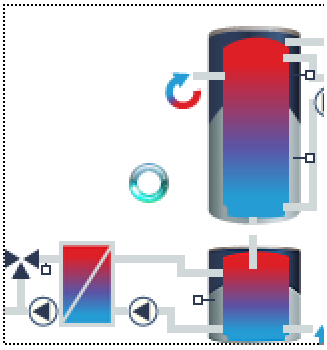
On the *Control* page, the *volume flow rate* of the primary and secondary loop pump is either specified as relative to mean DHW consumption or entered as an absolute value in liters per hour.

The temperature in the heat exchanger can be limited to a maximum temperature via the *mixing valve* field.

If you select the Anti-Legionnaire's Switch checkbox, the Anti-Legionnaire's page appears.

10.11.4 Dual Coil DHW Supply with a Solar Preheating Tank and Auxiliary Heating in the DHW Standby Tank

Variant menu *System Definition › DHW Supply* or system schematic



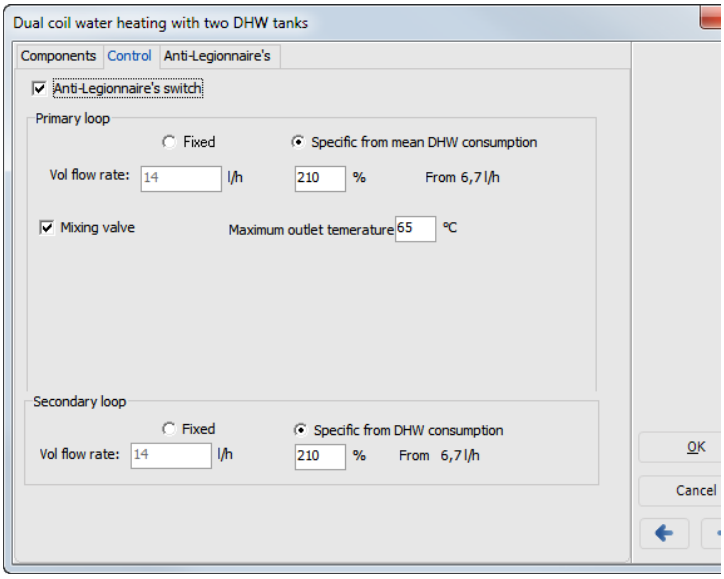


Image 10.11.4 : Dialog for dual coil DHW supply with two DHW tanks in installation C1

This component is only used in the additional module for SysCat large-scale systems.

The dialogs on the External Heat Exchanger, Auxiliary Heating, and DHW Standby Tanks can be accessed via the *Components* page.

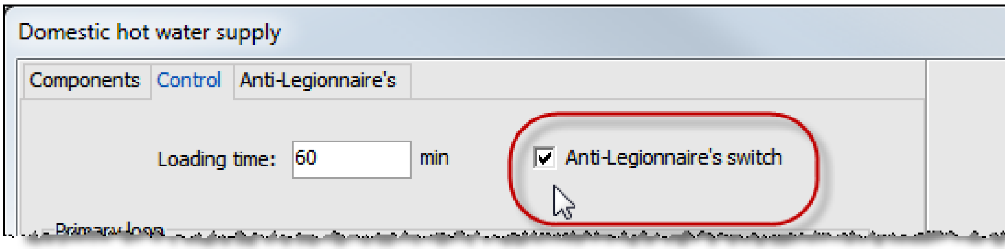
On the *Control* page, the *volume flow rate* of the primary and secondary loop pump is either specified as relative to mean DHW consumption or entered as an absolute value in liters per hour.

The temperature in the heat exchanger can be limited to a maximum temperature via the *mixing valve* field.

If you select the Anti-Legionnaire's Switch checkbox, the Anti-Legionnaire's page appears.

10.12 Anti-Legionnaire's Switch

Variant menu *System Definition › DHW Supply*



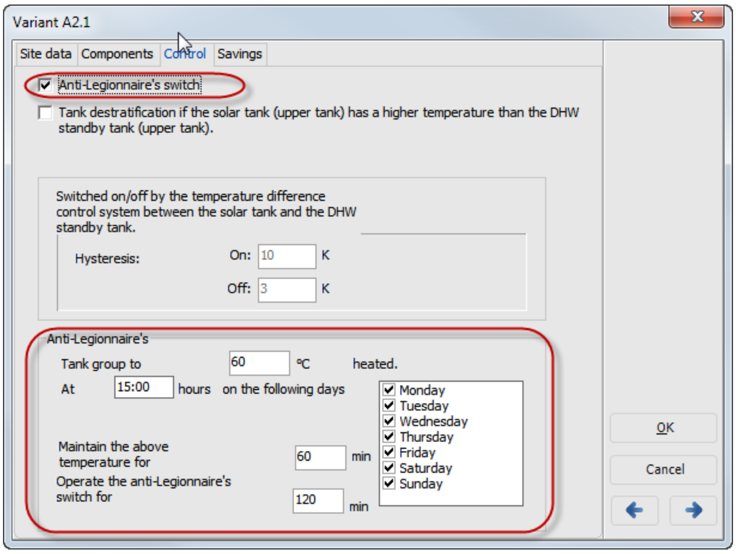


Image: Input dialog for Legionnaire's switch

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

10.13 Example: Configuring a Solar System for DHW Supply

Objective:

A solar system for domestic hot water supply is due to be erected on a new bungalow in Aachen. When it is completed, the bungalow will house a family of five. The longitudinal axis of the building runs from south-east to north-west. The usable area is 240m².

How large is the required collector surface area?

At what tilt angle should the collectors be installed on the flat roof?

How often will the tank temperature of 35 °C fall below this level?

How much heating oil can be expected to be saved?

What other measures should be observed in the construction of the building?

This solar system is frequently used in single and two-family homes. Preconfigured systems such as are offered by many collector manufacturers are typically used. Enter the configuration, consisting of the number of collectors, associated tanks, and other components. You can save frequently used systems in a template project, where required copy them into new projects, and then need only modify values such as the location and collector installation and orientation.

For these systems, the calculations in T*SOL® primarily serve to determine the primary energy savings which can be expected and the solar fraction of the system. Another important result is also verification that the system is not oversized, characterized by frequent attainment of the maximum temperature in the tank and consequently high collector temperatures.

Parameter setting

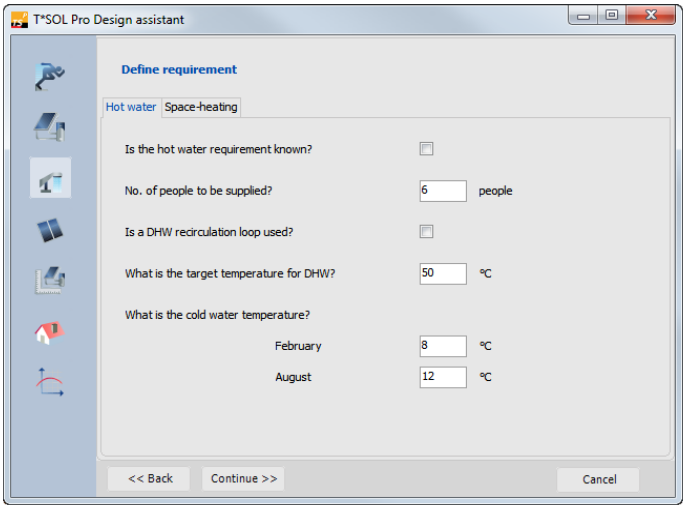


Image: Dialog for entering DHW requirement

After loading the *Aachen* climate file from the climate database for Germany, click on the blue arrow to access the next dialog, *DHW Consumption*. Here, enter the average daily consumption for the operating period given on the *Operating Times* page, typically the average daily consumption for a year.

In our example of the single family home in Aachen, we know that five persons have been named as consumers. If a high standard is assumed, you can expect 35 liters per person and day, i.e. a total of 175 liters per day at a temperature of 50 degrees Celsius. This daily consumption is not distributed equally over the day but rather in certain intervals with differing draw-off volumes. This process is displayed in the load profiles. Various load profiles are saved in a database which you can load by clicking the *Select* button.

By clicking on the *Parameters* button, you can check and also modify this load profile (see chapter *7.2* DHW Consumption).

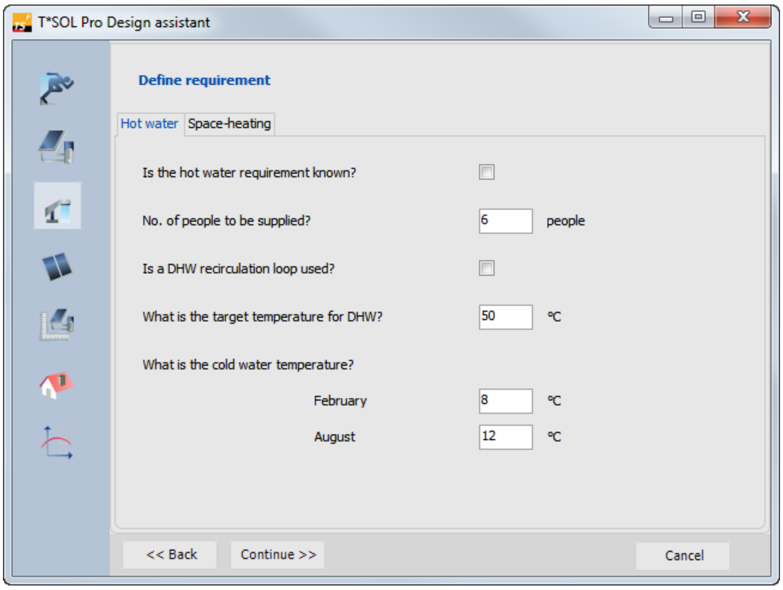


Image: Dialog for entering DHW requirement, Circulation page

In our example, DHW circulation is to be installed. Check the *Circulation* box at the top of the *DHW Consumption › Parameters* page. A new tab appears with the name *Circulation*. Enter all required data.

The DHW Consumption dialog is now complete, so click on the forward blue arrow to access the *Collector Loop Connection* dialog. Here, you can modify the volumetric flow rate in the collector loop and the composition of the heat transfer medium, e.g. to simulate a low flow system. In this case, the volumetric flow rate in the collector loop would be between 10 and 20l/m²/h.

Click on the blue arrow again to access the *Collector Array* dialog. Via *Parameters › Collector › Select*, you will reach the collector database, from which you select one from the manufacturers listed.

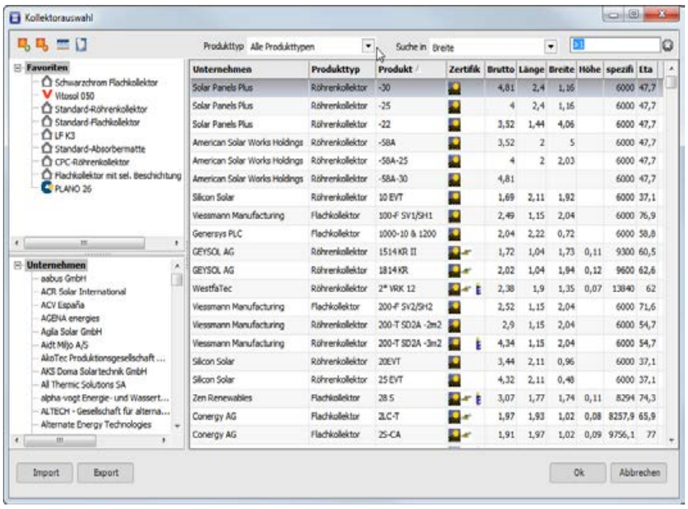


Image: Dialog for selecting the collector with favorite, sort, and search functions

Double-click on the desired collector or on *OK* to select the collector for the project. The collector surface area is determined from the information on the number of collectors and displayed. First, you decide on three collectors with an overall active solar surface of c. 7m². The active solar surface is the area available for converting solar radiation as well as that used as a foundation for determining the collector coefficients at the testing institute. The testing institute responsible for the various collectors can be found in the appendix to this handbook.

On the next page, *Installation*, you will find the system definition for the orientation of the collector array. The azimuth angle is the horizontal deviation between due south and the standard angle of the collector. In our case, the longitudinal axis of the building runs from south-east to north-west. If the collectors are installed parallel to this axis, the standard angle of the collector (vertical to the active surface) is to the south-west. The azimuth, in our case, is therefore the angle between south and south-west, i.e. +45 degrees.

As our example concerns purely domestic hot water supply, you can orient the installation of the collectors to the greatest possible irradiation. The absolute irradiation can be seen in the lower part of the dialog. For the south-west orientation, it is greatest between an installation angle of 30 and 35 degrees. For spring, fall, and winter, however, it is more effective to select the steeper angle. So, you can now answer the architect's question regarding the installation: 35 degrees from the horizontal. You can later further optimize this angle by carrying out several simulations with different angles and comparing the results.

If you already have information on pipe routing from the boiler room to the roof, these can be entered in the dialog on the *Piping* page. If not, you can use the default values.

Click on the blue arrow again to access the next dialog, the *Dual Coil DHW Tank.* As you are expecting hot water consumption of 175 liters, choose a tank with double this size, i.e. 350 liters, which can be loaded from the relevant database by clicking *Select*. If you want to use a storage tank not contained in the database, you can also change the tank's volume after loading it. The tank will then be saved with the modified data for this project.

