All papers submitted for publishing to the RECENT® journal are subjected to the scientific review procedure.

The objective of scientific review is to ensure that all papers accepted for publishing meet the requirement of an adequate scientific level and provide original and significant contributions to the respective field.

The scientific review procedures practiced by the RECENT® journal are "*Expert Peer-Review*" (scientific review by experts, including the members of the Scientific Board of the journal) and "*Editorial Board Peer-Review*" (review, scientific included, by the members of the Editorial Board). All members of the Scientific Board and of the Technical Board of the journal are holders of PhD degrees, are members of the scientific community and experts in their respective fields of activity.

The complete scientific review procedure of submitted papers practiced by the RECENT® journal is available at http://www.recentonline.ro/PeerRew.htm

RECENT®

REzultatele CErcetărilor Noastre Tehnice

Industrial Engineering Journal

Transilvania University of Brasov, Romania

Vol. 14 (2013), No. 4(40) **ISSN 1582 - 0246**

ICEEMS 2013
7th International Conference on Economic Engineering and Manufacturing Systems

- selected papers -

iceems

40

November 2013

CONTENTS

Vol. 14, no. 4(40), November, 2013

All papers submitted for publication to the RECENT® journal undergo a peer-review procedure.

The objective of peer review is to verify and endorse that all papers accepted for publication are of adequate scientific level and include original and significant contributions in their respective field.

The RECENT® journal provides *Expert Peer-Review*, including by members of the Scientific Panel as well as *Editorial Board Peer-Review* by the members of the Editorial Board. All members of the Scientific Panel and of the Technical Panel have PhDs, are members of the academic community and experts in their respective fields of activity.

The received papers undergo initial *Editorial Board Peer-Review* by the members of the Technical Panel of the RECENT® journal, conducted mainly by the scientific secretaries. Evaluation concerns with priority whether the paper matches the fields covered by the journal and meets its standards.

Complete scientific evaluation procedure is available at http://www.recentonline.ro/PeerRew.htm

Electronic version of RECENT® journal, ISSN 2065-4529, is available at www.recentonline.ro

ENERGY SIMULATION OF A SOLAR THERMAL SYSTEM FOR DOMESTIC HOT WATER AND SPACE HEATING

Elena EFTIMIE
Transilvania University of Braşov, Romania

Abstract. Analyzing the use opportunity of solar heating systems is based on factors such as necessary heat load, solar energy available to the location where it is implemented, auxiliary power capacity, cost of investment and its recovery time, etc. The energy saved in a solar-thermal installation due to solar energy use compared to a conventional thermal installation depends on the climatic conditions of the implementation site, the adopted scheme of installation as well as the solar collector dimensions.

This paper proposes the use of a software of building energy simulation (TRNSYS) for modelling of a solar-thermal installations used both for providing hot water and space heating; in this way, it was achieved the energy simulations of a complex system of parallel use of renewable solar energy (solar thermal collectors) and the gas auxiliary source. TRNSYS software allowed the accurate establishing of thermal energy demand of the analyzed building, creating the link between weather data files and building, allowing the introduction of elements that affect indoor air properties (information on solar radiation and the incidence angle, relative humidity and air temperature, and also information on operating programs of the building); the operation modelling of the solar-thermal collectors within an installation, thus taking into account all heat exchange processes that occur during operation.

The use of energy simulation programs from the design stage of solar-thermal installation leads to the possibility of identifying optimal solutions in terms of both energy consumption and the comfort parameters, allowing simulation of various scenarios for energy consumption. The use of computer simulations also enables operational behaviour analysis of solar collectors (as part of an installation) and transient analysis of characteristic parameters.

Keywords: solar-thermal system, solar energy, building energy simulation, TRNSYS simulation

1. Problem description

Implementation of renewable energy systems in the built environment has become a global issue due to depletion of conventional energy resources. In addition, using renewable energy systems the negative environmental effects are reduced by reducing emissions of greenhouse gases.

Major consumers of energy in buildings are heating, ventilation and air conditioning (HVAC). In assessing the cost of a new building, HVAC systems can represent between 30% and 50% of costs for commercial buildings, and 5% to 10% for housing [3]. The ability to make well-founded decisions when selecting and designing of HVAC systems is of paramount importance in terms of economic and environmental impact.

