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SHWwin: freeware (beta stadium) for Universities and schools for the simulation of solar thermal plants

Wolfgang Streicher[1] (Author), Dietmar Siegele[1]

[1] University of Innsbruck, Unit for Energy Efficient Buildings, Innsbruck (Austria)

Abstract

The simulation software SHWwin is being developed since 1993, first at the Institute of Thermal Engineering at Graz University of Technology, Austria and since 2009 at the Unit for Energy Efficient Buildings at the University of Innsbruck, Austria. In 2015 a new Version compatible with 64bit Operating Systems (Windows 7© and higher) was relaunched. Several new features like swimming pool, second domestic hot water store, English language, statistics on temperatures and pressure distribution, thermotrophic or back cooled collectors and others were implemented and a new layout of the graphical user interface was developed.

Like the old Version also the new Version is available for free from the author to be used for education and research. SHWwin has a large number of sets of hydraulic layouts. As all parameters of e.g. heat stores (position of in/outlets, sensors) and control can be chosen freely, it is a nice tool to show students dependencies and relevance of the parameters and allows optimizing plants. Climate data can be taken from e.g. Meteonorm (2015) or any other source.

Keywords: *Simulation Tool, Solar Thermal Systems, Freeware, Education,*

1. Introduction (SWC_Heading1)

Several tools for the simulation of solar thermal plants are on the market. Besides tools with predefined hydraulics like TSOL (2015) or Getsolar (2015) there are tools with free definable hydraulics like Polysun (2015) or TRNSYS (2015) available. SHWwin is closest to TSOL-professional but is available for free for educational and research purposes. It is being developed since 20 years and the recent update has a new GUI and several new features like swimming pool, Tank-in-Tank storage, 2nd DHW store, thermotrophic layers as collector cover, maximum allowed temperature at stagnation for the collector pump to switch on, statistics about temperatures and pressures in the system with expansion device layout, and can be run under Windows 7© or higher. There is no online help desk available, but reports on bugs are always welcome and will be repaired as fast as possible with updates to all users. Translation of the GUI in other languages or the translation of the help file from German to English (and other languages) would be welcome.

2. Functions of SHWwin

SHWwin runs on all windows platforms starting with windows 7©. Additionally the kernel (an .exe) file can run standalone using the ASCII input files normally generated by the GUI. All input and output files including weather data can be edited also manually as ASCII files. So a coupling to other tools like e.g. MatLab or GenOpt is possible. SHWwin simulates dynamically solar thermal systems. Time steps can be chosen freely, but 3 or 6 minute time step is recommended.

Climate data on a hourly base can be used either from climate date generators (e.g. Meteonorm (2015)) or from other measured or produced hourly data.

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The following solar thermal plant designs can be simulated:

- Domestic hot water plants
- Combined domestic hot water and space heating plants (two store systems, one store system and DHW once through heat exchanger or Tank-in-Tank)
- Both of the above can be coupled with an indoor or outdoor swimming pool
- Solar assisted district heating networks

Each plant design allows several variations e.g. the choice of:

- Internal or external heat exchangers
- Fixed pipe positions or stratifying units or two inlets/outlets at the tank.
- All positions of heat exchangers, in/outlet pairs and temperature sensors can be freely chosen
- How the auxiliary heat is delivered (immersed electric rods or external boiler). The boiler can deliver only in the buffer (space heating) store or in both stores (SH and DHW)
- Auxiliary heat to DHW store (if chosen) can be either delivered directly from boiler or via the buffer store. Additionally an electric direct heating rod is available.
- Priority for solar heat input on space heating, domestic hot water, swimming pool or to the currently lowest temperature is available

Several collector volume flow strategies are available (see Figure 7, left column bottom)

- Fixed mass flow (can be freely chosen).
- Variable mass flow with either fixed collector outlet temperature or fixed ΔT between collector outlet and highest heat sink (e.g. for district heating systems)

Figures 1 – 3 show examples for hydraulic layouts.