You do not need to enter any further information for the tank, and the data for control can also be left unchanged. The default *0 K*(elvin) for the *Desired Tank Temperature* on the *Control* page means that the temperature of the upper tank is taken from the hot water target temperature, which you have set as 50 °C in our case.

Click on the blue arrow again to access the *Boiler* dialog. From the architect's plan, you know that there is a useable area of 240 m². As you must define a boiler but do not have a calculation of space heating requirements, estimate the required power as 240m² * 50 W/m² = 12 kW and load a corresponding oil boiler from the database. Adopt the default values for the efficiency of the boiler.

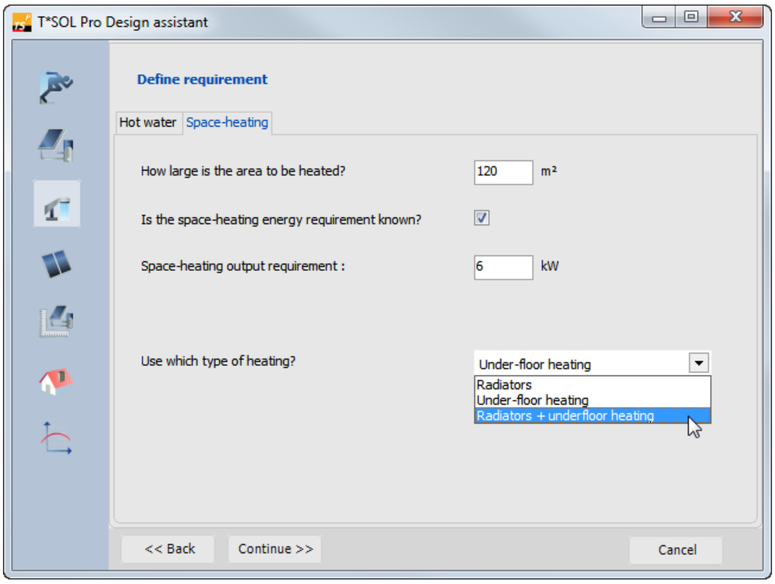


Image: Dialog for defining the boiler

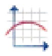
As the solar system is intended to provide the domestic hot water supply in the summer without the boiler, click on the months of June, July, and August in the Operating Times box to remove them (removed = color white).

You have now reached the end of the dialog chain and can exit the system definition by clicking *OK*.

Evaluation

An initial evaluation of the system is always possible via the project report. When you create the project report, you will see a summary of the key values, solar fraction, system efficiency, and fuel savings on the first page of the report. This page also answers the question regarding heating oil savings: the solar system saves c. 400 liters of heating oil annually.

The second page shows the key system data, while the third presents two graphs evaluating the system: the first shows a profile of the solar fraction over the year in weekly steps, while the second charts the maximum collector temperatures for every day of the year. .

In order to answer the question of the daily temperatures in the tank, you must call up the graphics tool. This can be done by clicking *Results › Graphics* or the symbol .

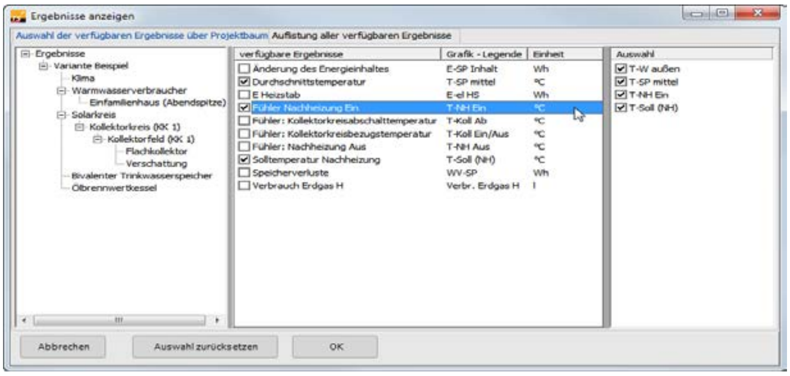


Image: Selection dialog for graphic presentation of results

You will first be given a selection of available results, which you can view for each component from the project tree in the left-hand column. Select the value *Sensor Auxiliary Heating On* from the *Available Results* for the dual coil DHW standby tank, which provides insights into the temperature in the upper part of the tank. By clicking on *OK*, you are initially given a temperature profile showing the average monthly temperatures. You can access the daily temperatures by clicking on the X-axis or clicking *Axes › X-Axis* in the graphics menu.

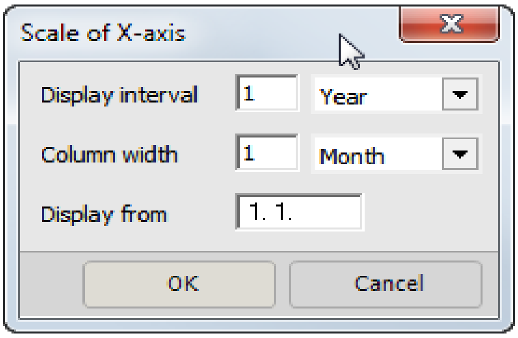


Image: Scaling the X-axis to show daily temperatures

You can now select the display interval and resolution. Enter the month and resolution days with a starting value of 6/1. The daily tank temperature from 6/1 will be shown. You can change the display interval with the blue arrow button and jump to the next month.

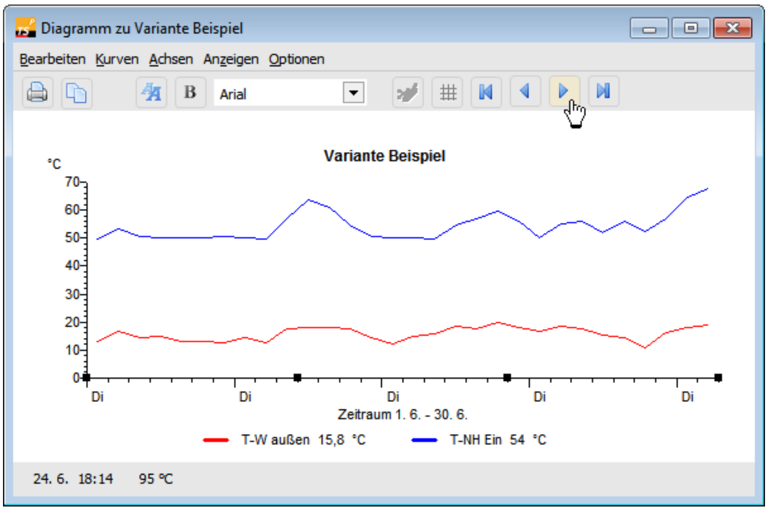


Image: Graphic representation of daily temperatures

The question regarding the number of days on which the tank does not reach 35 degrees can now be answered with the help of the graph. Converting the graph to a table via the *Table* command in the menu bar makes this even easier.

Continue the example by considering how the number of days on which the temperature drops below 35 °C can be reduced. Modify the individual system parameters such as tank size, tilt angle, and collector surface area! Run the simulation and assess the results.

To finish, there is the architect's question regarding further construction considerations. Suggest providing hot water connections for the washing machine and the dish washer and connecting these appliances. This measure increases domestic hot water consumption by 20 to 40 liters a day, which can be covered by the solar system and saves valuable electricity.

In the *Project › Open Project* dialog, you will find further examples.

11 Calculations

Variant menu *Calculations*

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

➔**The separate submenus are described in detail in their own chapters:**

- Design assistant
- Simulation
- Parameter Variation (T*SOL Expert only)
- Financial Analysis
- EnEV

11.1 Design Assistant

Variant menu *Calculations › Assistant*

The design assistant is intended to assist you in the design of a solar system. It should therefore be used where the values for the collector array and/or the tank to be installed are not known.

! The design assistant now calculates reliable recommendations with the help of the minutes simulation.

! Within your existing project, the current variant will be overwritten with the values determined in the assistant as soon as you click Accept on the final page. If, instead, you want to create a new variant, click *Variant › New Variant* and then select the option *Open Design Assistant*.

The design assistant guides you through all the required steps all the way to selection of the collector surface area and a suitable tank. These components are determined by quick simulation calculations following entry of a desired solar fraction.

11.1.1 Project Data

Variant menu *Calculations › Assistant › Project Data*

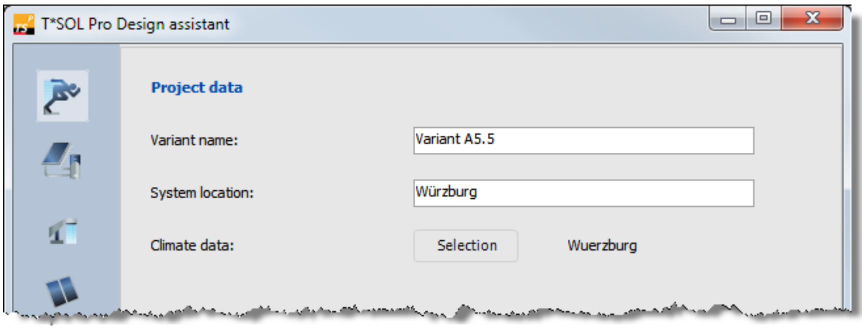


Image: Start page of the design assistant

First, give the planned solar system a name on the start page of the design assistant. As you can calculate several system variants within a single project, the term *variant* is used here.

Click on the *Selection* button to change the climate data record. In the *System Location* field, enter the location of the building scheme, e.g. the street where it is to be constructed.

To complete the process, you must now work through and fill out each page of the design assistant. For this, use the *Continue* and *Back* buttons at the bottom. You can also click on the symbols in the left-hand margin to jump directly to a specific page.

11.1.2 System Selection

Variant menu *Calculations › Assistant › System Selection*

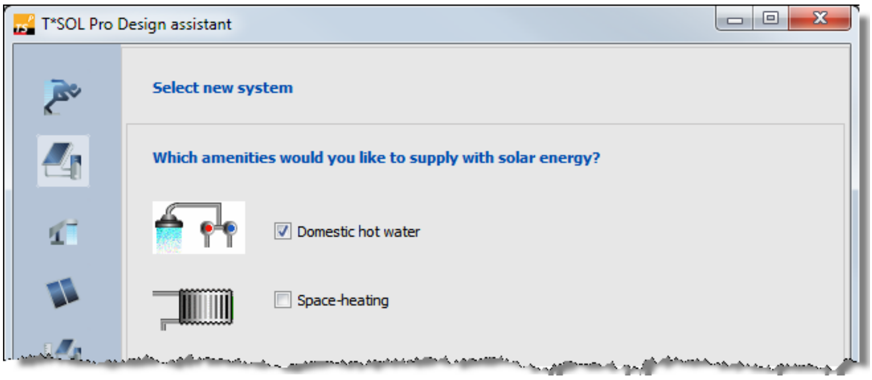


Image: System selection in the design assistant

The next two pages contain information on the system selection. This is dependent on the specific application of the system. First, enter whether the system will be used for DHW supply and/or space heating.

The space heating must therefore also be activated by clicking the checkbox. Depending on your entry, the assistant will now offer a range of systems on the next page. The range of different systems is divided into *small-scale systems*, *combination systems*, and *buffer tank systems*; a click on the respective tab reveals the available systems.

To determine the required collector surface area, the design assistant uses a reduced simulation process on an hourly basis. The use of this process is restricted to simple systems. As a result, the design assistant does not contain all the systems which can be found in the *System Selection* variant menu.

Back to our example: this requires a solar system for DHW supply and space heating in an apartment house. You select the A3 DHW system with heating buffer tank and click directly on the corresponding schematic. This selects it; now click *Continue*.

11.1.3 Define Requirements

Variant menu *Calculations › Assistant › Define Requirements › Hot Water* or *› Heating*

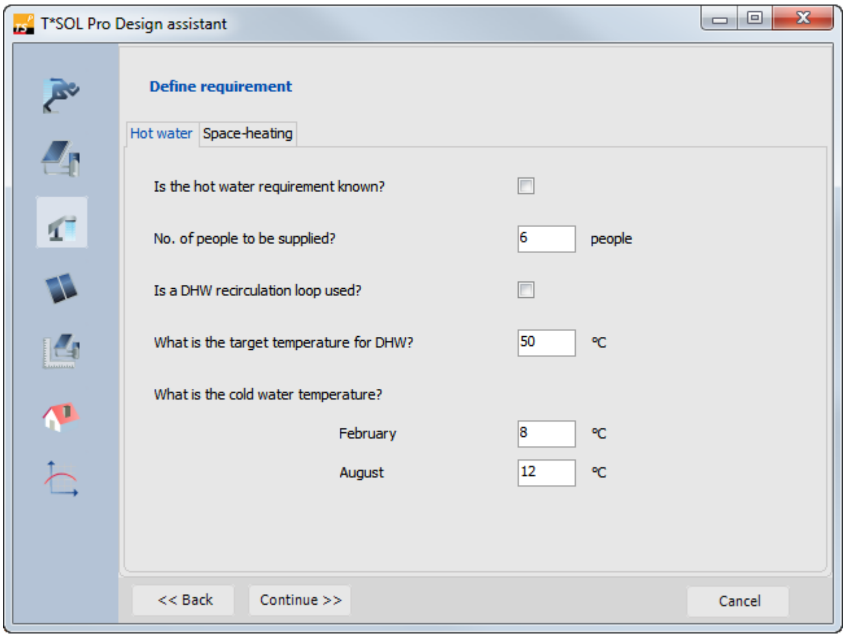


Image: Defining hot water requirement in the design assistant

Here, there are two pages to fill out: consumption of hot water and heating.

