Modeling of Solar heating systems in Latvia

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SUMMARY

Volatility and rising of fossil fuel price affected interest about solar energy usage in Latvia and partly desired to invest in alternative technologies.

The aim of paper is to investigate the Latvian environmental propriety for solar interceptor systems. To achieve objectives in the modeling program is designed for family home project; a house will be equipped with the combination solar thermal systems. The model of program houses will be placed in different areas at different solar luminescence intensity. Modeling program has been designed to simulate the combination of solar heat supply system and to address more important tasks. Depending on the input data model make simulation considering of model virtual location. Consequently, the results have been achieved that is why theoretically possible to determine the suitability of scheme in a specific place.

INTRODUCTION

Now in sight is activation of environmental problems increases humans' interest about different environmentally friendly technologies, as wind, earth heat, biomass and Solar heat. Exactly the Sun is large, inexhaustible source of energy, from which we use only small part. Solar energy use technologies are striving to deal with the fast-growing energy demand. Solar thermal systems are particularly important for solar heating, hot water preparing and even cooling that for many countries is very actual now. Solar thermal systems need a solar collector that guarantees substantially safe and effective operation. Besides the specific costs of the collector field also aspects like the resulting collector area and suitable collector technology for a specific system have an influence on the decision for a certain collector types. 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.

SOLAR HEAT USAGE IN LATVIAN ENVIROMENT

Each year Earth receives from the Sun 15 000 times more energy than produce all power industry. The main factors that somewhat impacts utilization possibilities of solar energy in Latvia are stereotype that in Latvia there is less sun unlike to countries located closer to equator. The amount of solar energy is variously available in some latitudes. The history of the usage of solar energy is very short in our country and that is why people do not believe in it. However, it has to change. Moreover, the third factor that influences the tendency towards usage of solar energy is legislation or involvement of government, as well as the interest of companies that has increased substantially in the last few years because of the technology development and increase of fund and it is predictable that this tendency will continue. [5]

Global radiance consists of direct and diffused radiance. Direct radiance is connected with the direction of sunbeams. Diffused radiance develops when molecule and particles in atmosphere disperse sunbeams in all directions. The duration and intensity of solar radiance depends on season, climatic conditions and geographical location. Global radiance of the earth on the horizontal area in the regions of solar zone may reach 2200 kWst/m$^{2.}$ Maximal volume of solar radiance in North Europe is 1100 kWst/m^2. [5]

Solar radiance in Latvia conditions may be uses 1700 till 1900 hours.

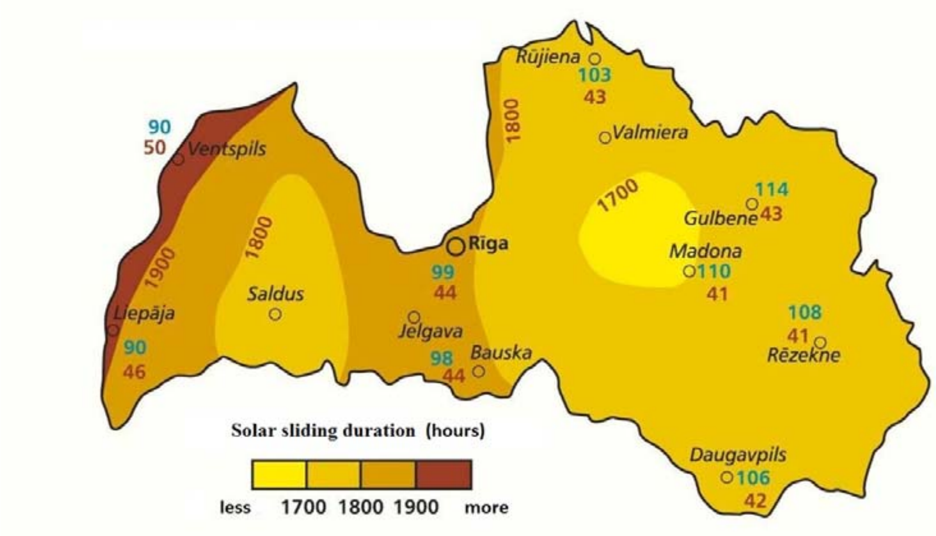

Figure 1. Solar sliding duration in area of Latvia

In accordance with figure 1 we can conclude that even in such small country as Latvia are several different solar sliding duration zones. In the zone along the Baltic Sea is the longest solar sliding duration – more than 1900 hours, in its turn in Vidzeme heights it is the least – less than 1700 hours. [5]

Volume of Solar radiance is the main factor of solar energy usage in Latvia.