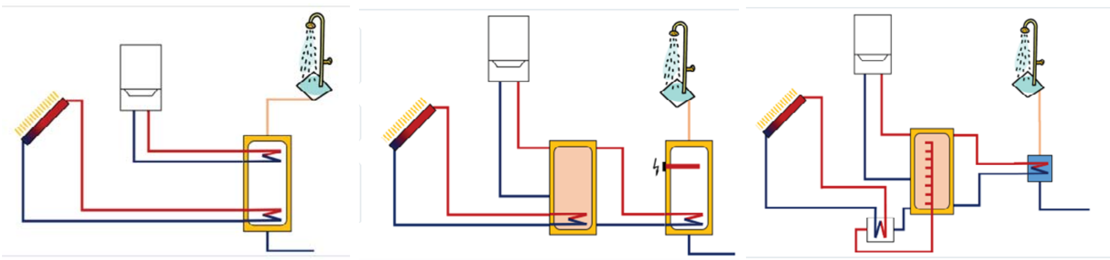


Fig. 1: Examples for hydraulics for domestic hot water (DHW) systems

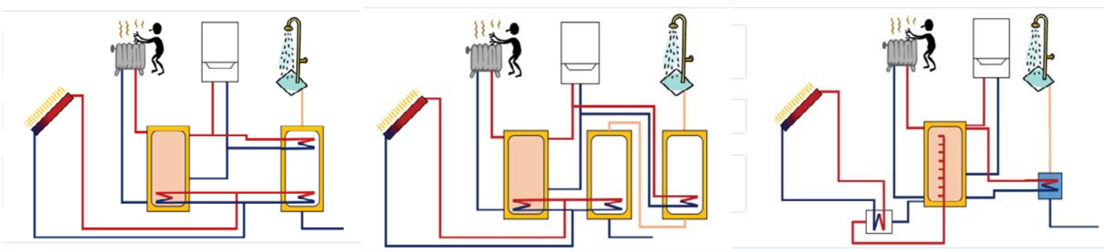


Fig. 2: Examples for hydraulics for domestic hot water and space heating systems (Combisystems)

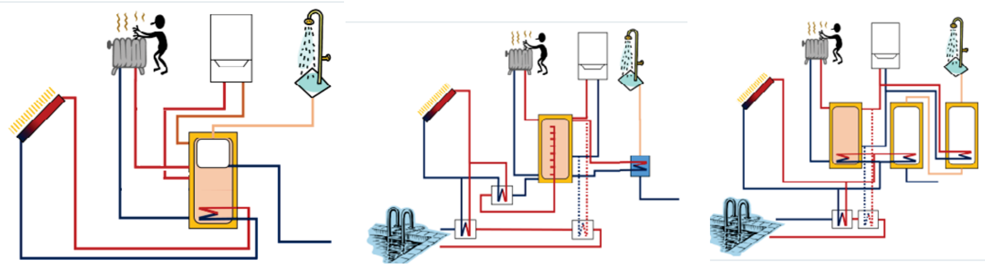


Fig. 3: Examples for hydraulics for domestic hot water, space heating and swimming pool systems

Plant Control settings

- On/Off temperature difference for the collector loop
- Blocking of state of collector loop for a specific time.
- Setting of a maximum temperature above which the collector pump cannot start to prevent the start of the collector pump during a stagnation period with steam in the collectors.
- Temperature settings of solar, boiler and electric rod input (maximum temperature, hysteresis)
- Temperature difference to load DHW store from space heating store to the domestic hot water store (if this plant design is chosen)

Additional available functions are

- Generation of statistics of temperatures and pressure in the collector loop. For this function the expansion vessel is either designed automatically or can be chosen. The volumes of each part of the solar loop have to be given by the user. For this function a coupling to Excel© is made. Results are tables and graphs, the latter are shown in Figure 4.

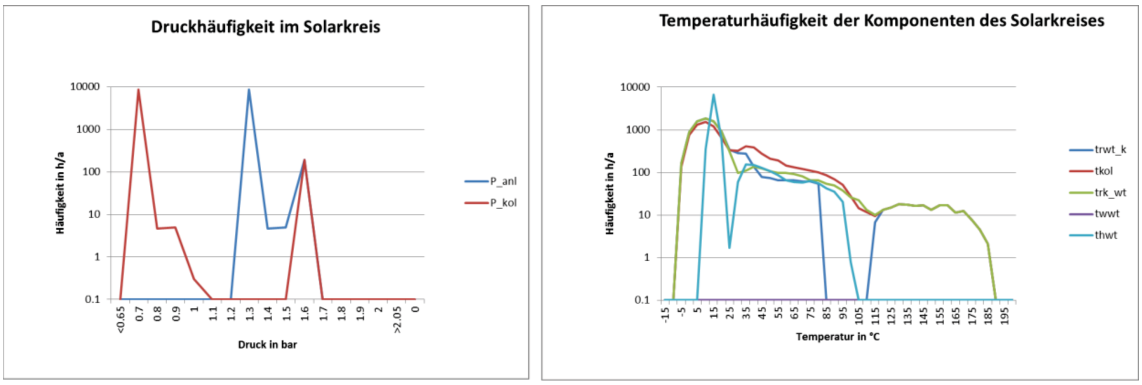


Fig. 4: Collector loop statistics of pressure and temperature in SHWwin

- If measured data of auxiliary heat input into the buffer store or the heating system, the domestic hot water demand or the space heat demand was measured in a real plant, this data can be used as input and overrules the respective simulation data.

3. Description of the SHWwin GUI

Currently the GUI is available in German and English language. To change between the languages the option button has to be clicked. When the language is changed, the program has to be shut down and restarted. The F1 online help is currently only available, if the German language is chosen.