There are two possibilities for entering hot water requirements: if you know the average daily requirement, you can enter it directly by clicking on the checkbox. If you do not know it, you can enter the probable or actual number of people to be supplied. This figure is then used to calculate the absolute requirement with a predefined specific requirement. The specific requirement per person can be entered and modified in the main menu under *Options › Design Assistant*.

The DHW target temperature and cold water temperature should be entered here and can also be preset under *Options*.

Click on the *Heating* tab to access the input page for heating energy requirements.

Here, too, you can either enter the heating energy requirement (e.g. calculated in accordance with DIN 4701) or, as this value is frequently not known, have this value calculated by internal characteristic values by entering the thermal standard of the building.

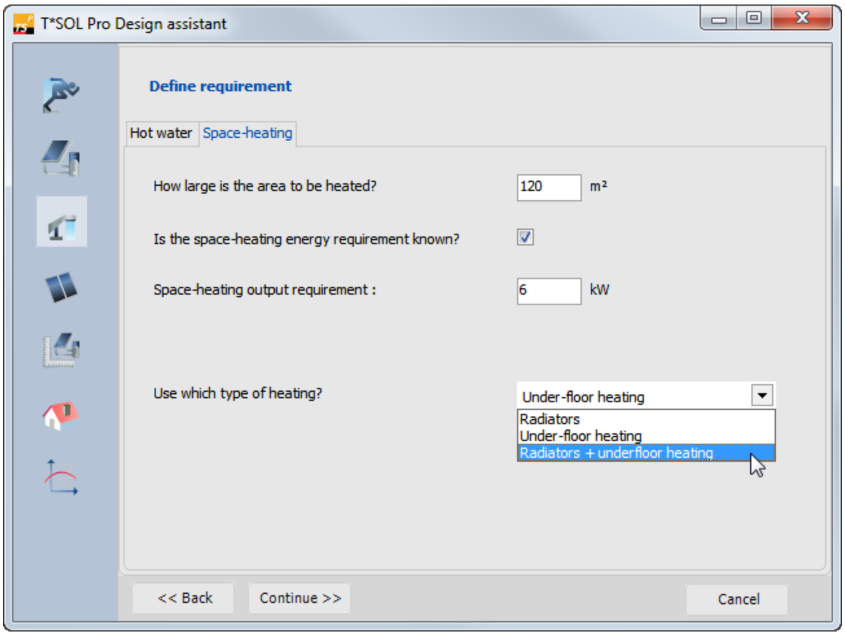


Image: Defining heating requirement in the design assistant

To determine the annual heating energy requirement, calculated for every hour of the year by T*SOL ®, entry of the standard outdoor temperature is required.

11.1.4 Set Collector Array

Variant menu *Calculations › Assistant › Set Collector Array*

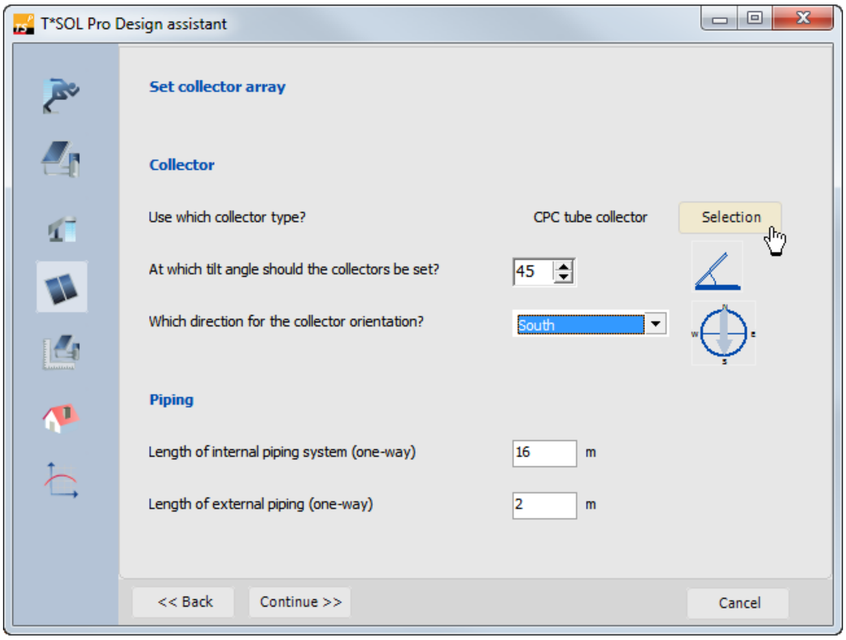


Image: Defining the collector array in the design assistant

In the design assistant, first use the standard flat-plate collector from the T*SOL ® database. In quality, this corresponds to a simple collector with a surface area of 1m². However, you can click on the collector symbol to select any collector or otherwise choose your preferred collector under *Options › Default settings*.

The tilt angle and orientation of the collector array are entered in the following fields. The entries for piping relate purely to the collector loop. The single length of the piping should be entered. This information is used to calculate thermal losses and hydraulic resistance of the piping.

11.1.5 Design Target

Variant menu *Calculations › Assistant › Design Target*

Image: Defining the design target in the design assistant

Here, enter the target of your design, i.e. the fraction of solar energy in terms of total energy consumption (DHW and heating).

11.1.6 Results

Variant menu *Calculations › Assistant › Results*

Click on the *Continue* button to first obtain a selection of tanks which the design assistant suggests for our system. You can make changes to this selection. To do so, open the *Selection* dialog.

Define an *auxiliary heating*.

A variation calculation is carried out with the three shown buffer tanks as soon as you click the *Continue* button.

Image: Graphic presentation of simulation results of the design assistant

A graph now appears on the monitor, showing the simulation results for one variation of the number of collector for the 3 different buffer tank sizes. The number of collectors with which the target of total solar fraction is reached is marked by a white o symbol.

Click on the *Design* tab to show the result as a chart.

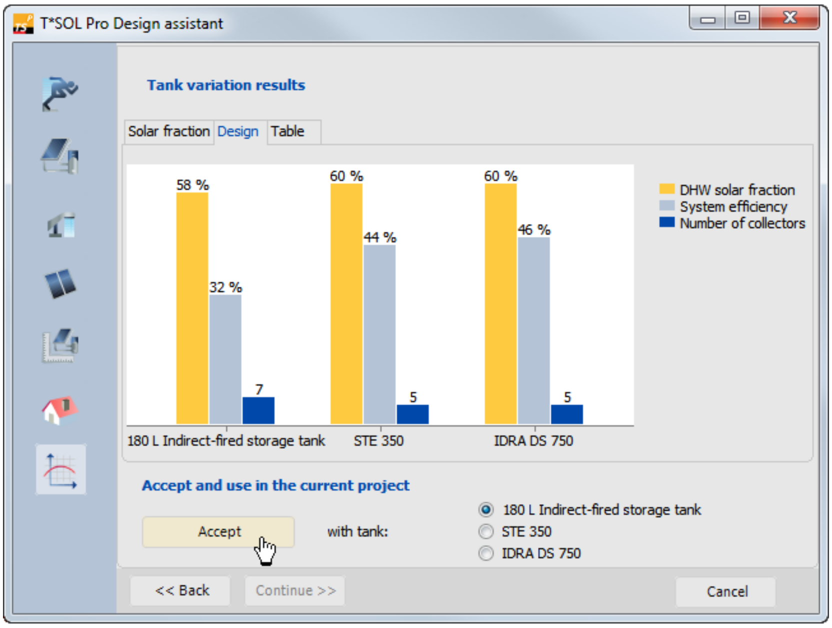


Image: Graphic presentation of simulation results of the design assistant

Alongside the solar fraction, the bar chart shows a further important value for making an assessment: the system efficiency. With a constant solar fraction, this rises with increasing tank sizes while the collector surface area falls.

Accept the parameters entered and calculated in the design assistant into the current variant. The assistant then closes and the system is displayed.

Here, you can immediately carry out a simulation by clicking on  or enter and change further parameters.

11.2 Simulation

Variant menu *Calculations › 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 Calculation Basics.

The simulation is carried out for the project's active variant.

è How to proceed:

1. Open the *Calculations › Simulation* variant menu to select the simulation period and the recording interval. Different *recording intervals* are available depending on the chosen *simulation period*.

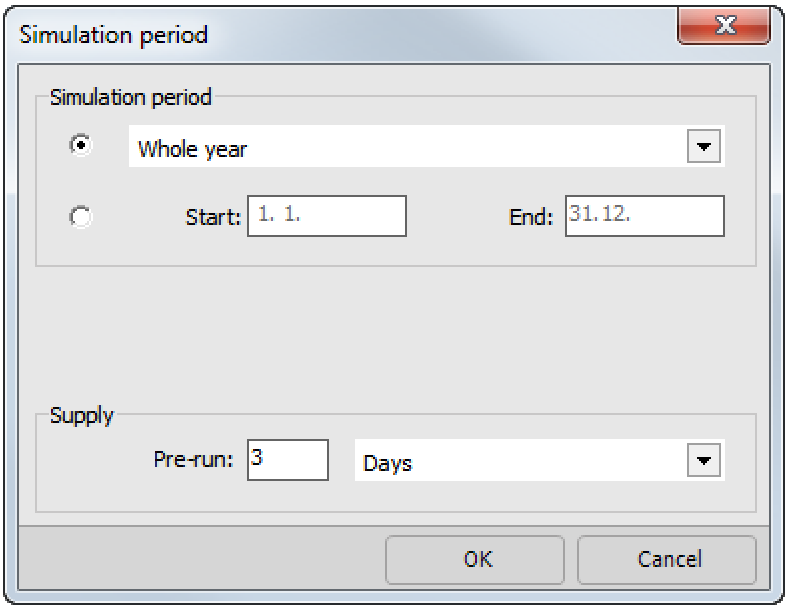


Image: Dialog for the time parameter of the simulation

2. The simulation period has a default value of 1 year. A recording interval of 1 day is sufficient for an initial calculation.
3. ! By default, the simulation is run for one year from 1/1 to 12/31. Although you can select a month or any other period less than a year, the simulation over an entire year is required for a final Financial Analysis.
4. Select a *recording interval* (hourly or daily) from which the values are to be averaged. This is dependent on the selected simulation period. A large recording interval is frequently sufficient for evaluating the simulation results. A more precise temperature profile is obtained with a recording interval of 1 hour.
5. Select a *pre-run time*. The pre-run causes the temperatures in the simulation model to even out to one operating state. A pre-run of 3 days means that the simulation starts 3 days before the first recording (January 1). A default *pre-run* of 3 days is included in a simulation, but other periods can also be set. If the simulation is to have an entire season as pre-run time to simulate seasonal effects on very large tanks, a pre-run of 1 year should be set.

The simulation results during the pre-run time are not included in the results file.

6. Start the simulation by clicking *OK*.

1. If you start the simulation via the  button, it will be immediately calculated with the currently preset values.

2. Click on the *Visualization* symbol to observe the temperature profiles in the system.

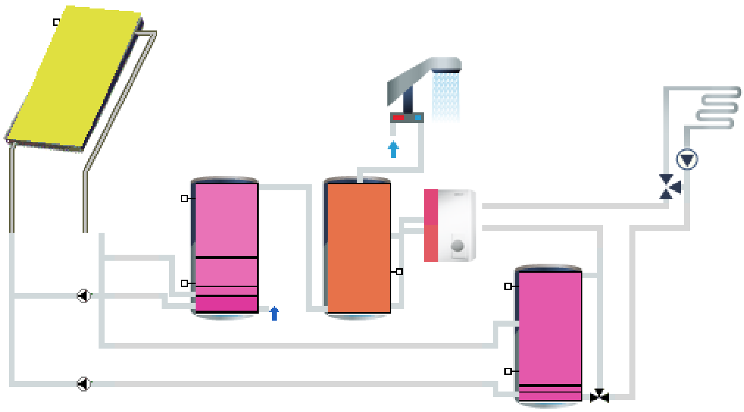


Image: Visualization: display of component temperatures during the simulation.

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

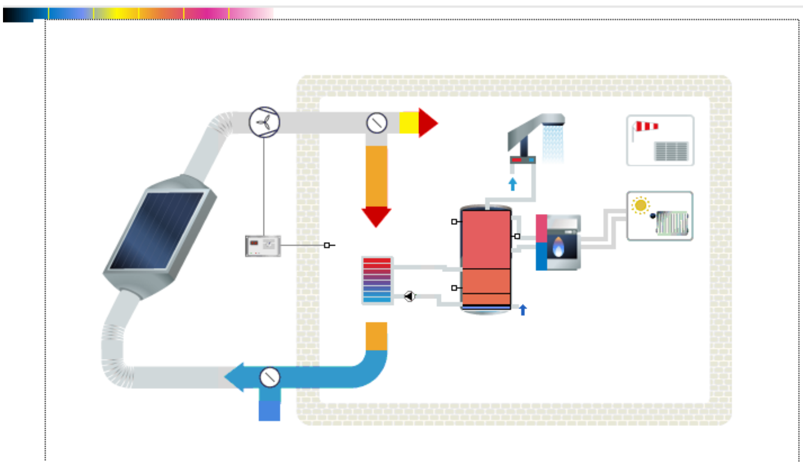


Image: Visualization: display of component temperatures during the simulation.

