Possibility of Modeling of Solar Collectors systems in Latvia

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ABSTARCT

The aim of the work is to explore suitability of Latvian environment to the usage of solar collectors system. For the attainment of objective monotype house will be modeled, the house will be equipped with the combined solar heat system, which will be placed in different regions. There are diverse amount of sunny days in different regions, as well as diverse average temperature, wherewith the amount of heat differs. For the modeling of building, modeling program model of solar collectors will be used, which is provided for several solar heat systems, inter alia for the calculation of combined solar heat supply system and for the solving of several relevant tasks. Wherewith results are achieved, after analysis of results it is theoretically possible to clarify suitability of specific system to specific place.

INTRODUCTION

Wherewith, activation of environmental problems increases humans' interest about different environmentally friendly technologies. One of the biggest air polluters are fallouts resulted from burning of fossil firing. That is why urgent becomes utilizations of renewable land resources for the energy obtaining, which are less nocuous to environment. Exactly the Sun is large, inexhaustible source of energy, from which we use only small part. There are countries which are located in sunny regions and which history of solar energy usage is very longstanding, wherewith also technological achievements are high, yet our contemporary rapid technology development enables to use ever more solar energy in the regions which are not so rich with the solar radiance, for example in Latvia. Interest about the usage of solar energy in Latvia increase – partly it is explicable to unpredictable and essential price rise of fossil firing resources and partly to the desire to invest in technologies which could reduce this rise in price in the future.

SUITABILITY OF LATVIAN ENVIROMENT FOR USAGE OF SOLAR HEAT

Comparatively, effective solar radiation may catch solar collector that is placed 55° anent to horizon or slope and 0° anent to the South or orientation and which has clean horizon, nothing puts a slur and otherwise do not effect the activity of collector, that is why received amount of solar heat takes as average from all models that are placed in corresponding place and location. It is obvious that greatest received solar heat in Riga is when solar collector is located 55° anent to horizon and 0° anent to the South.

Table 1 Percipient heat volume from 1 m^2 of solar collector in Riga dependance of location, kWh/m^2

N.r.	Orient.\ slope	0°	15°	30°	45°	55°	60°	75°	90°
1.	0°	259	325	382	417	426	425	401	348
2.	15°	259	320	376	412	422	423	406	359
3.	30°	259	325	380	412	417	414	385	324
4.	45°	259	310	362	396	407	408	395	357
5.	60°	259	322	370	396	397	393	358	294
6.	75°	259	297	341	370	380	381	370	335
7.	90°	259	314	355	373	369	363	325	262

As it was previously clarified, that such location is the most effective and in the table 1 there are the same data, then we can conclude that program *Polysun 3.3* is comparatively precise for the calculation in the Latvia conditions. The least received heat volume is when the solar collector is located 0° anent to the Earth horizon. This location is the most inappropriate for the detection of solar radiance. To 0° anent to horizon at any orientation, the volume of received heat is constant, because ray angle falling form the Sun anent to the area is constant at any orientation of solar collector. It is clearly seen how volume of received heat change and its changes are twice as much bigger, therefore the precise setting up of solar collector has significant meaning. Although this calculation was done only for one type collectors, though the calculation corresponds to previously defined, we can conclude that in wholesale it is similar to all collectors.

METHODS

It suits both for determination of hot water use and heating system use. Polysun 3.3 is practical tool in order to calculate parameters of solar heat system, and they are figured in graphics. With the help of this program it is possible to carry out research, the modeling, the calculation of heat supply solar systems. Initially combine desirable system, then enter necessary parameters for each part and then receive results through simulating, which help to determine the effectiveness of simulating system. When any component is changed it is visible that all effectiveness and productivity of the system is changing. It is possible to create new components of the system which may be introduced in life after successful modeling. Simulation of all type heating supply solar system is based on independent meteorological data. Time step of simulation is possible starting with one second even until one hour, it depends on situation, in its turn, there are a lot of versions of model simulation time periods – starting from one day until several years. The calculation basis in Polysun 3.3 program has been integrated from subprograms Meteonorm 95.

RESULTS

Since program Polysun 3.3 isn't potted to the conditions of Latvia, there isn't meteorological data, which are necessary for activity stimulating of the combined heat supply of solar system in the Latvian conditions in its data basis. Therefore initially it is necessary to use subprogram Meteonorm 95. Since this program contains meteorological data from all world, in order to get this necessary information, accurate coordinates from different towns of Latvia, which are located in different zones of sun shining: Riga, Liepaja, Daugavpils has been entered.

When exact coordinates has been entered Metenorm 95 defines, both average temperature at day, month and year, and direction and power of wind. For the more visible efficiency determination of heat supply solar system, also coordinates of typical sunny south city Bremen (Germany) and cool northern city Boden (Sweden).