When starting, first of all, a weather data file has to be chosen. All relevant main project data including a picture of the plant can be given (see Figure 5). Here also some general simulation values (start, end, number of time steps per hour ...) and the specific general functions stated above can be chosen. In the standard data set of SHWwin there are already some weather files available.

The next step is to choose the hydraulic system (Figure 6). Figures 1 to 3 show examples for systems available. Then, details for all components have to be defined. First the general system can be chosen in the above part and then hydraulic details can be added in the lower klick box area. The graph on the lower right side is changing accordingly, so that the user can directly see, which configuration is chosen.

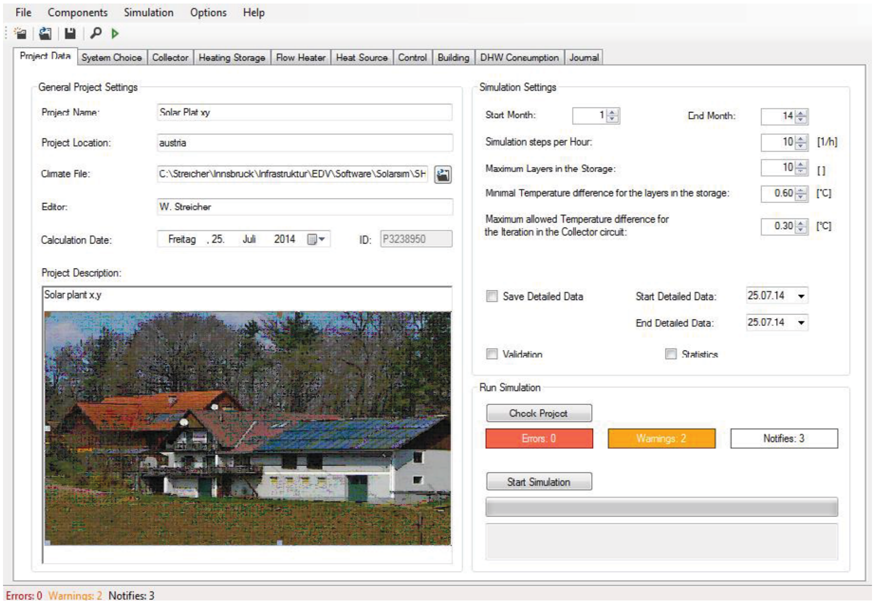


Fig. 5: System choice and visualization in SHWwin

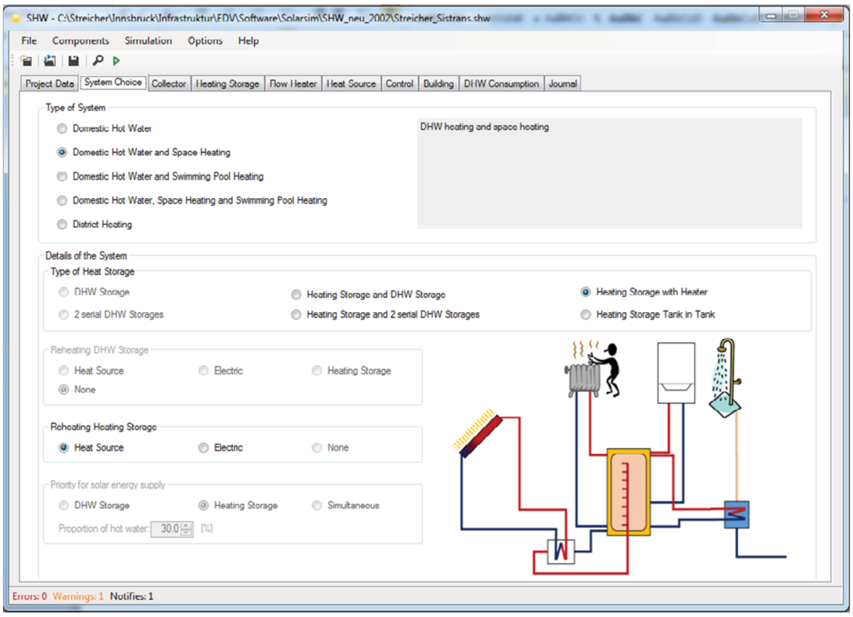


Fig. 6: System choice and visualization in SHWwin

After this, the input data of the different components have to be filled in. All fields are already prefilled with default values that allow immediately a simulation run. For many components databases are available, which are partly filled and can be edited and expanded by the user.

Figure 7 shows the inputs for the solar collector. The grey values on the left column are taken from database values (accessible by clicking on the first input box on the left column below collector). An old database from SPF Rapperswil, Switzerland is available for collectors which can be expanded by the user. Of course all values can be changed by the user clicking on “Edit Free”. The input is related to key values of collector tests (parameters for the characteristic curves for efficiency and incident angle modifier and the thermal active mass of the collector).