Example solar air heating and DHW

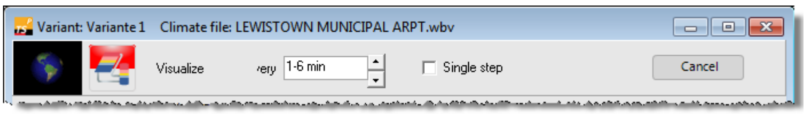


Image: Visualization: setting the simulation interval during the simulation.

3. 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.

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

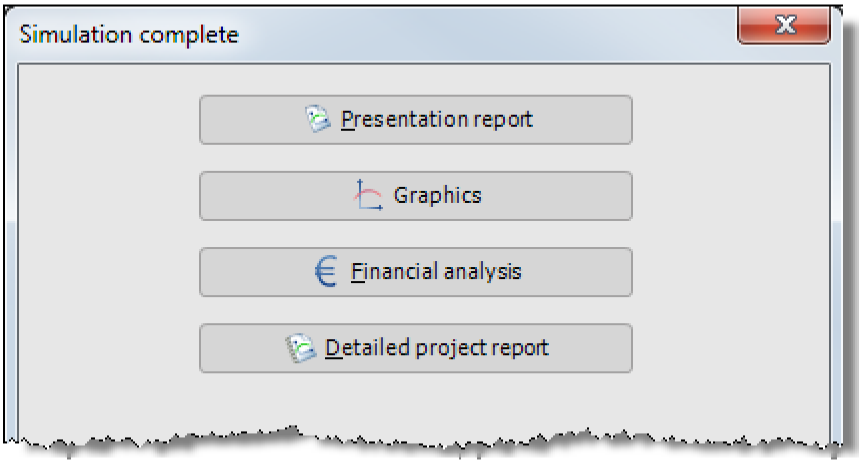


Image: Selection dialog at end of simulation

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

11.3 Financial analysis

Variant menu *Calculations* › € *Financial analysis*

Here, you can check whether investment in a solar system is viable. The common variables of the calculated investment as well as a graph are presented in the result. The yearly itemized results can be displayed in a table.

In the presentation, the most important input parameters, the graph and the results are given. This section in the presentation can be enabled and disabled in the options.

This is not a comparative financial analysis, since only the investments for a solar system are considered. Comparative systems (e.g. gas boilers) are monetarily considered through savings only.

The financial analysis is aimed at two target groups, who look at the results from different perspectives.

- Owners or system users
- Investors

Owners/users

- The owner is interested in the savings, which means the substitution of natural gas with solar energy.
- Owners have more or less a higher percentage of capital, which means that the remaining investment is relatively high.
- To make the results clear, calculations are made similar to a bank account into which the savings are paid and interest is added (reinvestment premise). After the end of the term, a balance results from which a yield can be determined (the so-called modified internal interest rate, MIRR) that a bank would have to offer if the client had not invested in a solar system, but instead had deposited the total amount in the bank.

Investors

- Investors work (mostly) with very little of their own capital and a high percentage of borrowed capital.
- The purchase of the solar system is compared with other investments. Here, known variables from finance mathematics are included (e.g. capital value, internal interest rate (IRR)).
- Purchases that are uninteresting for investors because there are more profitable investments, can still pay off for owners.

-> Requirement:

The results of a one-year simulation are required for the financial analysis.

-> How to proceed:

1. Go to *Calculations* › € *financial analysis* The *financial analysis* dialog then opens. It contains several pages:
Parameters, Investments, Renumeration, Operating costs, Savings, Financing and *Results*

2. The preset parameters are partially assumed from the dialog *options › presets › financial analysis* and can be changed for the special system.

11.3.1 Parameters

Variant menu *Calculations* › € *Financial analysis* › page *Parameters*

All entries listed here can be pre-defined in the *Options*. These are then used for new projects. Using the *Reset to Defaults* button, these settings are then reloaded.

General

The *lifespan* is the time span defined by the manufacturer, over which the system is foreseeably operational. For solar installations, a lifespan of 10 - 20 years is estimated.

The *interest* on capital is the basic interest rate for determining the capital value and the variables derived therefrom (pay-back time and initial costs of solar).

The *reinvestment return* is used under the so-called reinvestment premise. Investment surpluses (=pos. cash flows) earn interest and are compounded with this rate.

Savings are determined with the *specific fuel costs*.

To determine the operating costs, the *specific power costs* are required.

Inflation rate

With the rate of price increase for *energy usage* (= combustible fuel or electricity) and the *operating costs*, the savings and capital value are calculated.

11.3.2 Investments

Variant menu *Calculations* › € *Financial analysis* › page *Investment*

The investment reduced by grants results in the remaining investment. The residual investment is the capital, which the client must raise. Loans reduce the investment.

Investments

Here, you can enter *absolute investment* or *specific investment* in €/m^2 collector surface.

Grants

The subsidies can be entered as an *absolute grant* (e.g. in Germany: BAFA, KfW), a *specific grant* per m^2 of collector surface or as a *prorated grant* for the total investment.

11.3.3 Remuneration

Variant menu *Calculations* › Financial analysis › page *Parameters* €

Remuneration is a subsidy, which is paid per solar generated kWh.

Currently, such subsidies are given in Great Britain (http://www.ofgem.gov.uk/RHI).

Unlike grants, remuneration does not minimize the residual investments, since the are paid during the live of the investment.

Remuneration for solar generated heating

Amount
The amount paid is calculated per solar generated kWh and is adjusted yearly (see below).

Payment period
The payments begin immediately with the operation of the system and are guaranteed throughout the entire payment term.

Adjustment
This allows the inflation and degression to be viewed The later is when the reimbursements become increasingly smaller over time.

11.3.4 Financial Analysis: Running Costs

Variant menu Calculations › € *Financial Analysis* › Page *Running costs*

The operating costs increase annually with the increase factor for the operating costs.

Fixed 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.

Operating costs of auxiliary energy:

The running costs of the pumps are results of the running time, pump output, and electricity costs calculated by the simulation.

11.3.5 Financial Analysis: Savings

Variant menu Calculations › € *Financial Analysis* › Page *Savings*

Fuel

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

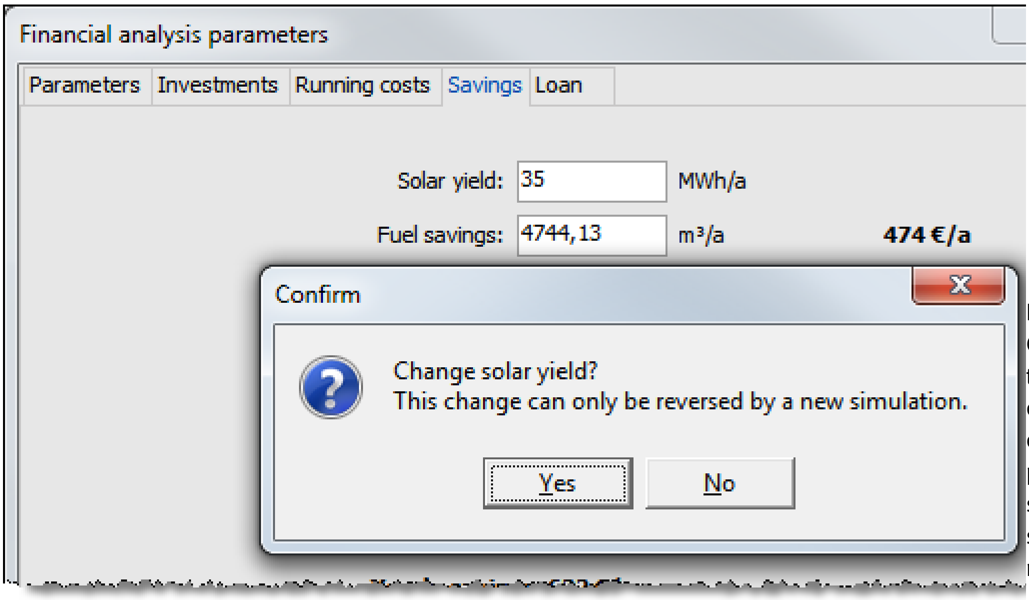


Image: Changing the economic efficiency parameters from the simulation

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

The other parameters are simulation results. 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.

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

11.3.6 Financial Analysis: Loans

Variant menu Calculations › € *Financial Analysis* › Page *Loans*

Up to three loans can be defined.

Description

Loan capital
The amount of the loan taken out in €.
(You can enter a grant on the page *Investments*.)

Term
Period of time agreed for paying back the loan.

Grace period

The period in which the loan may be paid without accruing further interest or penalty.

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 paid back within the term (after the grace period).

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.

Present value of loan (Cash Value) [€]

11.3.7 Results

Variant menu *Calculations* › € *Financial analysis* › page *Results*

Financial analysis

The *initial costs for solar* (also called heating cost) is calculated with the equation

```
Solar production costs  = total annuity/ yearly solar yield
```

Another way goes through the capital value. If the solar yield is multiplied by the heating costs and included in the capital value in addition to the combustible fuel costs, a capital value of null is generated.

The *remaining investment* is calculated as

```
remaining investment = total investment - grants - loans
```

and therewith corresponds to what is known as the deductible or private capital, which must be provided by the investor or client.

The *capital return time* is reached when the accumulated cashflows have reached the remaining investment.

The *amortization period* is the assumed lifespan at which the capital value will reach null. If the capital value is negative, the pay-back time is longer than the assessment period.

The following applies: *Remaining investment payback time › Capital return time* › *Amortization period*

Profitability

The *Return on assets* is determined with the equation

```
Return on assets = return on capital / (total investment -
grants)
```

The *Return on equity* results from the equation

```
Return on equity  = return on capital / remaining  investment.
```

The *internal interest rate* (IRR) is the interest on capital, by which the capital value is null. With a negative internal interest rate, no positive capital value is reached. In this case, payment of the internal interest is waived. The higher the internal interest rate, the more profitable the investment. The internal interest further implies how high the loan interest can be, so that payments minimally finance the loan. An important advantage of the internal interest as a return is that it does not depend on the capital interest.

The *capital value* is the total cash value, which means all discounted payments over the live of the investment. Even if the capital value is negative, the investment can be profitable for the owner/user when the return on the investment is (MIRR) positive.

Reinvestment premise

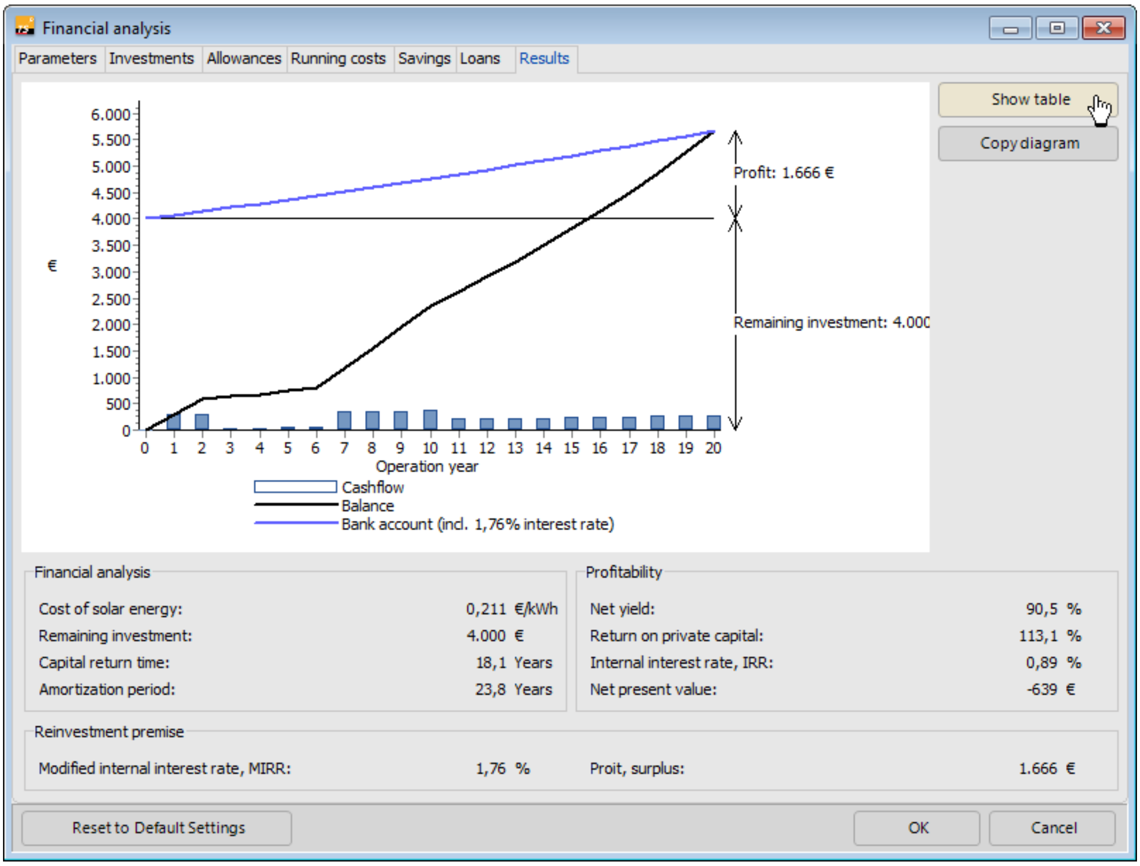
The modified internal interest (MIRR) is a return, which the bank account must reach if the remaining investment is deposited in a bank account that will reach the end balance. As an owner/user, one can see this as follows. If the bank pays an interest rate (reinvestment interest, RI) that is less than the internal interest rate, the investment than earns a higher end balance. The interest rate, which the bank then must pay to reach the balance is described as a modified interest rate (MIRR):

- The IRR is therewith, a limit. If the IR is below the IRR, the investment in a solar system is more profitable. The following applies: `RI < IRR`
- The MIRR is the return that the solar system achieves. For an economic investment `RI < MIRR` must apply.
- As a result, the following inequality must apply: `RI < MIRR <= IRR`

For the investor and owner/user, the following, different limits are apply:

- The investor compares the alternatives, therefore `RI < IRR` must apply.
- For the owner/saver however, MIRR is more important, since it produces the following return: `RI < MIRR`
  Therefore with `IRR < RI < MIRR`, the investment in a solar system is also interesting. Also here, if the capital value is negative, the solar system earns a higher yield than the virtual bank account.