Using renewable energy sources to ensure energy demand of a building is a solution to the problems identified in the buildings. Thus, in addition to reducing dependence on fossil fuels will also notice advantages such as:

- reducing costs for heat used for space heating and domestic hot water;
- increasing indoor temperatures with low energy consumption;
- reducing environmental pollution and CO_2 emissions.

Analysis of the appropriate use of solar heating is based on factors such as:

- thermal load required,
- solar energy available to the location of implements,
- auxiliary source capacity,
- investment cost and
- duration of its recovery, etc.

2. Geographical and climatic description of the implementation site

Climatic characteristics of the area of implementation of systems using solar energy have influence on the behaviour and equipments performance, requiring a thorough analysis of meteorological parameters for specific area. This analysis is necessary both for a proper and accurate dimensioning of these and for energy simulation of solar installations.

Braşov urban area is located in the central-eastern Romania, 25°36' East longitude and 45°39' North latitude. Located in Braşov Depression, in the internal curvature of the Carpathians, Braşov has an altitude of 790 m. Braşov Depression, by its geographical position, presents natural boundaries due to the mountains that surround depression, these being those that amplify or diminish a number of processes and weather phenomena in the region.

Climate characteristics are changed due to the geographical conditions, so that depression is characterized by a climate of high variations, frequent thermal inversions, early frosts that pass late, continental regime of precipitation and wind regime affected by mountain massifs that surrounds depression [6].

Thermal inversion phenomenon is manifested by temperature increase with altitude. This phenomenon acts as a “hot air cap” and keeps pollutants and dust at a low altitude.

Crucial situations of air pollution are frequently observed during winter when turbulent air masses are existing at the low level of the basin, preventing solar radiation, leading to intensity increase of thermal inversion phenomenon, because low convection [1, 2, 6]. Also due to thermal inversion, hail is often encountered in Braşov.

Braşov has a temperate-continental climate characterized by transition between oceanic temperate climate and that continental temperate climate, more humid and cooler in mountain areas, with relatively low rainfall and temperatures slightly lower in areas low.

Table 1. Geographical and climate description of Braşov

Site description Latitude: 45°39' North Longitude: 25°36' East Weather type: temperate-continental Basin area	
Annual mean of wind speed	1.13m/s
Annual mean of ambient temperature	9.44°C
Annual minimum ambient temperature	-20.03°C
Annual maximum ambient temperature	35.85°C
Annual mean of total solar radiation	1170kWh/m^2
Annual mean of direct horizontal radiation	656kWh/m^2
Annual mean of diffuse radiation	514kWh/m^2

In order to design renewable energy conversion systems (solar, wind), Department of Renewable Energy Systems and Recycling of Transilvania University of Brasov uses for recording the meteorological data an automatic meteorological station, Delta-T type, data recording being achieved from January 2006. The weather station is automatic with a flexible structure consisting of a set of sensors that measure various meteorological parameters (global and diffuse solar radiation, air temperature and humidity, wind speed and direction) and a data logger for data reading every minute, recording a value representing the average readings every 10 minutes [1, 2].

Some weather data specific to Brasov area, registered with Deta-T weather station for the period 2006-2012 are shown in Table 1 and Figures 1 and 2. The analysis of this diagrams lead to the following conclusions:

- the monthly average of global energy ranges during a year between 23 kWh/m^2 (December) and 172 kWh/m^2 (July);
- the monthly average of direct energy ranges between 9 kWh/m^2 (December) and 103 kWh/m^2 (July);
- the diffuse energy represent between 40% (July) and 62% (December);
- the annual diffuse energy is about 44% of global energy.

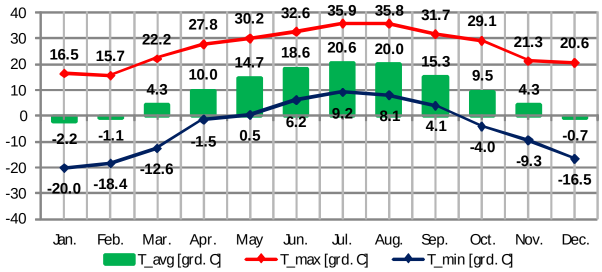


Figure 1. Monthly ambient temperature for Braşov

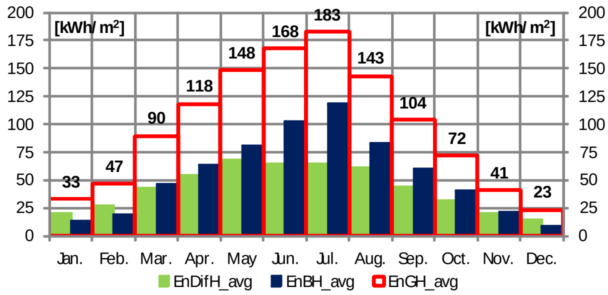


Figure 2. Monthly distribution of solar radiation for Braşov (Romania)