The right column shows the volume flows through the collector to different stores. The input is given as relative value [kg/m$^2_{collector_area}$, h] grey values give the absolute resulting volume flow. Also some fixed fluid properties and the connecting tube characteristics have to be given.

On the very low right side collectors with thermotrophic layer or backside cooler for maximum temperature control during stagnation of the collector can be defined by putting in parameters for the change of the collector efficiency curve depending on the mean collector temperature. For thermotrophic layers the conversion factor c0 and for the backside cooler the heat transfer coefficient c1 are altered by an additional temperature dependent factor fc0 or fc1. Figure 7 right shows a sample dependency.

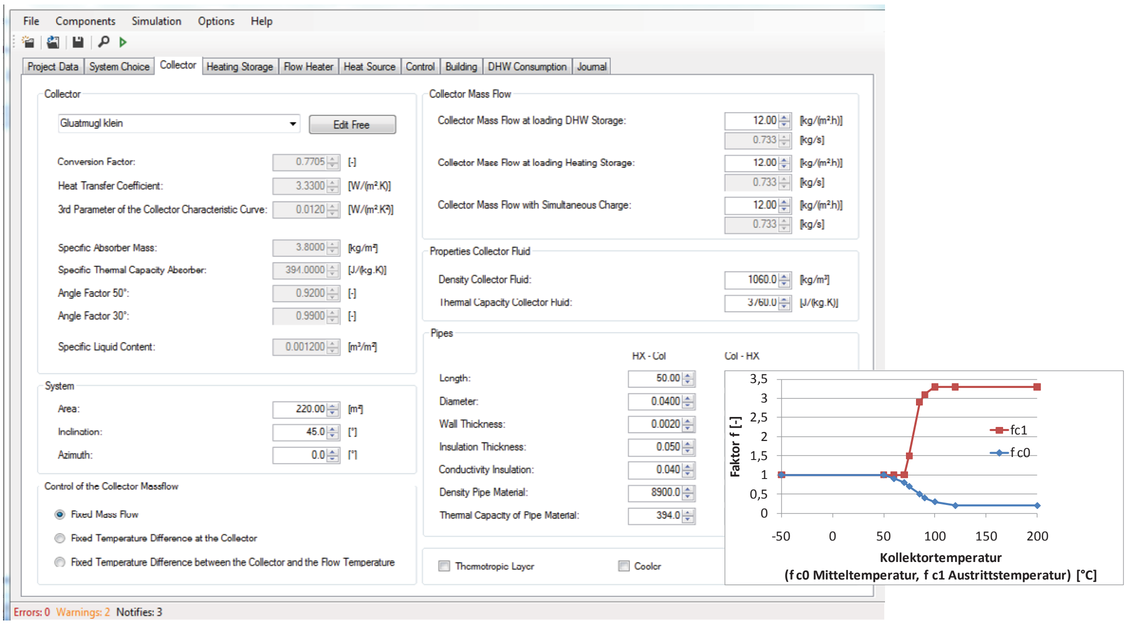


Fig. 7: Input for solar collectors and solar loop in SHWwin

Figure 8 shows the input data for domestic hot water store. All volumes, heights, insulation thickness and properties etc. can be freely chosen. The graph in the lower right is changing accordingly, thus the visual control of the store design is given. Additionally key values like volume for backup heating and solar are calculated simultaneously and shown to check the input data.