Example



In this example, see the following effects:

- The system should run for 20 years.
- At the end of the lifespan, a bank account with the same end balance would have earned a return of 1.76% (= MIRR).

- The loan is repaid in the operating years 3 to 6 and could results in a very small or negative cash flow during these years. The loan has two payment-free grace periods. The balance itself cannot be negative, since the repayment must be generated from the savings already earned. If this is not the case, additional capital is required. However, a small loan is therefore taken out at the beginning.
- In this example, the remuneration ends after 10 years, which can be seen by the dip in the balance and the low cashflows.
- *Remaining investment payback time* = 15,8 years, *Capital return time* = 18,1 years, *Amortization period* = 23,8 years
- This investment is not advantageous for the investor, as the return (1.76%) is below the assumed capital interest (here 2.5%). The capital value is therefore negative and the pay-back time is longer the the lifespan.
- For users/owners, the investment is still of interesting since they get hot water and a return; however small.

Table

Wirtschaftlichkeitsberechnung

Jahr	Betrieb	Fremdkapital	Einsparungen	Vergütungen	**Cashflow**	**Saldo**	**Bankkonto**
	(1)	(2)	(3)	(4)	**(3)+(4)-(1)-(2)**		
0							3.500 €
1	100 €	0 €	200 €	159 €	**258 €**	**258 €**	3.548 €
2	101 €	0 €	206 €	162 €	**266 €**	**531 €**	3.597 €
3	103 €	282 €	212 €	165 €	**-8 €**	**536 €**	3.646 €
4	105 €	282 €	218 €	169 €	**0 €**	**549 €**	3.696 €
5	106 €	282 €	225 €	172 €	**8 €**	**571 €**	3.746 €
6	108 €	282 €	231 €	175 €	**17 €**	**602 €**	3.798 €
7	109 €	0 €	238 €	179 €	**308 €**	**925 €**	3.850 €
8	111 €	0 €	245 €	182 €	**317 €**	**1.265 €**	3.903 €
9	113 €	0 €	253 €	186 €	**326 €**	**1.623 €**	3.956 €
10	114 €	0 €	260 €	190 €	**336 €**	**1.999 €**	4.010 €
11	116 €	0 €	268 €	0 €	**152 €**	**2.201 €**	4.065 €
12	118 €	0 €	276 €	0 €	**158 €**	**2.415 €**	4.121 €
13	120 €	0 €	284 €	0 €	**165 €**	**2.640 €**	4.177 €
14	121 €	0 €	293 €	0 €	**172 €**	**2.878 €**	4.235 €
15	123 €	0 €	302 €	0 €	**179 €**	**3.128 €**	4.293 €
16	125 €	0 €	311 €	0 €	**186 €**	**3.392 €**	4.351 €
17	127 €	0 €	320 €	0 €	**193 €**	**3.670 €**	4.411 €
18	129 €	0 €	330 €	0 €	**201 €**	**3.963 €**	4.472 €
19	131 €	0 €	340 €	0 €	**209 €**	**4.271 €**	4.533 €
20	133 €	0 €	350 €	0 €	**217 €**	**4.595 €**	4.595 €
Summe	2.312 €	1.128 €	5.361 €	1.739 €	**3.659 €**		

Tabelle kopieren   Schließen

In the table, the annual values are listed that form the basis for further calculations.

- The *operating costs* increase with the rate of the price increase are listed n the table.
- Repayment and interest are listed in the column *Loan capital*.
- The *Savings* are determined with the special combustible fuel costs.

- *Remuneration* refers to the subsidies for solar generated heat.
- *Cashflow* is the (non-discounted) sum of columns (1) to (4), whereby the operating and loan capital costs reduce the cashflow. The sum of all cashflows (see total line) is described as a return on capital and goes into the return on equity and loan capital yield.
- If the yearly surpluses (cashflows) are invested with the reinvestment interest rate, the outcome is the indicated *balances*.
- The column *Bank account* shows that the remaining investment was alternatively deposited in an account. The achieved yield corresponds to the calculated modified internal interest rate (MIRR).

11.4 EnEV - German Energy Conservation Regulations

Variant Menu *Calculations* › *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

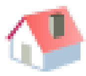
- a standard method of calculation as per DIN-V 18599 with standard parameters,
- a standard method of calculation as per DIN-V 18599 with planning values of the selected system, and
- an annual simulation in T*SOL.

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

➔How to proceed:

1. Go to the *Calculations › EnEV* variant menu.

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



Building parameters

Variant Menu *Calculations* › *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

Variant Menu *Calculations* › *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

Variant Menu *Calculations* › *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 11.5.1 Details on Heating Requirements

Parameters

Variant Menu *Calculations* › *EnEV* › *Parameters*

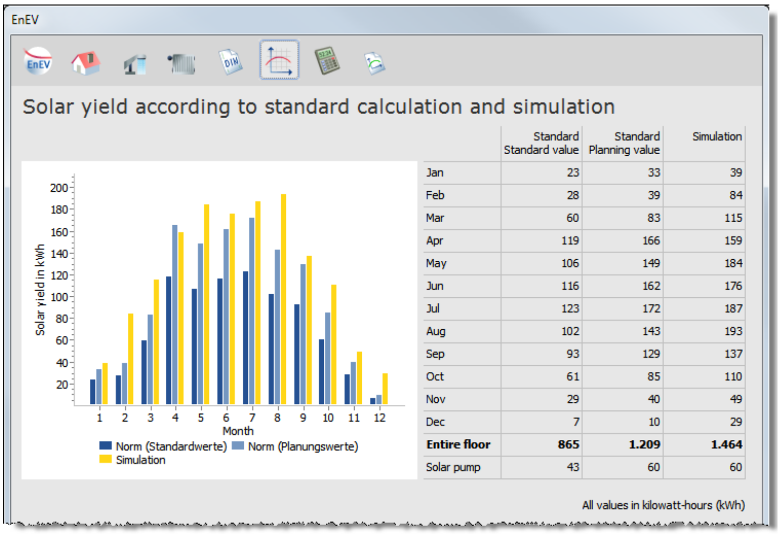
9. Move to the next dialog, Parameters, or directly to the simulation.
10. The overview lists the *Parameters of the solar system for the standard calculation as per DIN V 18599* for your information. From this, it can be seen whether the calculation in accordance with DIN V 18599 is made with DHW or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

Variant Menu *Calculations* › *EnEV* › *Simulation*

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



	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

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

Variant Menu *Calculations > EnEV > Project Report*

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

This completes the EnEV calculation.

11.4.1 Heating requirement details

Variant Menu *Calculations > 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

12 Results

Variant menu *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.

12.1 Project Report

Variant menu *Results › Project Report*.

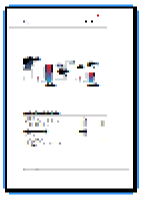
There is for each project variant a short presentation (formerly quick report) and a technical documentation (formerly detailed project report).

12.1.1 Project Report: Presentation

Variant menu *Results › Project Report › Presentation*

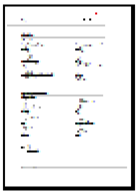
The presentation contains the system schematic, the input data, and the simulation results. You can print this summary from the page view.

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.



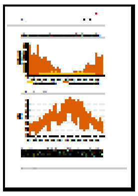
At the top of the first page features the system schematic:

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:

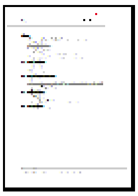
- Irradiation onto the collector surface area (absolute and per m^2),
- Energy from the collectors, energy from the collector loop (absolute and per m^2),
- Energy supply, solar energy for DHW – both space heating parameters for systems with space heating –,



- Auxiliary heating energy,
- Fuel savings, CO_2 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 › Variant*, the calculation of pollutants is reported for this system.

On the second page, the parameters for location, DHW, and space heating are listed.



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

The third page shows a graph of the solar energy fraction of total consumption as well as the maximum daily temperatures in the collector.

The presentation features an energy balance flow diagram: a Sankey Diagram.

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 is required to view PDF files. This is available on the T*SOL installation CD or at the website http://www.adobe.com.

12.1.2 Project Report: Documentation

Variant menu *Results › Project Report › Documentation*

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

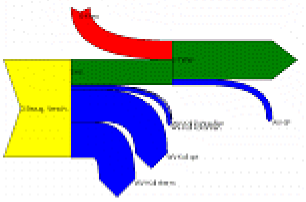
For a complete overview over the system, you need both: presentation and documentation.

-> See also:

Options › Default settings › Project Report

Sankey Diagram

Menu *Results › 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.

12.2 Graphics

Menu *Results › Graphics*

You can use the graphics output to display graphs of all the values calculated in the program.

The climate profile over time, the nominal output of the solar system for consumption, and the evaluation parameters such as fraction and efficiency can be displayed at any point of the simulated period with a resolution in hourly, daily, or monthly values.

A graphics window with its own menu appears. You can also open several graphics windows and arrange them as you like on the screen.

12.2.1 Select Display Results

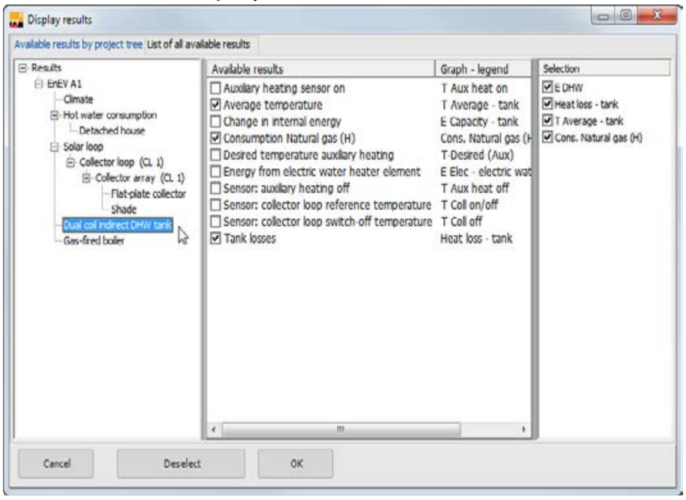


Image: Selection of simulation results for graphics display

You can select up to eight parameters to be displayed in a graphic by clicking on them.

This selection is saved to the Projekt.ini file automatically and it thus can be reused anytime.

-> See also:

- Graphics Output Interface
- Format Curves
- Format Y-axis
- Format X-axis
- Print Graphics
- Graphics in Tabular Form
- Graphics Output Speed Buttons

12.2.2 Interface of the Graphics Window

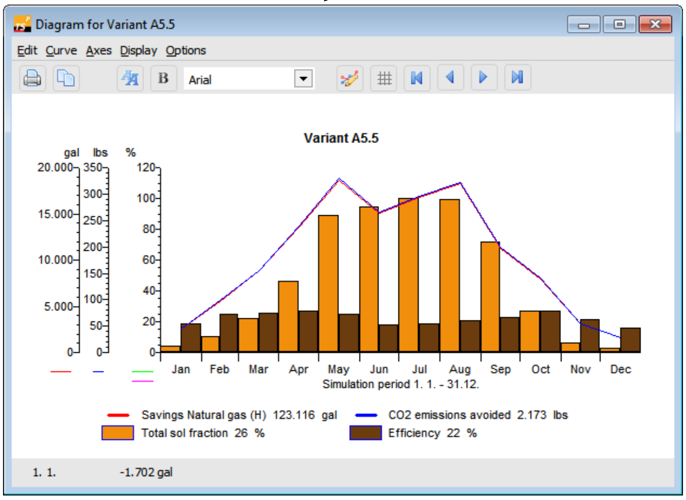


Image 12.4.2: Graphic representation of simulation results

The graphics have their own menu, a toolbar, and various context menus which can be accessed by clicking the right mouse button. The symbols and the context menus are dependent on the selected object. Objects are the separate curves, the two axes, and the legend and title bar.