Those data of communities that are used for the modeling of combined solar heat supply system enter in program Polysun 3.3 and they are shown in table 2.

Table 2 Meteorological data for Meteonorm 95

Nr.	City, State	Latitude	Degrees of longitude	Elevation above see level
1.	Riga, Latvia	56,88°	-24,13°	14 m
2.	Liepaja, Latvia	56,49°	-21,02°	1 m
3.	Daugavpils, Latvia	55,87°	-26,52°	105 m
4.	Bremen, Germany	72,80°	-12,58	121 m
5.	Boden, Sweden	65,78°	-21,67	31 m

In order to see more foreseeable the chosen place, they are figured in the map of Europe in the figure 3.

Initially model one family building with the floor space 150 m^2" 4 persons will live in that building. Heat loss through demarcation constructions of building (external walls, roof, windows etc.) makes essential part form total use of heat energy. Power efficiency of demarcation constructions is able to evaluate when thermal coefficient of given construction is U (W/m^2K). Because in Latvia there is relatively cool climatic conditions, than building must be well isolated with heavy constructions. Walls are made form bricks and from outside they have 0,2 m heavy insulation.
Air exchange 0,6 l/h and radiant - 400W. Heat capacity 64621 Wh/K. Required heating capacity 6.1 kW at -8°C.

Looking closely at balance sheet of used and acquired heat of each place we can conclude that in all chosen places development of heat use during year is similar, only volume of heat differs.

Table 3 Heat energy consumption for space heating depending from location, kWh/m^2 per year

Nr.	Location	Common use of heat energy for room heating (kWh/in year)	Use of heat energy for room heating on 1 m^2 (kWh/m^2 in year)
1.	Riga	12650	85
2.	Liepaja	12500	80
3.	Daugavpils	13615	92
4.	Bremen	9652	65
5.	Boden	27342	182

It is visible, that in warmer climatic zone use of thermal energy reduces. Because Bremen is located closer to equator and its average temperature is superlative for all viewed cities, for that reason required volume of thermal energy is the least. Yet looking closely at Boden, which is located close to the North, we can conclude that it is contrary. Distinction among Riga, Liepaja and Daugavpils brings about location of those towns' towards the sea. Temperature at the sea in winter is warmer wherewith volume of thermal energy for room heating is different, yet towns are located relatively close to each other, wherewith volume of thermal energy is not very different. As in the building lives 4 persons and it is known that on one person provides 2 m^2 solar collectors, than for the building model use 8 m^2 flat area collectors.

The name of collectors type and other parameters which helps to determine efficiency of collector. Efficiency depends on variable, which we will letter x. wherewith efficiency will be function from x. Function is second round polynomial with indexes c_0, c_1 and c_2:

$$\eta = c_0 - c_1 x - c_2 G_k x^2 \quad (1.)$$

where η – efficiency of collector; c_0, c_1, c_2 – coefficient of polynomial set in model; G_k – tightness of solar radiation, that falls athwart to the surface of collector,

$$x = \frac{T_m - T_a}{G_k} \quad (2.)$$

where *Tm* – collector flux in fluid temperature; *Ta* – average temperature.

It is worth to mention that such polynomial is used in modeling program Polysun 3.3 for the calculation of efficiency. In case we calculate real building model then the number of module planch must be only whole number. The total area of collector modules is 8 m^2. Previously we found out that solar collector works most effective when its slope angle is 55°C anent to horizon and 0°C anent to the South. We estimate position along vertical of solar collector modules. Horizon is taken as clean without shadows on the absorber area of collector. Wherewith, we can define thermal conductivity and thermal capacity of pipes, as well as the stream speed in pipes.

Program Polysun 3.3 also offers possibility to determine other parameters. For example, pump and system described values are calculated automatic after input of necessary data. In this case inputted values are the following: flow of pump, flow speed of there process120 l/h, and back process 0,06 m/s.

Usually water is used like heat carrier, due to its availability, low price and suitable physical qualities. In combined heat supply solar systems, water can be used only in the inner supply of heat and water. For the very reason in Latvia conditions pipes are excluded as heat carrier in exterior contour. Therefore glycol solutions must be chosen as the heat carrier in pretence model. Necessary volume of heat for the preparation of hot water in all climatic conditions is nearly identical– 4069 kWh in a year.

In some places suspended volume of solar heat is different. They are described in table 4.