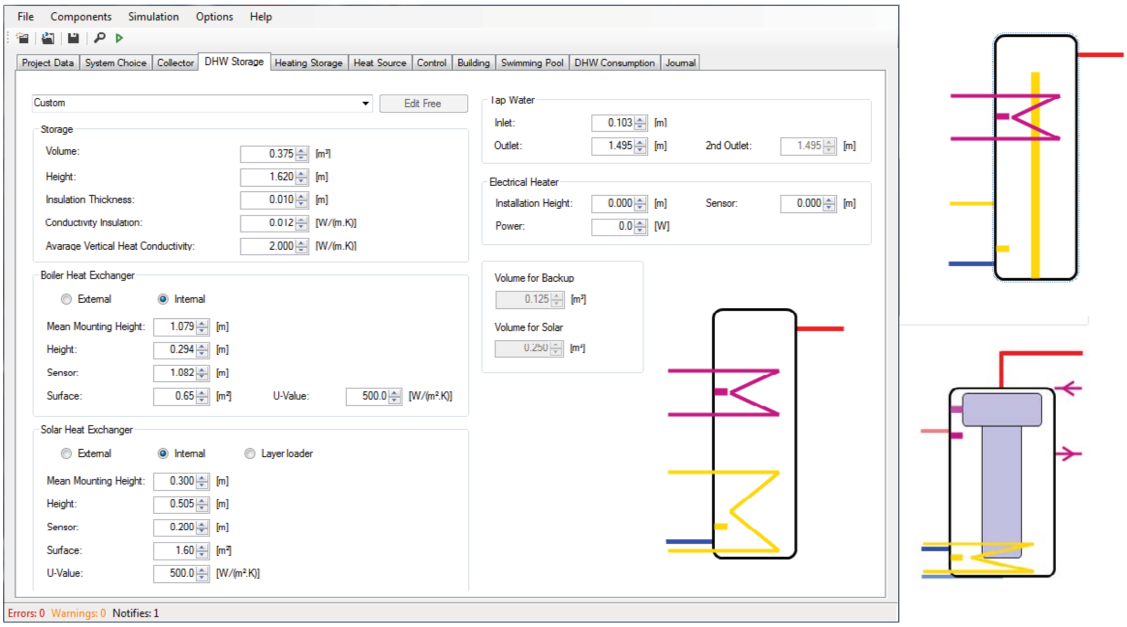


Fig. 8: Input and visualization of water stores for different types of heat input and output in SHWwin

The domestic hot water demand (Figure 9) can be given in terms of standard daily use with daily, weekly and monthly distribution. The cold water temperature can be varied via sinus curve variation over the year with the lowest temperature in February. Additionally a domestic hot water circulation can be defined.

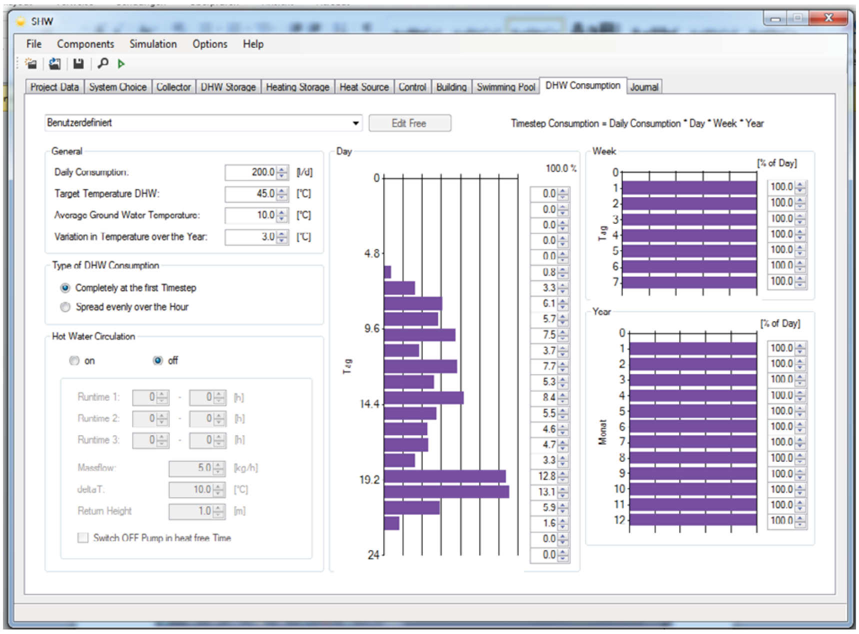


Fig. 9: Input and visualization of the domestic hot water demand in SHWwin

The space heating demand (see Figure 10) can be defined by the heat load reduced by internal gains and unheated parts as well as by the solar radiation passing up to 6 defined window areas. The flow/return temperature to the heating system is given as heating curve over the ambient temperature including a radiator exponent. The resulting curve is visualized for understanding and control purpose.

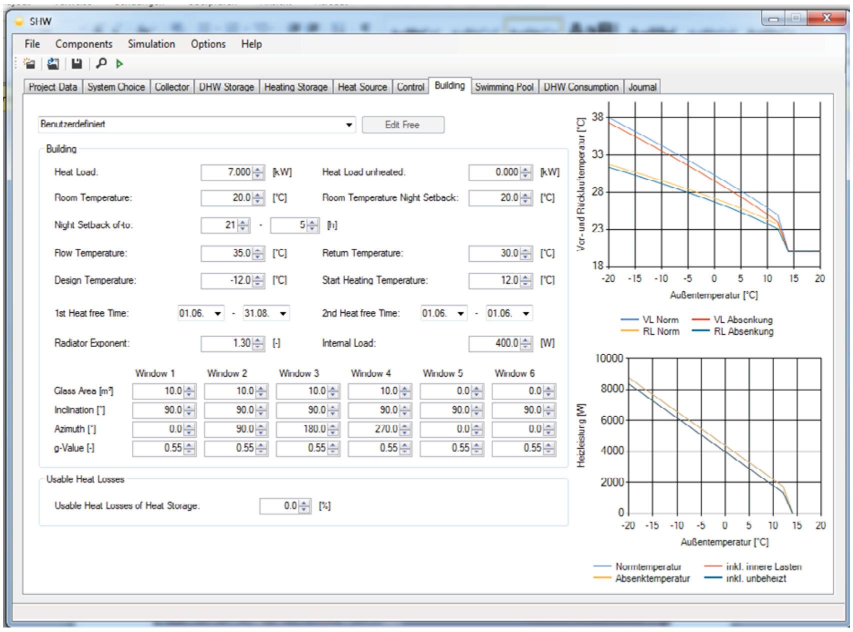


Fig. 10: Input and visualization of space heating demand in SHWwin

If a solar assisted district heating system is chosen the heat demand is defined by a space hating load and temperature curve over the ambient temperature (Figure 11). The domestic hot water demand is added to the given heat load.