You can change the graphics display to suit your needs. A detailed description can be found in the following chapters.

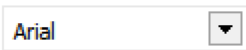
A number of formatting features for the selected part of the graphics output (data record, axes) can be quickly modified with the help of the graphic symbols:

Graphics toolbar

Click on the red arrow symbol to display the next or preceding time period (only if the display interval is smaller than a year).

Increases and reduces the type size of the selected object (axes, title, legend).

Toggles between normal and bold type for the selected object (axes, curve, title, legend).



Change font for all objects.

The selected curve toggles between line and bar display.

The draw area is rastered in accordance with the selected axis.

The values can be copied into other programs via the clipboard and, for example, edited in Excel.

Send graphic to printer.

12.2.3 Display Period

Graphics menu *Display*

Under Display, you can use Time Axes to define the period to be displayed over the time axis. You can choose from day, week, month, and year. A display of other periods (for example two months) can be selected under Axes / Format X-Axis.

12.2.4 Options

Graphics menu *Options*

Legend: here, you can choose whether or not to display the legend.

- Title: here, you can choose whether or not to display the diagram title.

12.2.5 Graphics: Print

The usual Windows Printer Settings dialog appears. Here, you can select a printer and its settings.

12.2.5.1 Title

Graphics menu *Curves* › Title or context menu

If you click the rectangular border in the graphics area, a dialog window opens in which you can give the graph a new title. After closing the dialog window, this title is displayed in the graphics output. Using the mouse, you can now move the title to any position within the graph area.

12.2.5.2 Curves

Graphics menu *Curves* or context menu

In the *Curves* graphics menu, all selected data records are listed and can be formatted. The currently selected formatting is marked with a check by the menu item.

The individually displayed data records and the Y- and X-axes can also be selected in the graph by simply clicking the left mouse button on them. The selection is made clear by dots on the graph. With curves and the X-axis, you must alway click below the line to select, with the Y-axis left of the axis!

If several Y-axes are displayed, the curve color of the curve it represents is shown below each Y-axis, making coordination simpler.

Double-click on the X- and Y-axis to open the Format X-Axis and Format Y-Axis dialogs.

A click with the right mouse button opens a context menu for the axes and curves with menu items for the current object.

The scaling of the axes and the position of the coordinates can be freely changed. Display interval of 1 day to 1 year. All axes and axis designations can be formatted and moved.

Own Y-axis: Allocate a further Y-axis for the selected data record. A dialog for scaling the new axis opens.

By selecting the relevant options, the curve can be presented in *bold* or *normal* type, as a *line* or *bars*.

Use *Change Color* to give the curve a different color.

Invisible: By selecting this, the selected curve is not drawn. The curve is not deleted but can be made visible again by selecting this option once more. At least one curve must be visible at all times.

You can also access this submenu by selecting the desired curve and clicking the right mouse button or via the symbol buttons.

12.2.5.3 X-Axis

12.2.5.4 Y-Axis

12.2.5.5 Legend

Graphics menu *Curves › Legend* or context menu

All the displayed data records are assigned to their respective representation in the legend.

If energy is displayed, the sum of energy in the presented period of time is shown after the respective data record name.

If power, temperatures, wind speed, and evaluation parameters (fraction, efficiency) are displayed, the average values are shown in the presented period.

The legend field can be selected and moved.

12.2.5.6 Coordinates field

The bottom bar of the graphics output contains a field with the current coordinates when the cursor is within the diagram. The date and time as well as the associated X-value of the cursor position are displayed.

12.2.5.7 X-Axis

Graphics menu *Axes › X-Axis* or context menu

The period of time to be displayed on a diagram and over which the values of the data record should be totaled or averaged is defined in this dialog window.

Different dialogs appear here depending on whether the graph shows a representation over time or not.

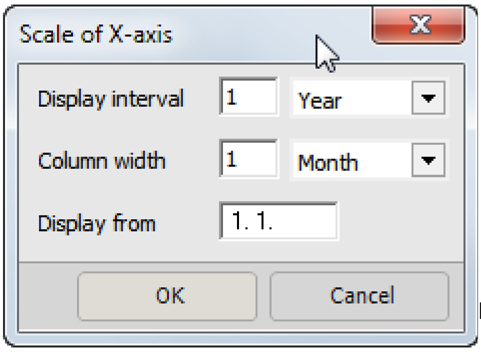


Image 12.4.4: Scaling the X-axis (daily display)

- Column width: The display period for which the data is to be summarized is defined under column width. Depending on the unit you have chosen, the values of the data record are either totaled (energy) or averaged (output, temperatures) here.
- Display from: This is where the time point in the year at which the display of data records should begin (in date format) is entered.
- Display interval: The period of time over which the graph should be displayed is defined under Display Interval. In addition to the time interval, with the choice of day, week, month, and year, the rate and designation of the main interval of the X-axis is also set.

12.2.5.8 Y-Axis

Graphics menu *Axes › Y-Axis* or context menu

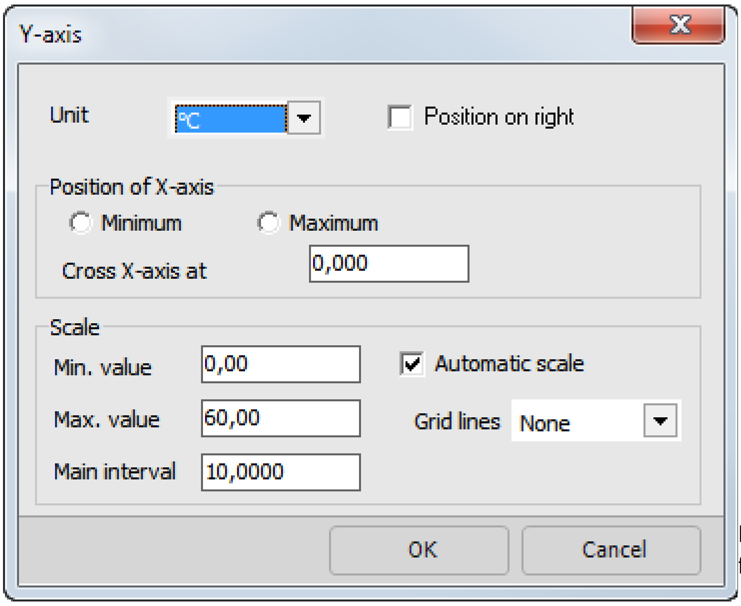


Image 12.4.3: Input field for formatting Y-axis

Access the dialogs for scaling the axes via the *Axes* graphics menu, by double-clicking the axis, or via the *Scaling* menu which can be opened with the right mouse button when the axis is selected.

The selected Y-axis is formatted in this dialog window.

Unit: here, select the unit in which the Y-axis and its associated curves are to be displayed. If you select the *Position on Right* box, the Y-axis is positioned on the right-hand side of the diagram.

Position of X-axis: this is where you define the intersection point of the X-axis and Y-axis. If you select *Minimum*, the X-axis is drawn at the bottom edge of the Y-axis. On the other hand, if you select *Maximum*, the X-axis is drawn at the top of the Y-axis. If you want to freely define the position of the X-axis, enter the desired Y-value in the *Cross X-Axis At* field.

Scaling automatic: if this field is selected, the axis is scaled independently of the entries below using the minimum and maximum values of the Y-axis curves. If the X-axis display interval is changed, the scaling is updated.

If the following scaling values are modified, automatic scaling is immediately deactivated. If this is the case, the entered scaling applies to all display intervals of the X-axis. This is especially useful for quick comparison of different display intervals.

Min. Value: the minimum value to be displayed is entered in the currently selected unit.

Max. Value: the maximum value to be displayed is entered in the currently selected unit.

Main Interval: definition of the labeled intervals. The interval is entered in the currently selected unit.

Sub-Interval: definition of subdivision of main intervals. The interval is entered in the currently selected unit.

Grid Lines: dotted or continuous lines are drawn at the level of the main interval.

12.2.6 Results in Tabular Form

Graphics menu *Table*

The curves can also be displayed as a table and then saved as ASCII files for possible evaluation of the data in external programs.

The recording steps and intervals are carried over from the curve display. If you want to change them, open *Axes › X-Axis* in the Graphics menu. You can also vary just the recording interval more quickly via the *Display* graphics menu.

Return to the curve display using the *Graphics* menu.

The number of decimal places is defined by the main interval of the Y-axis. To change the main interval, you must first return to the curve display (via the *Graphics* menu) and there open the *Axes › Y-Axis* menu. You can change the main interval or the unit and then return to the table.

You can copy the values to the clipboard by clicking *Edit › Copy* and from there into spreadsheets such as Excel.

12.2.7 Graphics: Printing

The usual Windows *Printer Settings* dialog appears. Here, you can select a printer and its settings.

13 Options

Menu *Options*

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.

13.1 Financial analysis

Menu *Options › Financial analysis*

In the *Options* dialog, on the *Financial analysis* page, you define the default settings for the financial analysis valid for all projects.

In the variant menu dialog *Calculations › Financial analysis*, you can adjust these values for the current variant.

General

- Life span
- Interest on capital
- Reinvestment return
- specific electricity costs

Cost Escalation Rate

- for energy and running costs

Investment and Subsidy

- spec. investments
- spec. subsidy

Allowance for solar heat

- Amount
- Payout duration
- Adjustment
- your own text
- Show in report
- free text

You may dismiss your entries by using "*Reset to Defaults*" or instead, save your entries as default.

13.2 Project Report

Menu *Options › 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 Pro 5.5 – 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.

13.3 Climate Data Record

Menu *Options › Climate Data Record*

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

13.4 Units

Menu *Options › Units*

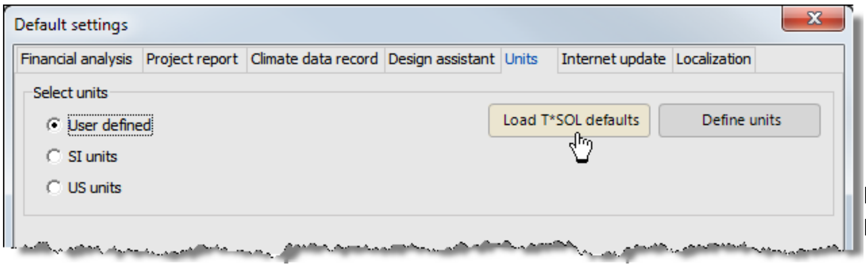


Image:
Dialog *Options › Units*

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

-> 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.

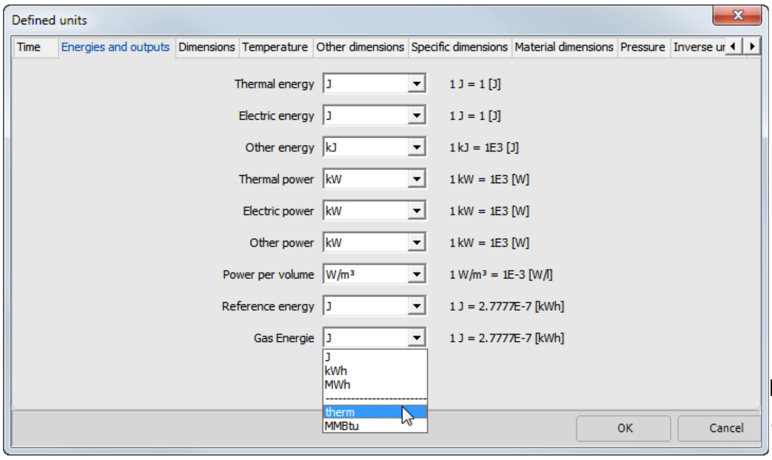


Image: Dialog *Options › Units › Defined units*

- 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 Pro 5.5\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
	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

13.5 Software Updates via Internet

Menu *Options › 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.

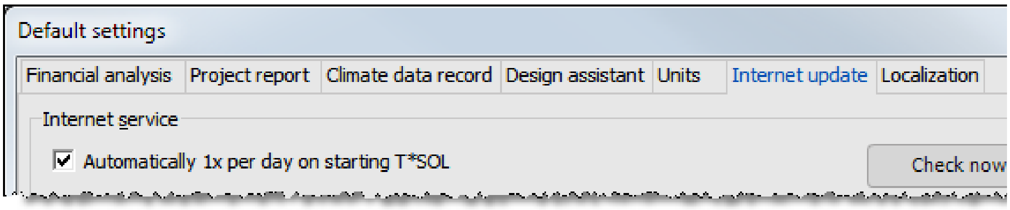


Image: window: Internet update preferences

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

-> 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 ...* .
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.

13.6 Localization

Menu *Options › 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 components 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 Variant* › Savings.
- *Display assistant:* The design assistant is helpful if you are not particularly acquainted with designing solar systems.
- You can also specify whether the efficiency of the auxiliary heating and the reference system should be related to the *higher heating value Hs* or *lower heating value Hi* for all new projects.
  If you want to change this setting in the current variant, please use the *System Definition > Variant > Savings* dialog.