3. Method used

3.1. Thermal model of the building

For this study it was considered the Solar House of the Department of Renewable Energy and Recycling Systems; the Solar House is a new building, built during 2005-2007 and being located on the campus of Transilvania University of Braşov.

The building was designed to study viable solutions of achieving comfortable and healthy indoor environment by using renewable energy sources and aiming at high energy autonomy [8].

The building is consisted of two storeys; its optimized architectural form allows natural air circulation between the two storeys, this benefiting fully of natural ventilation. The radiant heating floor provides thermal comfort of the building. The building is used as office space, the ground floor having a capacity of 12 seats and the storey is arranged as a room for meetings, presentations or formal meetings (about 30 seats).

To create the 3D model of the building this was divided into six zones, each zone having a different thermal conditions, namely:

- Zone I: entrance hall;
- Zone II: office;
- Zone III: bathroom;
- Area IV: small lobby;
- Area V: stairwell;
- Area VI: storey.

This delimitation was necessary for a calculation as accurately of heat transfer and for the dynamically simulation of the flow of energy.

The 3D model of the building is presented in Figure 3. The building was represented to real scale and every surface was modelled according to its specific type: window, door, adjacent wall, ceiling, floor, etc.

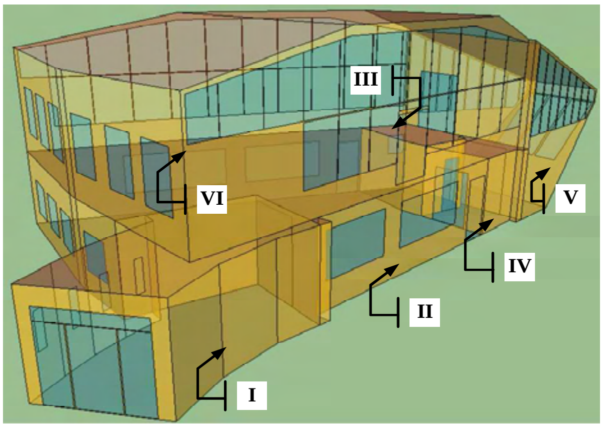


Figure 3. Geometric model of the solar house (Google SketchUp – Trnsys3D)

Thus, the attached data file will contain precise data on floor area, the percentage of glazing, etc., for each area.

The construction materials are of the latest generation with high thermal resistance. The building is thermally insulated with a layer of 10 cm of polystyrene foam for exterior. Thus, the building has low power consumption, this fits successfully into the category of energy efficient buildings.

The editing of 3D building model was carried out in TRNBuid module; this module also allowed establishing occupancy rate of the building through its operation program, respectively from Monday to Friday between $7^{\underline{30}}$-$19^{\underline{30}}$. For every zone, occupation regime can be set separately, a heating and cooling program with different temperatures, etc. In this case it was considered the same program for the electronic equipment (PC, laptop, printer, and so on).

Table 2. Building construction materials

Building Elements	Material	Total thickness [m]	U value [W/m^2 K]
External wall	gypsum plaster (2.5 cm), concrete slabs (10 cm), expended polystyrene (10 cm), gypsum plaster (2.5 cm)	0.45	0.247
Interior wall	gypsum plaster (1 cm), insulation, gypsum plaster (1 cm)	0.02	2.818
Exterior windows *Case I*	aluminium ASHREA metallic Solar factor g=0.755		2.83
Case II	Solar factor g=0.591		1.27
Roof	steel (0.1 cm), insulation (mineral wool) 15cm, steel (0.1cm), gypsum plaster (2 cm)	0.172	0.299
Heating floor area: 215.95 m^2			

3.2. Determination of the heating demand

Compared to conventional methods of calculating the energy consumption, software simulation tools are proving to be the most accurate calculation methods, due to the possibility of achieving dynamic simulation at short time intervals (for example 0.125 h). Classical method of calculating the thermal energy load [10, 11, 12], involves a calculation based on monthly averages, which introduces approximations and generates over-assessment of energy needs for heating and cooling.