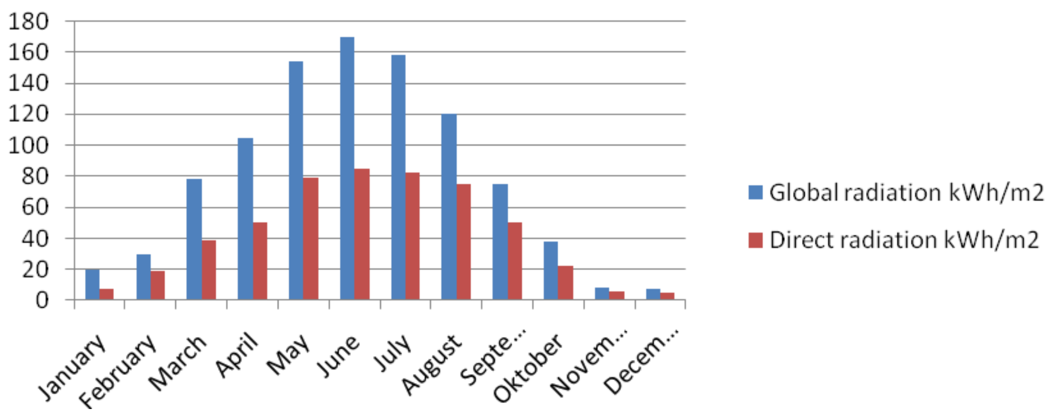

Figure 2. Solar radiation energy in Latvia [5]

In the *Head of Resources Laboratory Institute of Physical Energetic* new researches have been carried out about output of new type solar collector with high heat transmission, as well as in collaboration with production company *Energy-R,* experimental and industrial solar collectors for the output of hot water have been developed up. It is possible to fit out all concerned persons with those collectors, their expenses approximately is 50 –60 Ls/m^2. In *FEI* several versions of combined systems have been carried out, in order to use solar energy together with traditional energy resources (gas, heating oil or electricity). [5]

Table 1. Volume of Solar radiation on horizontal collector plate kWh/m²

Location	LAT	January	February	March	April	May	June	July	August	September	October	November	December	Per year
Berlin	52,6	18,3	31,8	75,5	116,2	147,7	163,1	163	137,4	91,4	49,4	22,7	14	1031
Copenhagen	55,8	14,2	30,4	69,1	112,3	156,8	181	157,4	127,4	89,5	45,9	18,1	10,9	1013
Riga	57,2	12,1	28,6	79,1	120	170,3	206,3	192	146,5	87,0	43,3	15,4	9,1	**1109**
Stockholm	59,4	10,4	26,7	69,3	110,3	164,1	197,3	173,1	135,7	80,9	37,2	13,7	7,2	1026
Helsinki	60,3	8,6	23	64,6	105,6	162,1	191,7	180,1	132,9	73,6	33	9,6	4,5	980

Compared Riga with Berlin, Helsinki, Stockholm and Copenhagen volume of average solar radiation is the most biggest. In Riga average solar radiation is 1109 kWh/m², Copenhagen 1013 kWh/m², Stockholm – 1026 kWh/m², Helsinki – 980 kWh/m² and in Berlin 1031 kWh/m². There are several countries where solar energy have been used for centuries.

There is theoretical posibility that solar collector may covered heat consumption of all living house, bet such kind project is too expensive aun complicated.