13.7 Design Assistant

Menu *Options › Design Assistant*

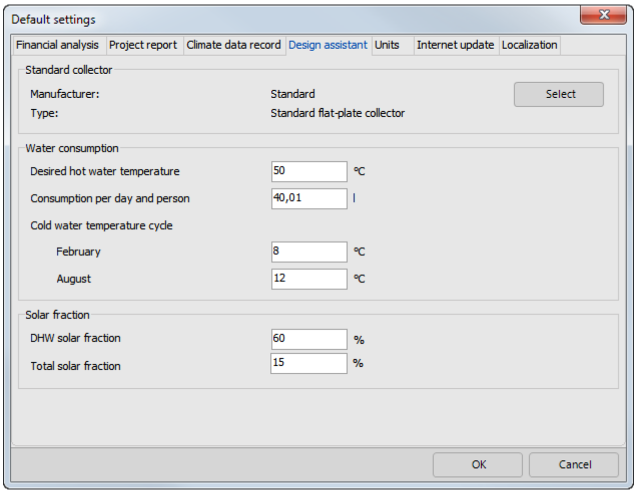


Image: Dialog *Options › Design Assistant*

14 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

In addition, under *Options › Site Data › Project Report › Language*, you can set the language for the project reports in the following other languages:

- Polish
- Portuguese
- Romanian
- Slovak
- Slovenian
- Czech
- Hungarian

15 Windows Menu

Here, you determine whether the current project's open variants and graphics should be displayed as *All Visible* or *Overlapping*.

	The windows are displayed side by side.
	The windows are displayed overlapping.

As is usual under Windows, the currently active variant can be identified by the darker color of its window's headline.

The buttons in this headline also function in the normal Windows way. You can click the variant names in the *Window* menu to switch between them.

16 Help Menu

Menu *Help*

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

- Click *Quick Guide* to open an abridged version of the manual (16 pages .pdf file).
- 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.
o	*Onlineshop*	http://www.valentin.de: Online Shop › Solar Thermal	http://valentin-software.com › Solar Thermal
o	*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
o	*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. **-> see also:** Registering the Program

17 Appendix

17.1 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

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17.1.1 Literature in German

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

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

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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

17.2 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 CO_2 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) → CO_2 emissions

Capital value **V_o**

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

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

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.

CO_2 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/m²)
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 m² 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 **V̇ Flow [l/h] [l/m²h]**

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.

17.3 Proportionate energy savings

In systems for hot drinking water supply with and without backup heating, the proportionate energy savings as per DIN CEN/TS 12977-2 are output in the project report.

Proportionate energy savings = $(Q_{conv} - Q_{aux}) / Q_{conv}$

Q_{conv} is the energy expenditure of a comparable conventional system. (formulation in the standard: "gross energy requirement of reference system"

Q_{aux} is the conventional energy expenditure of the simulated solar system, i.e. the energy which the auxiliary heating supplies to the system. This is described in the standard as follows: "Q_{aux} is the gross additional energy requirement of the solar heating system to cover heating requirements." Here, the same boiler efficiency as in the conventional system is assumed.

In calculating Q_{conv}, recirculation losses are taken into account. Because recirculation is taken into account in the simulation (*Parameters › Hot Water Consumption › DHW recirculation loop used*, Q_{aux} is larger, because the auxiliary heating supplies the system with more energy than would be the case without recirculation.

The proportionate energy savings are equal to 1 or 100% when the additional energy requirement Q_{aux} is equal to 0. In this case, all energy was supplied by the solar system, auxiliary heating was operational at no time.

The proportionate energy savings are negative when the additional energy requirement Q_{aux} is larger than Q_{conv}.

The following also applies:

1. $Q_{conv} = \eta_{conv} * Q_{conv.net}$
2. η_{conv} = efficiency of the comparable system

   $Q_{conv.net}$ = net energy requirement in [Wh]

1. $Q_{conv.net} = Q_H + Q_{hw} + Q_{tank.conv}$
2. Q_H = energy requirement for heating
3. Q_{hw} = energy requirement for hot water
4. $Q_{tank.conv}$ = energy requirement for the tank = 0,16 * √tank volume * ΔT * operating hours

   The temperature difference ΔT is calculated by the difference between the tank temperature and the ambient temperature of the tank. It is typically 30 K.

17.4 ITW System Layouts

17.4.1 ITW System Layout - Broetje

Manufacturer: Broetje GmbH

Test report no.: : 04STO98 und 03CTR08

This solar system with combination storage tank for hot water and space heating is labelled an ITW system layout. This means that this combination storage tank and, where available, its controller have been measured and tested by the Institute for Thermodynamics and Heat Engineering (ITW) at the University of Stuttgart.

In the T*SOL mathematical model, the system parameters have been adjusted by parameter identifications such that the simulation results agree with the measurements.

The adjusted parameters in this system are therefore fixed and not changeable. In this system, this concerns the entire storage tank, the control parameters of the collector array, and the performance controller of the collector loop pump.

As a result of testing by the ITW and the subsequent validation procedure for the simulation, this system holds the status of a "tested company system".

Find more information on the selection of systems under System Selection.

17.4.2 ITW System Layout - Buderus

Manufacturer: BBT Thermotechnik (Buderus)

Test report no.: 04STO96 und 04CTR15

This solar system with combination storage tank for hot water and space heating is labelled an ITW system layout. This means that this combination storage tank and, where available, its controller have been measured and tested by the Institute for Thermodynamics and Heat Engineering (ITW) at the University of Stuttgart.

In the T*SOL mathematical model, the system parameters have been adjusted by parameter identifications such that the simulation results agree with the measurements.

The adjusted parameters in this system are therefore fixed and not changeable. In this system, this concerns the entire storage tank, the control parameters of the collector array, and the performance controller of the collector loop pump.

As a result of testing by the ITW and the subsequent validation procedure for the simulation, this system holds the status of a "tested company system".

Find more information on the selection of systems under System Selection.

17.4.3 ITW System Layout- Feuron

Manufacturer: Feuron GmbH

Test report no.: 03STO94

This solar system with combination storage tank for hot water and space heating is labelled an ITW system layout. This means that this combination storage tank and, where available, its controller have been measured and tested by the Institute for Thermodynamics and Heat Engineering (ITW) at the University of Stuttgart.

In the T*SOL mathematical model, the system parameters have been adjusted by parameter identifications such that the simulation results agree with the measurements.

The adjusted parameters in this system are therefore fixed and not changeable. In this system, this concerns the entire storage tank, the control parameters of the collector array, and the performance controller of the collector loop pump.

As a result of testing by the ITW and the subsequent validation procedure for the simulation, this system holds the status of a "tested company system".

Find more information on the selection of systems under System Selection.

17.4.4 ITW System Layout - Ratiotherm

Manufacturer: Ratiotherm GmbH

Test report no.: 03STO91

This solar system with combination storage tank for hot water and space heating is labelled an ITW system layout. This means that this combination storage tank and, where available, its controller have been measured and tested by the Institute for Thermodynamics and Heat Engineering (ITW) at the University of Stuttgart.

In the T*SOL mathematical model, the system parameters have been adjusted by parameter identifications such that the simulation results agree with the measurements.

The adjusted parameters in this system are therefore fixed and not changeable. In this system, this concerns the entire storage tank, the control parameters of the collector array, and the performance controller of the collector loop pump.

As a result of testing by the ITW and the subsequent validation procedure for the simulation, this system holds the status of a "tested company system".

Find more information on the selection of systems under System Selection.

17.4.5 ITW System Layout - Teufel und Schwarz

Manufacturer: Teufel und Schwarz GmbH

Test report no.: 02STO83, 02CTR07 und 03CTR09

This solar system with combination storage tank for hot water and space heating is labelled an ITW system layout. This means that this combination storage tank and, where available, its controller have been measured and tested by the Institute for Thermodynamics and Heat Engineering (ITW) at the University of Stuttgart.

In the T*SOL mathematical model, the system parameters have been adjusted by parameter identifications such that the simulation results agree with the measurements.

The adjusted parameters in this system are therefore fixed and not changeable. In this system, this concerns the entire storage tank, the control parameters of the collector array, and the performance controller of the collector loop pump.

As a result of testing by the ITW and the subsequent validation procedure for the simulation, this system holds the status of a "tested company system".

Find more information on the selection of systems under System Selection.

17.4.6 ITW System Layout - Wagner

Herstellers: Wagner Co GmbH

Test report no.: 03 STO88 und 03CTR11

This solar system with combination storage tank for hot water and space heating is labelled an ITW system layout. This means that this combination storage tank and, where available, its controller have been measured and tested by the Institute for Thermodynamics and Heat Engineering (ITW) at the University of Stuttgart.

In the T*SOL mathematical model, the system parameters have been adjusted by parameter identifications such that the simulation results agree with the measurements.

The adjusted parameters in this system are therefore fixed and not changeable. In this system, this concerns the entire storage tank, the control parameters of the collector array, and the performance controller of the collector loop pump.

As a result of testing by the ITW and the subsequent validation procedure for the simulation, this system holds the status of a "tested company system".

Find more information on the selection of systems under System Selection.

17.4.7 ITW System Layout - Weisshaupt

Manufacturer: Max Weishaupt GmbH - Max Weishaupt Str. 14 88475 Schwendi

Test report no.: 04STO97 of 30.1.2004

This solar system with combination storage tank for hot water and space heating is labelled an ITW system layout. This means that this combination storage tank and, where available, its controller have been measured and tested by the Institute for Thermodynamics and Heat Engineering (ITW) at the University of Stuttgart.

In the T*SOL mathematical model, the system parameters have been adjusted by parameter identifications such that the simulation results agree with the measurements.

The adjusted parameters in this system are therefore fixed and not changeable. In this system, this concerns the entire storage tank, the control parameters of the collector array, and the performance controller of the collector loop pump.

As a result of testing by the ITW and the subsequent validation procedure for the simulation, this system holds the status of a "tested company system".

Find more information on the selection of systems under System Selection.

17.5 Company Systems

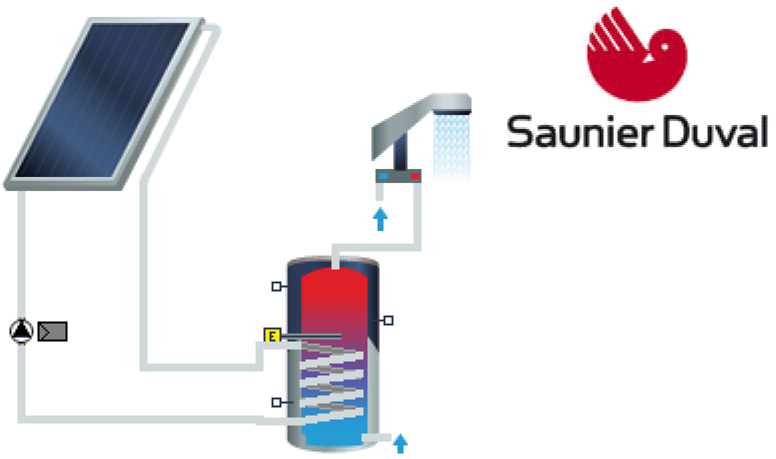
17.5.1 Saunier Duval Systems

The following system layout are exclusively offered by Sauner Duval.

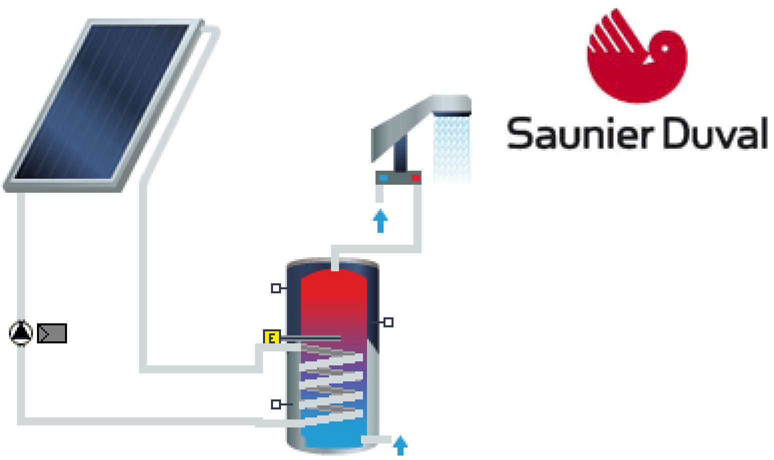
These are drain back systems, the collector loop will be emptied on system downtime, as overheating protection.

Further information can be obtained from http://www.saunierduval.com/.

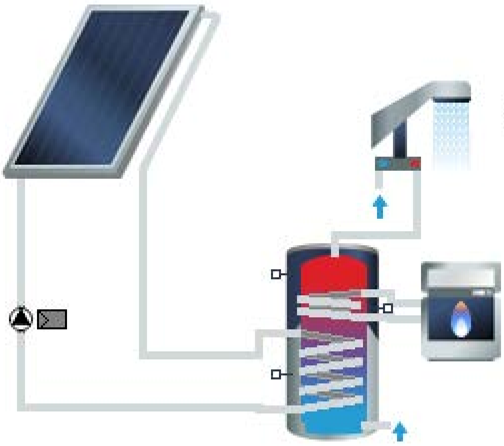
Find more information on the selection of systems under System Selection.



Saunier HelioSet 1.1, A1.0



Saunier HelioSet 1.2, A1.2



Saunier Duval

Saunier HelioSet 1.3 A1

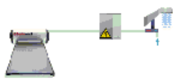
17.5.2 Solahart Systems

The following system layout are exclusively offered by Solahart.