Due to the flexibility of TRNSYS software, it was possible to analyze different heating programs to determine optimum heating program, taking into account the thermal behaviour of the building. Analyzing the variation of thermal comfort parameters (PMV and PPD) throughout the simulation period (one year or 8760 hours), the optimal heating temperature was set at 21 °C [8].

The simulation of energy demand was performed for Solar House (Figure 3), considering two situations (Table 2), namely:

- Case I, where exterior windows are double glazing windows with the overall heat energy transfer rate U-value = 2.83 W/m^2·K and

- Case II, situation where exterior windows have been replaced with high quality double glazing windows with the overall heat energy transfer rate U-value = 1.27 W/m^2·K and a glazing factor g-value = 0.591).

The solar-thermal system was designed to supply hot water for domestic hot water and also for space heating.

The specific demand of cold water and hot water was determined using the STAS 1478-90, according to the building destination [13]. Because the building is an office building, the domestic hot water demand is low, respectively 120 litters of hot water at 60 °C.

The quantity of water consumed in buildings is variable over time and it depends on the following factors:

- structure of water consumption correlated with the building destination (residential, social, cultural, industrial, agricultural);
- total number of consumers, their distribution by sex and by age category;
- degree of comfort;
- operation regime of installations, which can be continuous or intermittent (with a certain program);
- openness of armature (tape water, the possibility of battery for mixing cold water with hot water, etc.) mounted at the point of water consumption;
- other factors of local importance.

Hot water consumption is an important part of the heat demand of a building because it is relatively constant throughout the year.

It is noted that energy demand for space heating is much higher than for domestic hot water supply (Table 3), which is the reason why collectors were linked both to the water tank for supplying domestic hot water and to the tank for supplying the water for space heating.

For Case I, a total energy of 36544 kWh/year, respectively 140 kWh/m^2/year resulted and for Case II, a total of 27310 kWh/year, respectively 105 kWh/m^2/year. It is also note that during May-September period, the available solar energy covers the demand for domestic hot water.

Table 3. Monthly energy demand (SH and DHW) and available solar energy

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Rg_21*S_coll	465	716	1312	1481	1844	1789	1985	2121	1780	1249	877	398
Q_SH+DWH_Case_I	**7945**	**7315**	**3447**	**1904**	667	122	36	35	179	**2642**	**5782**	**6469**
min(Q_soll, Q_heat_Case_I)	465	716	1312	1481	**667**	**122**	**36**	**35**	**179**	1249	877	398
Q_SH+DWH_Case_II	**5921**	**5400**	**2401**	1267	554	255	250	250	258	**1834**	**4184**	**4735**
min(Q_soll, Q_heat_Case_II)	465	716	1312	**1267**	**554**	**255**	**250**	**250**	**258**	1249	877	398

3.3. Calculation of fractional solar consumption

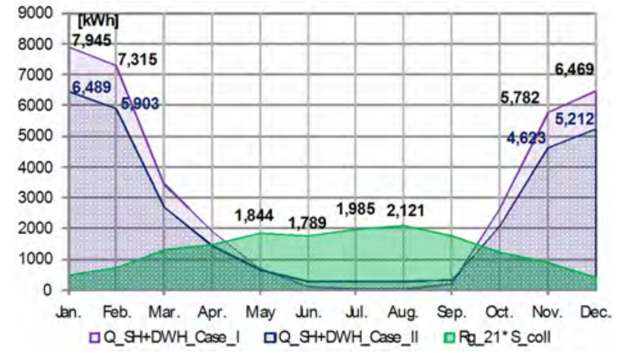
In this stage, it is proposed to calculate the solar fraction consumption (FSC) for the situation considered [5]; in this way, relation (1) will be used

$$FSC = \frac{Q_{solar\_usable}}{E_{ref}} = \frac{\sum_{1}^{12} min\left(E_{ref\_month}, S_{coll} \cdot R_g\right)}{\sum_{1}^{12} \frac{Q_{SH} + Q_{DHW} + Q_{loss\_ref}}{\eta_{boiler\_ref}}} \quad (1)$$