In Latvia, some scientist made teoretical estimate, that combisystems are most effective for not so big family houses (one family or 2-3 family)

Table 2. Inclination angle of solar collector

Inclination angle to the horizontal	0°	15°	30°	45°	60°	75°	90°
Heating	0,71	0,85	0,94	1,00	1,00	0,98	0,88
Heating and DHW	0,59	0,74	0,89	1,00	1,06	1,06	0,97

Table 3. Orientation of solar collector

Deviation from the south	0°	15°	30°	45°	60°	75°	90°
Heating	1,00	0,99	0,97	0,93	0,88	0,81	0,73
Heating and DHW	1,00	0,98	0,95	0,89	0,81	0,73	0,64

Looking at table 2. which shows the quantity of heat dependence on solar collector inclination angle, and Table 3. which shows the amount of heat, depending on the location of solar collector orientation, we can conclude that the combined solar heating system successfully work in the importance are location of solar collector.

Through research, where the collector was positioned at various angles, both to the ground (tilt angle), and against the south (azimuth angle of a turn or collector), reach the conclusion that the greatest uptake of solar radiation amount is when the solar collector is placed directly on the south or the azimuth angle is 0 ° and the tilt angle is 55 °. Data about the volume of receivable heat from 1 m^2 solar collector that depends from location, to be more precise in what angle as to the ground it has been put and in what orientation as to the South solar collector will catch the greatest volume of heat, has been put in the table. Data defined with program is summarized in the first table. 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.

METHODS

Modeling program makes the design of solar thermal systems simple and professional. Reliable yield-forecasts generate trust and promote the understanding of solar thermal systems. Detailed illustrations of the system within the simulation lie at the basis of a targeted system optimization and fair system comparisons. The convenient modular unit construction system allows the combination and parameterization of different system components through simple menu prompts. Operation with solar thermal systems modeling program is relatively simple but very effective. 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. Than data are compiled, analyzed and structured until it is getting possible to make resolution about solar energy usage in Latvia.

RESULTS

In order to define, how great volume of heat from building total use of the heat is possible to secure using solar heat energy, the model of the building will be created using modeling program. 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. 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). Wherewith, computer models will be created for different climatic zones and conditions in the European Union countries. Those data of communities that are used for the modeling of combined solar heat supply system enter in program and they are shown in table 4.

Table 4. Meteorological data for Meteonorm 95

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

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). However, program Polysun 3.3 offers already ready types of building models with already stated heat conductance of demarcation construction. Because in Latvia there is relatively cool climatic conditions, than building must be well isolated with heavy constructions.
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 5. Heat energy consumption for space heating depending from location, kWh/m^2 per year

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)
Riga	12650	85
Liepaja	12500	80
Daugavpils	13615	92
Bremen	9652	65
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 collector, than for the building model use 8 m^2 flat area collectors. It is worth to mention that such polynomial is used in modeling program Polysun 3.3 for the calculation of efficiency. Total area of collector module. 3,2 modules of solar collectors have been set up. It is not important that number of modules is not whole number, because calculation is theoretical. 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. The required volume of hot water for one person is 480 L. So that hot water temperature is 50 °C, but cold water temperature is 10°C, then we presume that required volume of hot water will be 240 L and volume of cold water will be 240L.

Program Polysun 3.3 also offers possibility to determine other parameters. Usually water is used like heat carrier, due to its availability, low price and suitable physical qualities. Though, water can be used only in rooms where water cannot freeze. 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.
*volumes regarding thermal capacity when its temperature is, 50°C

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 6.

Table 6. Perceptive solar heat volume, kWh/in a year

Place of location	Volume of perceptive solar heat (kWh/in a year)	Percepted volume of solar heat form one m^2 (kWh/in a year)
Riga	3200	400
Liepaja	3345	418
Daugavpils	3165	395
Boden	2930	366
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. As it is seen 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 one 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.