Table 4 Perceptive solar heat volume, kWh/per year

Nr.	Place of location	Volume of perceptive solar heat (kWh/per year)	Percent volume of solar heat form one m^2 (kWh/in a year)
1.	Riga	3200	400
2.	Liepaja	3345	418
3.	Daugavpils	3165	395
4.	Boden	2930	366
5.	Bremen	2890	360

Conclusion is that it is not possible to unequivocal assert that solar collectors works more effective closer to the South and to the North they do not work effective. The most effective works solar collector that is located in Riga and not the solar collector in Bremen that is closer to the South. It is explained by the less requirement of system for room heating, because during the year in all models the volume of warm water for the preparation of hot water and containers heat loss is equal. In a period when room heating is necessary but available volume of solar heat energy is sufficient not only for the preparation of hot water but also for the room heating, combined solar system has been used valuable. In the Northern models such periods are longer, wherewith the volume of used solar energy is greater. Riga's model in comparison with Bremen model volume of used solar energy is greater, because the air temperature in Bremen at the beginning and at the end of the year is a bit lower, but available solar heat is greater, wherewith the volume of used solar thermal energy increase.

In all versions the volume of produced heat in auxiliary boiler is greater than necessary for the building. It is explained by the extra load of auxiliary boiler for the production of hot water. Because several simulations with different combinations has been carried out with different capacity auxiliary boilers and electricity, then average result has been accepted as the volume of produced heat of auxiliary boiler.

In existing versions of auxiliary boilers more to the North, the volume of produced heat increase on the count of necessary volume of the heat for the production of hot water. At the beginning of colder season auxiliary boiler has been started later, because sufficient volume of the heat is stocked up in the container, which ensures room heating and preparation of hot water for the short period. In that way heat has been stocked up for the later use, which is on of the formation preconditions of the combined heat supply solar system.

It is not important to evaluate the productivity of solar collector but the relations of produced capacity in the power balance of the building. Therefore it is necessary to look at figure 3. As models of Riga, Daugavpils and Liepaja is relatively similar and let the chart is more obvious only Riga, Bremen and Boden will be compared.

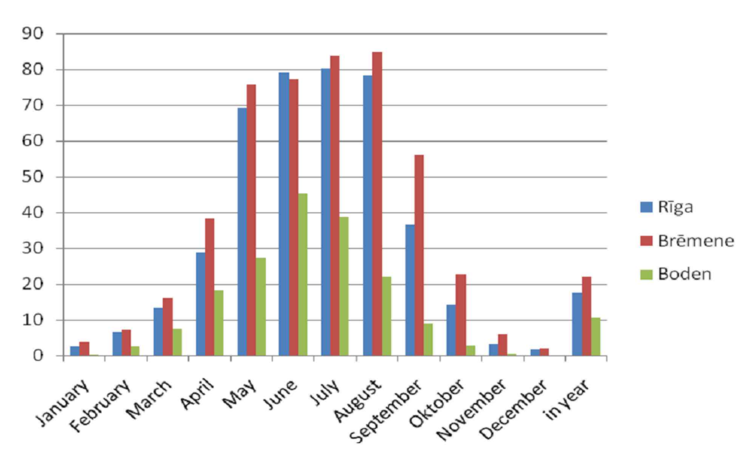

Figure 3. Percentage of produced heat from solar collector, %

In accordance with the figure, we can conclude that solar collectors may cover the necessary volume of heat during the summer month. Capacity of heat is not necessary for the room heating during the summer month, capacity of heat is necessary only for the preparation of hot water. It is important that solar collectors of Riga's model produce practically the same volume of heat energy from building heat balance as it is in Bremen. The decrease of heat volume necessary for room heating reflects not only in the volume of used heat but also partly in not received volume of solar heat. In its turn, the volume of solar heat that is used in the preparation of hot water is growing, because the volume of solar heat is available. For that reason the bigger part of the solar heat energy is observed in used volume of heat. Important conclusion in that during the cooler month (November, December, January and February) volume of received heat is minimal and very similar to all viewed models. Consequently during those months combined solar heat supply system has reduction of usefulness. Probable it is worth to consider on solar collector unlock during the cooler season, in such a way raising its usefulness. Though already in early spring solar collectors may provide 30% from the use of building heat for the room heating and hot water.

CONCLUSIONS

The activity of the system depends on the weather conditions of particular place, which have an impact of the geographical fix, available volume of solar heat. It depends also on the individualities of particular place: the hills, the sea etc. The systems used in simulation model are relatively simple and do not show maximal benefits form such systems but it gives little insight into overall workings of the system and shows possible benefits from the formation of such system. Perceived volume of solar heat is considerable in the comparison with the other world.

The greatest volume of perceived solar heat in Riga is in the situation when solar collector is placed 55° against horizon and 0° orientation against the South.

Innovations in the framework of heat storing containers are capable to reduce heat loss until the minimum, wherewith solar heat perceived during the summer will be capable to store heat until the winter. Usage of solar energy has great perspective both in Latvia and in the world.

REFERENCES

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