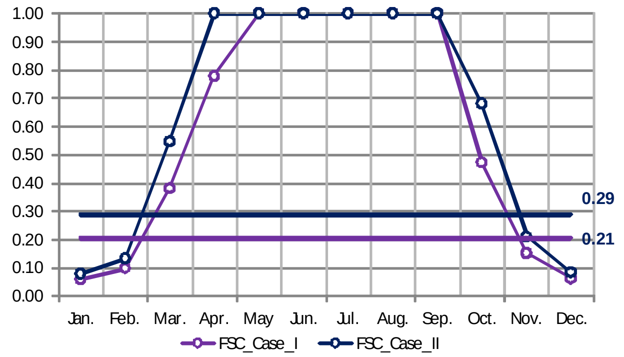
where:

- Q_{solar_usable} represents the building energy consumption that can be saved by using solar energy;
- Q_{solar_usable} is calculated for each month by multiplying collector surface S_{coll} [m^2] with the solar energy value on collector R_g [kWh/m^2];
- E_{ref} – annual energy consumption of a heating system (reference system that is not equipped with renewable energy sources);
- E_{ref} is calculated as the sum of monthly energy consumption for domestic hot water (Q_{DHW} – monthly consumption of domestic hot water), space heating (Q_{SH} – monthly consumption for space heating) and monthly losses of the tank (Q_{loss_ref});
- η_{boiler_ref} – efficiency of the reference heating system.

Considering the collectors surface S_{coll} = 10.12 m^2, the tilt angle of collectors 21° (optimum calculated value for Braşov urban area [7]), the hot water consumption of 120 l/day and the program of space heating with a temperature set to 21 °C, in Figure 4 is represented the monthly variation of fractional solar consumption.



a. energy consumption for a reference system



b. monthly solar fractional consumption

Figure 4. Fractional solar consumption for Case I and II

The monthly variation curves of fractional solar consumption are represented for the two Cases of space heating demand, respectively for the two types of external windows (using external windows with a U-value = 2.83 W/m^2·K and U-value = 1.27 W/m^2·K).

Analyzing these diagrams, for Case II during period May-September the maximum value of fractional solar consumption was obtained.

Unfortunately due to geographical and climatic conditions of Braşov basin area (direct solar radiation is diminished during autumn, winter and early spring), the annual values of fractional solar consumption resulted just around 0.29 for Case II.

4. Results and discussions

4.1. Description of the solar-thermal system

The solar-thermal installation of Department of Renewable Energy Systems and Recycling is a hybrid system used for hot water and space heating. The installation consists of four collectors whose total area is 10.12 m^2.

When dimensioning the collector area it was taken into account that solar thermal equipment captures also solar energy when there is no demand and storage tank is already fully heated. Therefore, in these cases there is also efficiency for zero consumption and all solar energy excess is lost. A correct design criterion is to not install an excessive number of collectors. A properly designed solar installation should cover 100% of energy need in the summer months only.

Thus, the heat demand does not coincide with the available of solar energy because, in the cold period when the heat demand is higher, the amount of solar heat is smaller and this decreases with time reduction sunshine.

Since the available solar energy is shifted compared to the heat demand for heating, resulted the need for effective measures resulted, such as:

- the use of a heat storage component within system,
- additional insulation of the building and
- the providing of auxiliary sources.

The use of solar energy as heat source requires both a unique architecture of the buildings and their orientation relative to the Sun [4].

Taking this aspect into consideration, the four solar collectors were placed on the roof of the house, South oriented at a 21° tilt from horizontal; this tilt angle resulted from the condition to maximize the annual global solar energy on collector surface [7].

In order to validate the results of simulations carried out with TRNSYS software, the parameters of components used will be set so that they coincide with the existing system parameters.

The main equipments of the existing solar-thermal installation are: solar collectors South oriented, storage heat tank 200 litters; water tank for domestic hot water supply 200 litters; two auxiliary heaters (24 kW).

Several characteristics of the solar thermal systems are presented in Table 4. Solar energy is absorbed by the solar collectors and carried through the solar loop into insulated storage tanks where is yielded to water, which is used for domestic consumption and / or heating heat.

For the cold periods, when the solar energy contribution does not cover the heat demand of the building, the installation must be provided with two additional conventional energy sources; it is taken into consideration that heat energy can not be fully supplied by the solar power to ensure the needs consumption for the entire year.

4.2. Building Energy Simulation

The energy saved in solar-thermal equipment due to the use of solar energy compared to conventional thermal equipment depends on the climatic conditions of the implementation location, the design of adopted system and also the type and size of the collector.