Table 7. Summarize of different models

Charasterisitcs	Without heat exchanger	With one heat exchanger	With two heat exchanger
Heat directly from solar collector	3121	2994	3362
Heat directly from auxilary heater	14514	15821	15737
Heat loses in tank	1389	1070	1300

From this table we conclude that the heat storage tank heat loss is smallest when the system has been equipped with heat exchanger - hot water. By contrast, the greatest loss model has when in heat transfer takes place in hot water storage tank through the insert in hot water tank. However, the heat transfer solar collectors system is most effective in the third case, when the system is equipped with 2 heat exchangers. Previously was found how to place the solar collectors to receive the maximum amount of solar radiation. Was determined most economically advantageous secondary boiler, but the system also affects the handling characteristics, such as heat exchangers. They fulfill the important function as a heat-transfer. Need to know how important it is, whether the resulting solar collector heat storage tank is given by the mixing of heat already is there or whether the fluid is more effective when the heat from the solar collector storage tank into the system through a heat exchanger.

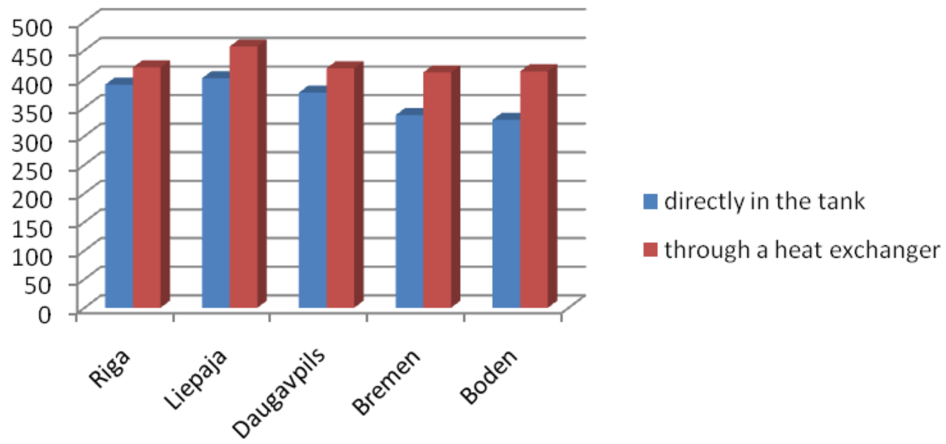

Figure 2. Heat quantity W/m^2 depending of heat transforms type in system

After the figure viewing can be seen that the heat transfer from the solar collector system to the heat storage tank through a heat exchanger is about 14% efficiently than in cases where heat transfer occurs mixing of solar collector fluid transforms the heat in the tank. This is explained by the fact that the liquid flowing through the heat exchanger is less than the local losses. As well as more efficient heat exchange takes place.

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. To be more precise solar collectors in Riga's model produce more heat energy than Bremen model but heat loss of building is greater in Riga. 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 is 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. The volume of suspended solar heat do not show real possible volume of solar heat energy that may be used, because conveying of solar heat energy to the storing container happens during almost all light period of day, only disconnecting circulation pumps of model in short periods.

CONCLUSIONS

The System operation is dependent on weather conditions, particularly in areas that impact on the geographic extent available solar heat. It depends on the individualities of specific places: mountains, sea, solar intensity etc. Consequently, compared with the simulation models, which are located in different places, it is generally accepted. Systems using simulation model is relatively simple and do not show the maximum benefit from this system, but only provides insight into the general work of the system and demonstrates the potential benefits from the formation of such a system. Latvia has a great potential for using solar energy. Perceived amount of solar heat is significant compared to the other world. It is beneficial to maximize the solar collector, while continues rapid increase of produced solar energy. After starting in pursuing the asymptotic values of the required hot water, it is advantageous to increase the area of solar collectors, since the experience does not refute the energy costs incurred in setting up solar collector. Received the largest amount of solar heat in Riga is a situation where the solar collector is 55 ° from the horizon and 0 ° orientation to the south.

The heat transfer from the solar collector system to the heat storage tank through a heat exchanger is about 14% efficiently than in cases where heat transfer occurs mixing of solar collector fluid transforms the heat in the tank. This is explained by the fact that the liquid flowing through the heat exchanger is less than the local losses. As well as more efficient heat exchange takes place.

Every day, innovations have been introduced and more efficient solar collectors perceive solar radiation and convert it requires energy. Innovation in the heat of containers can reduce heat losses to a minimum, thus the solar heat received during the summer will be able to keep the heat up for winter.

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