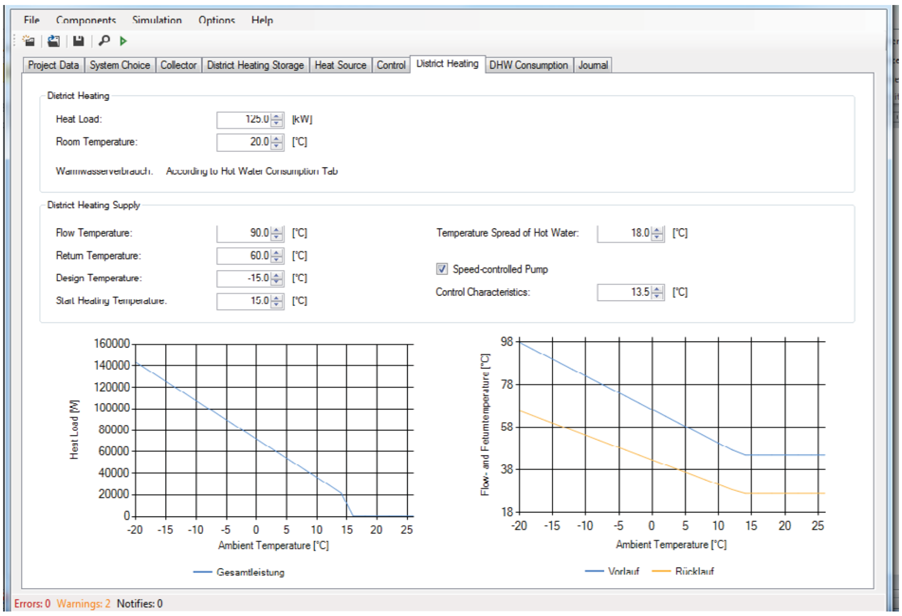


Fig. 11: Input and visualization of district heating network demand in SHWwin

An Online Help via the F1 button is available, if the German language is chosen. For every input value the online help can be invoked by clicking on the respective input button and then pressing F1. A help message with description of the value and some additional information will pop up (see Figure 12).

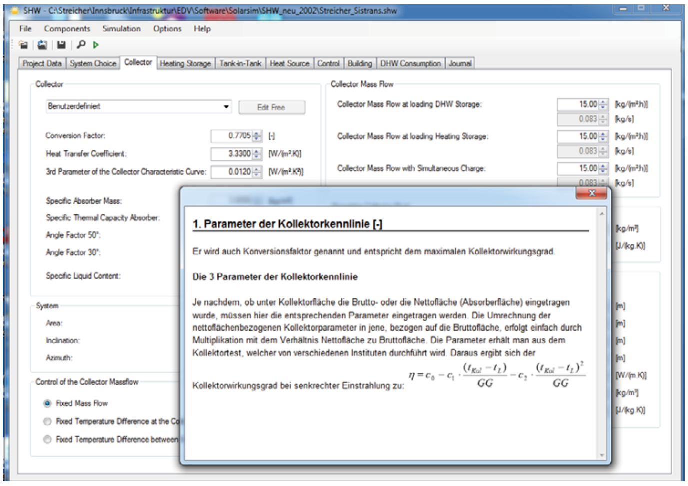


Fig. 12: Online Help via F1 in SHWwin (only if German language is chosen)

Before starting the simulation a check of the input data is performed and Errors, Warnings and Infos are delivered. This check can be invoked manually by pressing the magnifying glass. Also in the lower left edge of the window the actual number of Errors, Warnings and Infos is shown. By clicking on it, clear text messages about the nature of Error/Warning/Info (in German) show up and hints how to correct the input data are given. This is very important, as the input data can be freely chosen and e.g. heat exchangers or sensors could be placed above or below the storage. Additionally stability values are checked (e.g. if the volume turned around between an inlet/outlet pair in one time step is bigger than the volume available). The input boxes that induce the error are marked red. Figure 13 gives an example for errors occurring at a tank-in-tank buffer store inputs. As long as there are Errors in the input file (e.g. the heat exchanger is below or above the store) the simulation does not start.

Warnings give the user information about control settings that are not matching to the temperatures of the demand or too low auxiliary power. The simulation can be started despite the existence of Warnings. The respective input boxes are marked orange. Info's just give some hints on detailed system layout.