Table 4. Characteristics of solar-thermal system

Solar collectors *Type 539*	Type: Flat Plate Solar Collector with Capacitance and Flow Modulation Collector area: 10.12 m^2 Location: South oriented with a tilt angle of 21°
Storage tank *Type 534*	Type: Cylindrical Storage Tank with Immersed Heat Exchangers Number of storage tanks: 2 - one for the domestic hot water supply - one for space heating Volume: 0.2 m^3 Height: 1 m Number of immersed heat exchangers: 2 - one for the solar collectors - one for the auxiliary heater
Heating floor *Active Layer*	Area: 215.95 m^2 Maximum inlet temperature: day 40 °C; night 35 °C
Daily DHW	Load volume: 120 litters/day Set temperature of DHW: 60 °C Set temperature of domestic cold water: 10 °C

An efficient way to design HVAC systems (Heating, Ventilation and Air Conditioning) that lead to an optimum in terms of energy consumption, of the peak load and of other practical constraints is to study the thermal behaviour of the building using more accurate simulations.

The use of computer simulations makes it possible the evaluation of the energy use in network for various design alternatives [9], these being today the most popular and flexible method for analyzing the energy consumption of buildings.

Simulation of the building energy consumption consists of the dynamic analysis of energy behaviour of the buildings using computer modelling and simulation techniques.

Determining the energy characteristics of buildings and of the related systems require the calculation of loads building and of energy consumption.

By means of the energy consumption simulations of buildings can investigate complicated issues of installations design and it can be quantified and assessed their behaviour.

The importance and benefits of energy simulation software TRNSYS are also highlighted by the simulation possibility of thermal installations in correlation with the 3D model of the building, thus being able to analyze their "living" behaviour; it is noted that most software tools being singular, allow either only the building simulation or only of the installation.

All simulations will be performed for the weather conditions of Brasov area, using component Type 99, that allows the introduction of a personalized weather data file. This component reads the data provided at regular intervals of time.

TRNSYS model proposed is presented in Figure 5. The collectors are connected with data files containing measured weather data of Braşov area (through subroutine Type 99).

Simulation programs such as TRNSYS represent a highly effective tool in energy simulation, especially by allowing analysis of different calculation scenarios.

4.3. System performance

It must be mentioned, the solar fraction is not a precise performance evaluation factor of a solar thermal system; it is taken into consideration that this factor does not take into account the particularities and the design of solar thermal installations.

This factor represents maximum theoretical fraction energy savings for a solar-thermal system with no losses [5].

At the performance analysis of a solar-thermal installation should be considered the energy behaviour of collectors within an installation characterized by an imposed heat demand; in addition the solar energy obtained on an oriented surface is affected by energy losses characteristic to the adopted installation variant (efficiency of solar collectors, energy losses in network and boiler, etc.).

Considering this aspect, as a performance indicator is proposed the fractional thermal savings ratio calculated with the following relation [5]:

$$f_{sav\_therm} = 1 - \frac{\dfrac{Q_{boiler}}{\eta_{boiler}}}{\dfrac{Q_{boiler\_ref}}{\eta_{boiler\_ref}}} = 1 - \frac{E_{aux}}{E_{ref}} \qquad (2)$$

where:

- Q_{boiler} represents the thermal energy load of auxiliary heater;
- Q_{boiler_ref} – thermal energy load of a heating system (reference system that is not equipped with renewable energy sources);
- η_{boiler} – the annual mean efficiency of auxiliary boiler;
- η_{boiler_ref} – the efficiency of the reference heating system [5].

Calculation of fractional thermal savings was achieved for Case II, but two variants for the connecting scheme of solar circuit were considered, namely:

a. the system was designed so that the solar circuit is used to supply hot water for domestic hot water and also for space heating (scheme "a") and the second situation where

b. the solar energy provided by solar collectors is used only in the circuit of hot water supply (scheme "b").