They comprise thermosyphon systems with optional downstream flow heater.

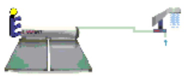
Further information can be obtained from www.solahart.com.

Find more information on the selection of systems under System Selection.

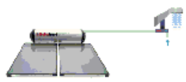


Solahart 151Kf

Solahart 181Kf

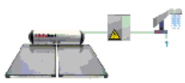


Solahart 302Kf-sa



Solahart 222Kf-sa

Solahart 302Kf



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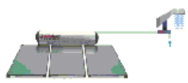
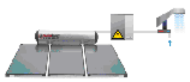


Solahart 303Kf-sa



Solahart 303Kf

Solahart 151Kf-sa

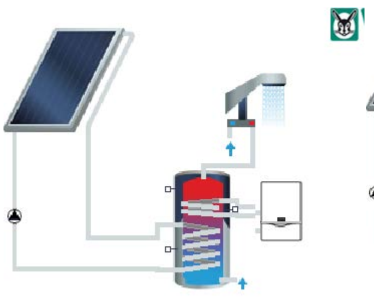
Solahart 181Kf-sa

17.5.3 Vaillant, allStor & auroStep Systems

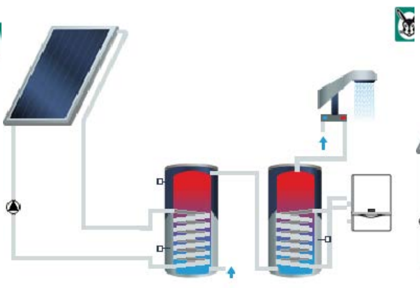
The following system layouts are exclusively offered by Vaillant.

Vaillant collectors, storage tanks, and condensing boilers can be individually selected. Further information can be obtained from http://www.vaillant.de/Produkte/Solartechnik.

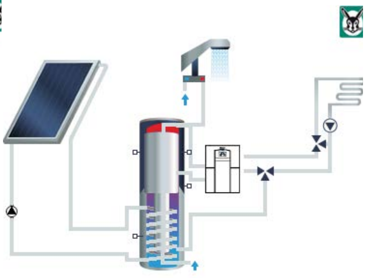
Find more information on the selection of systems under System Selection.



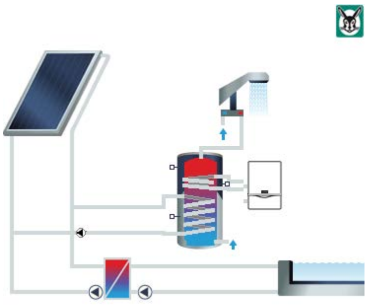
Vaillant A1



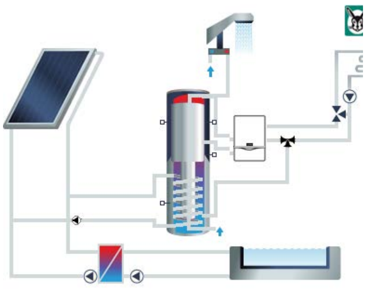
Vaillant A2



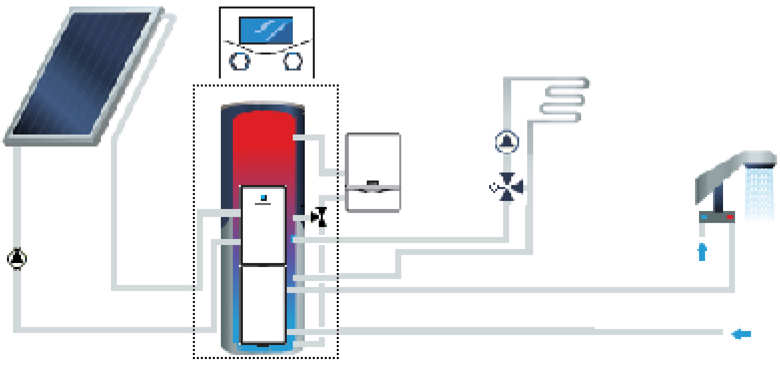
Vaillant A5.2



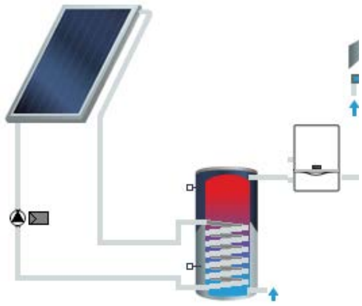
Vaillant B1



Vaillant B5.2

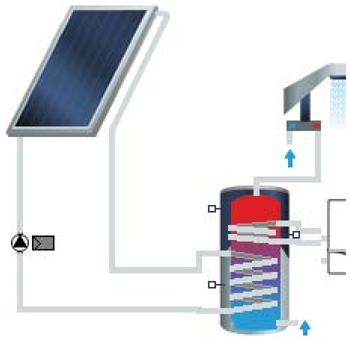


Allstor



auroSTEP plus A 1.1

auroSTEP plus A 1.2



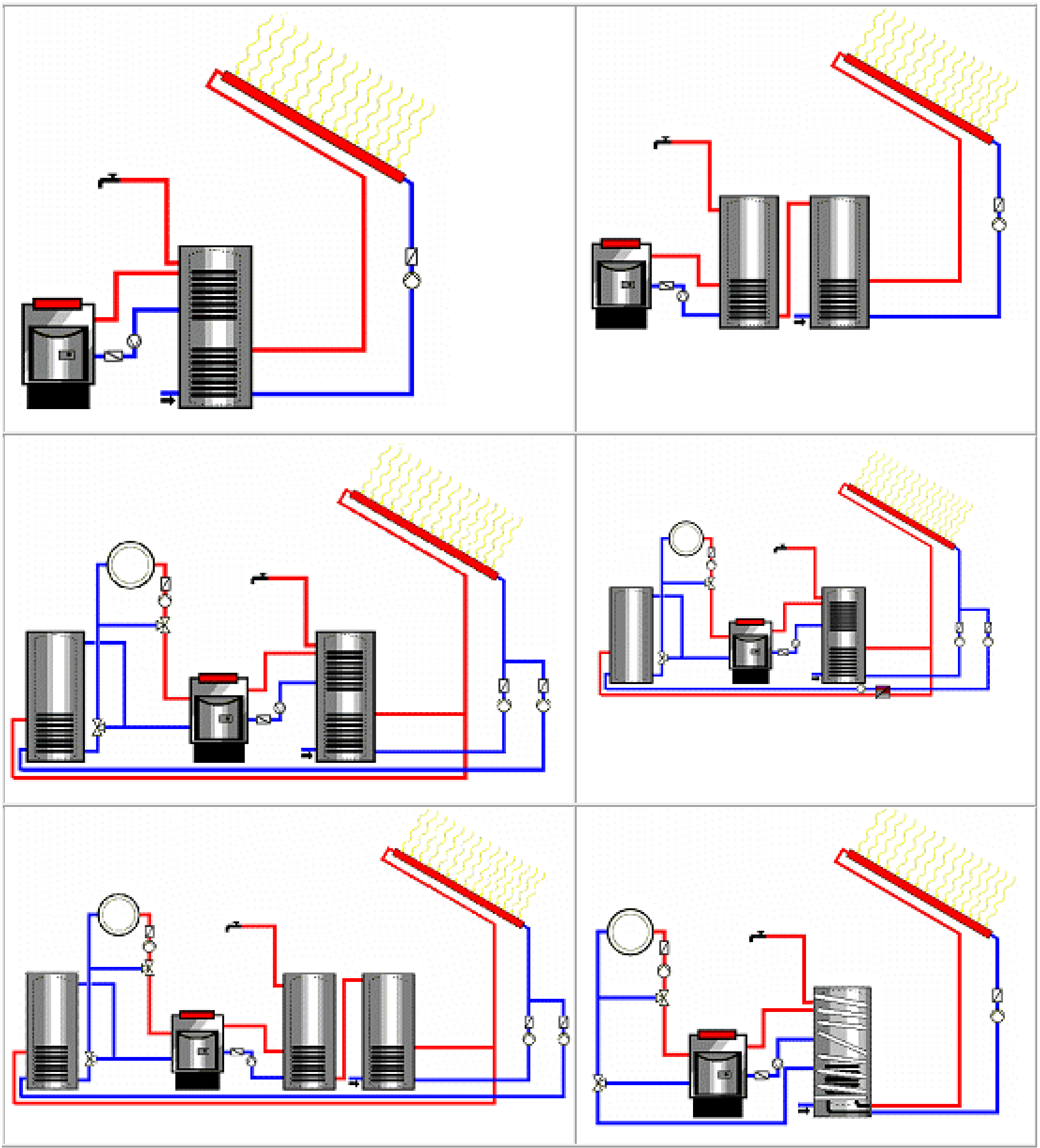
auroSTEP plus A 1.3

17.5.4 Viessmann Systems

The following system layouts are exclusively offered by Viessmann.

Viessmann collectors, storage tanks, and condensing boilers can be individually selected. Further information can be obtained from www.viessmann.com.

Find more information on the selection of systems under System Selection.

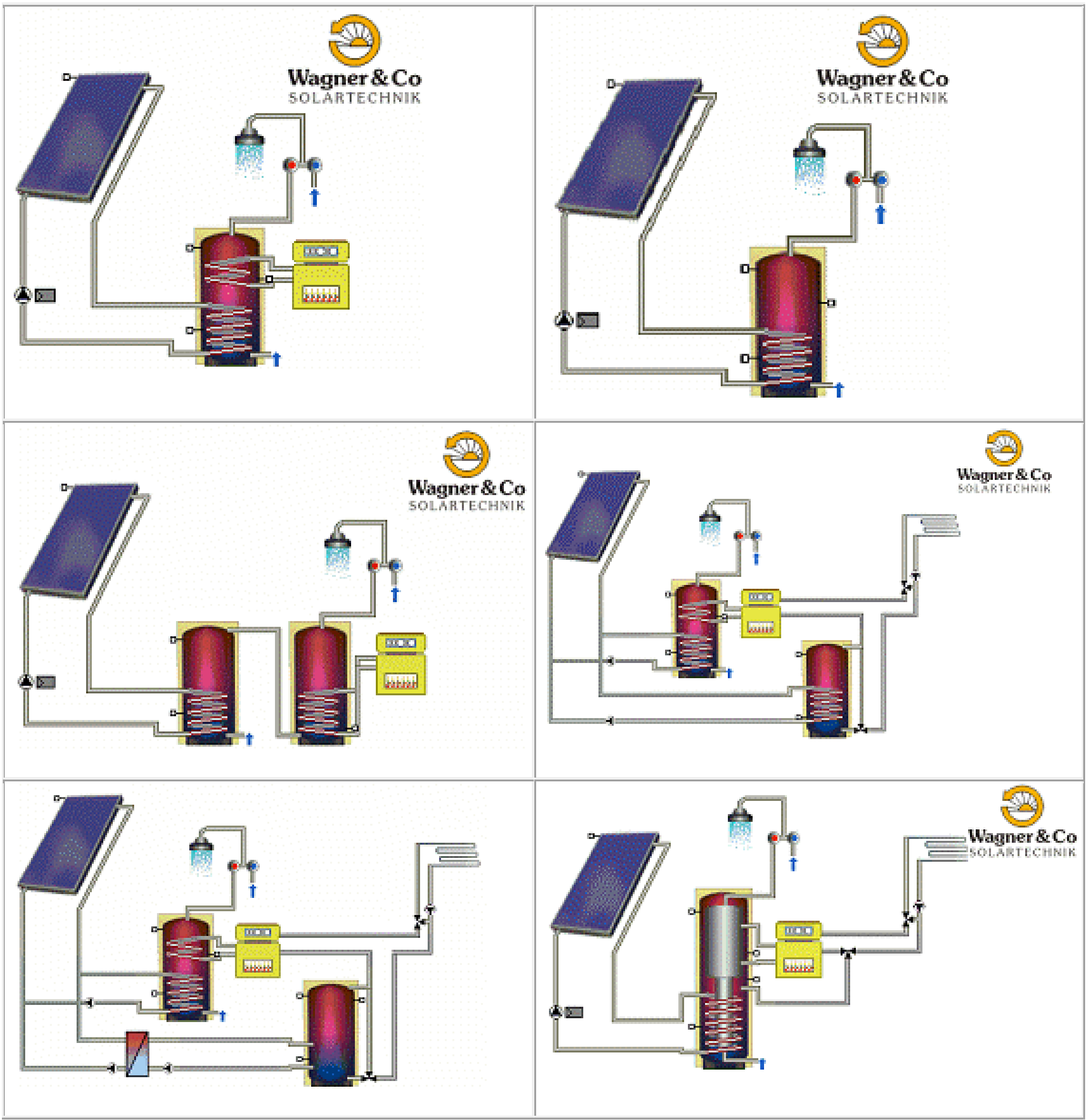


17.5.5 Wagner Systems

The following system layouts are exclusively offered by Wagner Solartechnik.

Wagner collectors, storage tanks, and condensing boilers can be individually selected. Further information can be obtained from www.wagner-solartechnik.de.

Find more information on the selection of systems under System Selection.



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