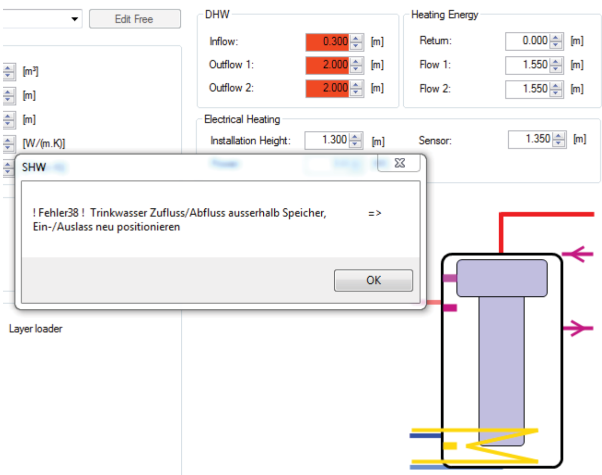
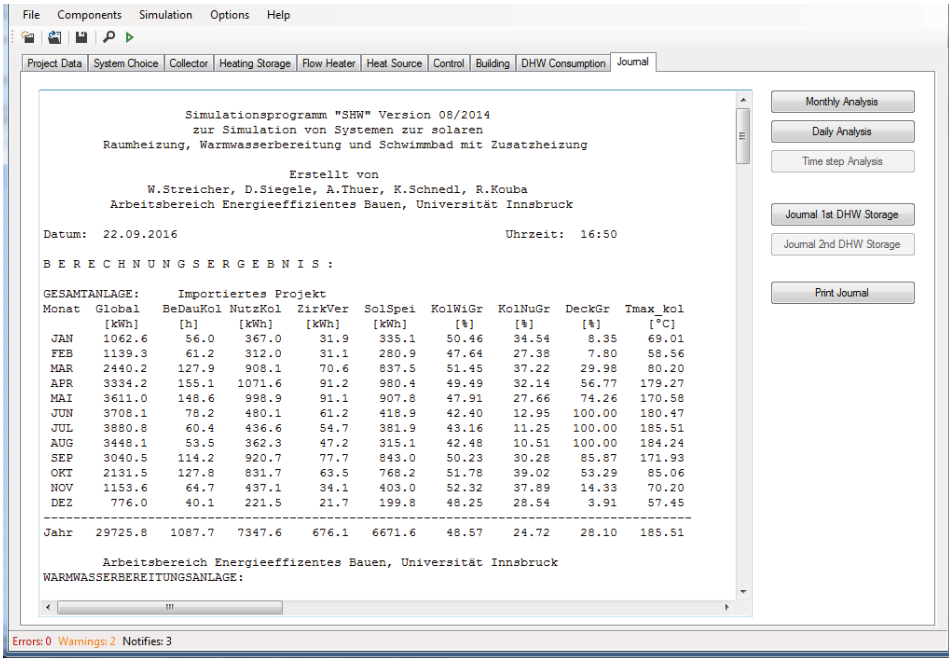


Fig. 13: Inherent input data check and display of input mistakes including suggestions for improvement

After the simulation is finished a summary with monthly and seasonal data and KPI's (key performance indicators) and some graphical and ASCII-data output is available. Additional this output includes all input data in (German) text including the units and can be seen as simulation protocol. Figure 14 shows the respective window with the first part of the output data.



Simulationsprogramm "SHW" Version 08/2014
zur Simulation von Systemen zur solaren
Raumheizung, Warmwasserbereitung und Schwimmbad mit Zusatzheizung

Erstellt von
W.Streicher, D.Siegele, A.Thuer, K.Schnedl, R.Kouba
Arbeitsbereich Energieeffizientes Bauen, Universität Innsbruck

Datum: 22.09.2016 Uhrzeit: 16:50

B E R E C H N U N G S E R G E B N I S :

GESAMTANLAGE: Importiertes Projekt

Monat	Global [kWh]	BeDauKol [h]	NutzKol [kWh]	ZirkVer [kWh]	SolSpei [kWh]	KolWiGr [%]	KolNuGr [%]	DeckGr [%]	Tmax_kol [°C]
JAN	1062.6	56.0	367.0	31.9	335.1	50.46	34.54	8.35	69.01
FEB	1139.3	61.2	312.0	31.1	280.9	47.64	27.38	7.80	58.56
MAR	2440.2	127.9	908.1	70.6	837.5	51.45	37.22	29.98	80.20
APR	3334.2	155.1	1071.6	91.2	980.4	49.49	32.14	56.77	179.27
MAI	3611.0	148.6	998.9	91.1	907.8	47.91	27.66	74.26	170.58
JUN	3708.1	78.2	480.1	61.2	418.9	42.40	12.95	100.00	180.47
JUL	3880.8	60.4	436.6	54.7	381.9	43.16	11.25	100.00	185.51
AUG	3448.1	53.5	362.3	47.2	315.1	42.48	10.51	100.00	184.24
SEP	3040.5	114.2	920.7	77.7	843.0	50.23	30.28	85.87	171.93
OKT	2131.5	127.8	831.7	63.5	768.2	51.78	39.02	53.29	85.06
NOV	1153.6	64.7	437.1	34.1	403.0	52.32	37.89	14.33	70.20
DEZ	776.0	40.1	221.5	21.7	199.8	48.25	28.54	3.91	57.45
Jahr	29725.8	1087.7	7347.6	676.1	6671.6	48.57	24.72	28.10	185.51