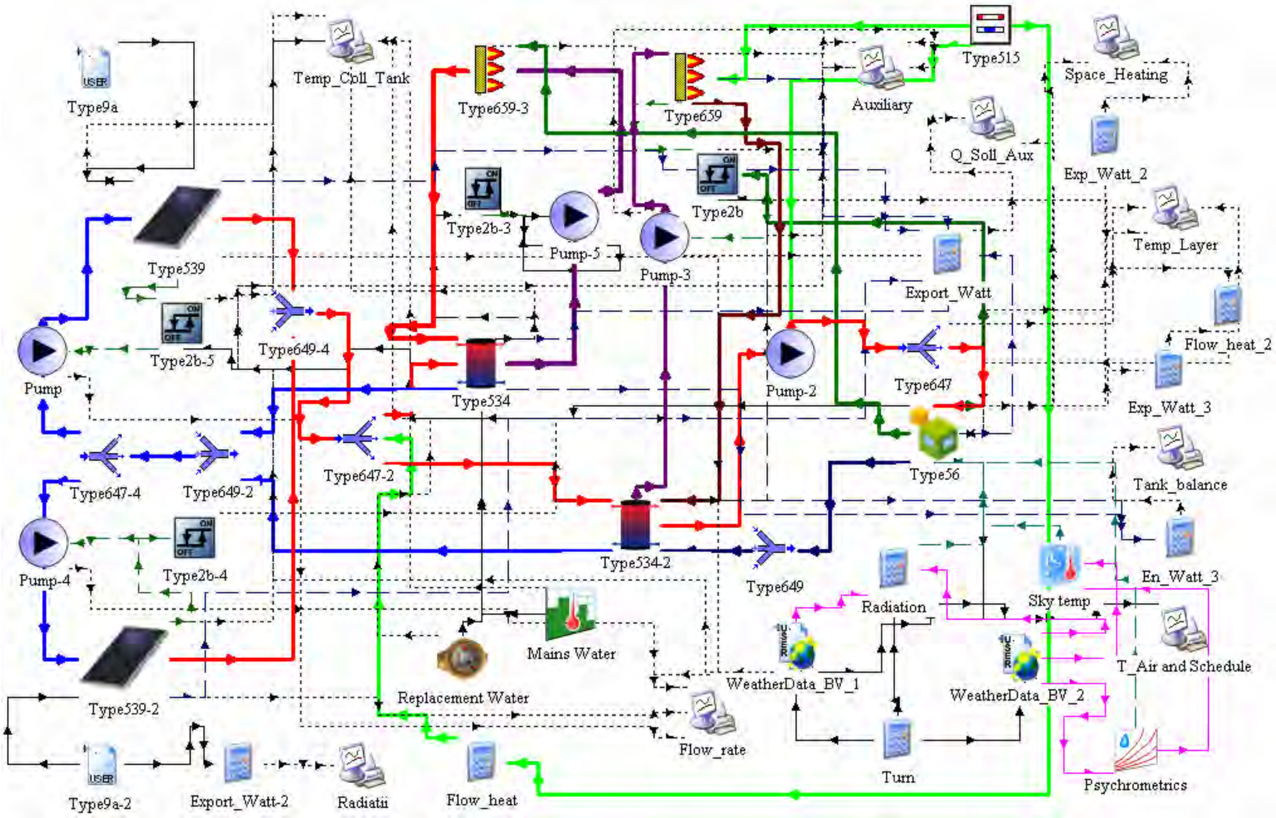


Figure 5. TRNSYS model of the experimental solar-thermal system

Following simulations, the value of fractional thermal savings was 12.42% for the situation in that the solar energy was used both in the circuit of space heating and in that of hot water supply respectively 10.98% for the situation where the solar collectors were used only in the circuit of hot water supply.

Analysing the solar energy gain provided by the solar collector fluid (for the two connection schemes of solar circuit – Figure 6) it can be noticed that the value of solar energy gain provided by the scheme "a" is 3288 kWh compared to 2955 kWh for scheme "b".

In percentage terms, during months of January, February, March, October and December, the monthly values of solar energy gain provided by installation under the scheme "b" may be higher with 20% - 37% than those for the installation "a".

During May to September, between the two connection schemes of solar circuit, the differences between the solar energy gains are unimportant (monthly values of fractional thermal savings are between 85% and 97%).

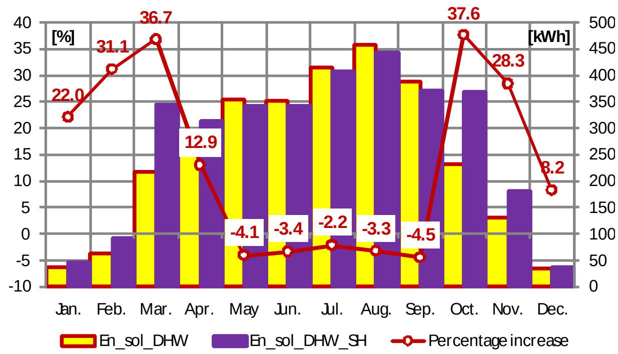


Figure 6. Solar energy gain supplied by solar thermal installation using two connection schemes of solar circuit

5. Conclusions

With the computerized tools, different energy saving options can be evaluate before deciding to implement one of them; energy simulation is a useful tool for the better understanding the behaviour of the building.

The use of specialized software for building energy simulation (TRNSYS) enables accurate calculation of the energy needs; it is taking into consideration that the classical methods of calculating the heating requirements using constant average temperatures that are much below the actual values recorded and for the a long time, leads to an over-sizing of solar thermal installations.

The worded conclusions – based largely on measured data processing – open new perspectives of expansion of theoretical and experimental research, one of them consisting of finding solutions to increase energy efficiency at the level of solar thermal installation.

References

1. Eftimie, E. (2011) *Estimating clear sky solar radiation using Linke and ngstrom turbidity coefficients in Romania*. Journal of Energy and Power Engineering, ISSN 1934-8975, no. 5, p. 29-41
2. Eftimie, E. (2009) *Radiative Parameters Specific to Braşov Urban Area*. Recent Advances in Environment, Ecosystems and Development, ISSN 1790-5095, p. 208-211, Puerto De La Cruz, Tenerife, Canary Islands, Spain
3. Hensen, J.L.M. (1995) *On System Simulation for Building Performance Evaluation*. 4th IBPSA World Congress on Building Simulation '95, Madison. Available at: http://www.bwk.tue.nl/bps/hensen/publications/95_ibpsa_syssim_for_bpe.pdf. Accessed: 07/05/2013
4. Ilina, M., Berbecaru, D. (2002) *Manualul de instalaţii. Instalţii de încălzire (Installations handbook. Heating installations).* Artecno, ISBN 973-85936-1-1, Bucureşti, Romania (in Romanian)
5. Letz, T. (2002) *Validation and background information on FSC procedure.* A Report of IEA SHC - Task 26 Solar Combisystems. Available at: http://www.aee-intec.at/0uploads/dateien51.pdf. Accessed: 07/05/2013
6. Marcu, M., Huber, V. (2003) *Air Thermal Stratification in the Depression Area Forms. "Depression Effect". Phytogeographical Implications*. Anale I.C.A.S., ISSN 1583-2023, Vol. 46, p. 141-150
7. Şerban, C., Eftimie, E. (2012) *Annual Energy Performance of Solar Thermal Systems in Braşov, Romania*. Bulletin of the Transilvania University of Brasov, Series I: Engineering Sciences, ISSN 2065-2119, Vol. 5 (54), no. 2, p. 39-46
8. Şerban, C., Vişa, I., Eftimie, E., Coste, L. (2011) *Energy simulation of a building in Braşov urban area*. Proceedings of 26th European Photovoltaic Solar Energy Conference and Exhibition, ISBN 3-936338-27-2, p. 4084-4088, Hamburg, Germany
9. Wang, H., Qi, C., Wang, E., Zhao, J. (2009) *A case study of underground thermal storage in a solar-ground coupled heat pump system for residential buildings*. Renewable Energy, ISSN 0960-1481, Vol. 34, Issue 1, p. 307-314
10. *** Normative Mc001/1 (2007) *Partea I – Anvelopa clădirii* (*Part I - Building envelope)* (in Romanian)
11. *** Normative Mc001/2, 3 (2007) *Partea a II-a - Performanţa energetică a instalaţiilor din clădiri. Partea a III-a - Auditul şi certificatul de performanţă energetică a clădirii* (*Part II - Energy performance of installations in buildings. Part III - Audit and energy performance certificate of buildings)* (in Romanian)
12. *** Normative Mc001/4 (2009), *Partea a IV-a – Breviar de calcul al performanţei energetice a clădirilor şi apartamentelor (Part IV - Summary of calculating the energy performance of buildings and apartments)* (in Romanian)
13. *** STAS 1478-90. *Alimentarea cu apă în construcţii civile şi industriale (Water supply in building and civil engineering)* (in Romanian)