Arbeitsbereich Energieeffizientes Bauen, Universität Innsbruck
WARMWASSERBEREITUNGSANLAGE:

Fig. 14 Output from for monthly and seasonal energy balance

Additionally the values can be shown as graphs on monthly or daily bases (Figure 15) as well on a time step bases for a selected time period (one file per day). To select the time step based output, the respective values have to be set in the project register card (see Fig. 5) in the middle right. The values to be shown can be chosen, the nomenclature can be found in the (German) handbook.

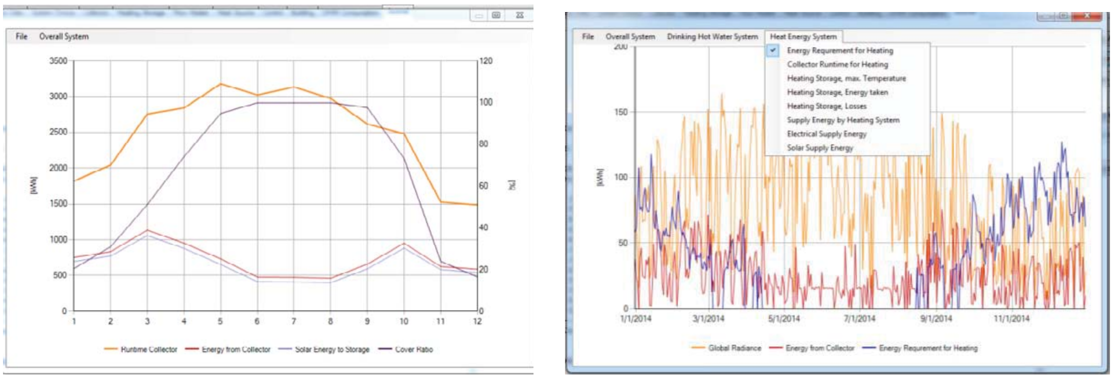


Fig. 15 Graphical output for selected values on monthly and daily bases

Input files or project files can be shared. Each project gets a number and one can save the project file at any place of your computer. This file is very small and can be sent to colleagues that can open it again with their SHWwin Version.

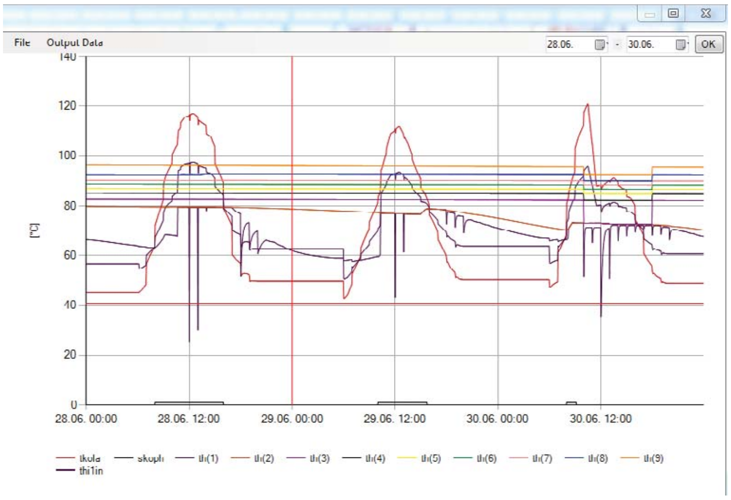


Fig. 16 Graphical output for selected values on time step bases
(store temperatures, collector outlet temperature, store inlet temperature, running time collector)

The whole program is available for free for educational or research purpose at Innsbruck University. Just send an E-Mail to wolfgang.streicher@uibk.ac.at. A ZIP file will be delivered with the installation files, some weather data and a full German manual. As it is freeware, there is NO online support available. Of course, there may be some bugs in the program. The author would be happy, if you can send him a description of the bug and the respective input and weather data file.

As the full program is only available in German language and the GUI also in English language, the Authors are looking for helping hands to translate the GUI and the HELP files into other languages. As .xml structures are used for all text inputs this can be quite simply integrated. Volunteers can contact the author for more details.

No liability is taken by the authors for any results of simulations with the SHWwin program.

4. References

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