ANALYSIS OF SYSTEMS FOR DOMESTIC HOT WATER PRODUCTION USING SOLAR ENERGY

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1. INTRODUCTION

The different tourist servives are connected to significant energy costs. Energy production in its conventional forms is associated with environmental problems. The alternative use of electricity is not economical. The renewable energy sources are one of the possibilities to improve the heat production technologies.

The main aims of the study are analysis of the hot water consumption in short and long term in the hotels "Kaliakra", "Dobrotitsa" and "Tervel" in Albena Resort. Synthesis of solutions for hot water reqirements satisfaction by solar instllations, economic analysis of the variants for prognosis of investment and operational costs, profit within installation life-time, analysis of the invetsmet parameters for efficient use of solar energy for domestic hot water production.

2. STRUCTURAL DESIGN OF SOLAR WATER HEATING ISTALLATIONS

It is foreseen to apply indirect active solar systems for hot water production with heat accumulators. The structural designs of solar installations are developed on the basis of analysis of type of hot water consumers in the investigated hotels, life-time of the installations, existing sub-stations, pre-determined supplementary energy source – electricity. Recommendations and results of large scale solar thermal installations have been used.

In the study are used *flat solar collectors* with the following parameters: selective abosrber plating, overall losses coefficient 5.0 W/m²C, relative absorbing capacity of 0.750.

3. ANALYSIS OF THE COVERAGE FACTOR FOR THE INVESTIGATED INSTALLATIONS

Average daily consumption of hot water is forecasted in compliance with the norms in force and with the information obtained from the hotel administration about the average monthly occupancy of the hotels. The forecasted maximum overall hot water consumption in the investigated hotels is: "Kaliakra" - 42 000 l/day; Dobrotitsa" - 21 000 l/day; "Tervel" - 34 125 l/day.

The diversification of consumers' specifics and the dynamics of hotel occupancy require to assess different variants of solutions for the installations.

The analyses have been performed using a software, based on the developed by Univercsity of Wisconsin, Solar Energy Laboratory, USA, F-chart method for long-term assessment of active solar thermal systems. Integral data are used for the real climatic conditions in Varna. The close distance between Varna and Albena Resort and the similarity of the geographic situation give us the justification to consider that there should not be any significant differences in the integral climate characteristics.

"Kaliakra" Hotel. The solar installation is operational only during the tourist season. Variants with different number of collectors (from 50 to 250) have been investigated. The choice of installation with 150 collectors complies with the requirement for annual coverage factor *f~0.5.*

"Dobrotitsa" Hotel. The solar installation is operational only during the tourist season. Installations with different number of collectors (from 50 to 250) have been investigated. The annual coverage factor reaches 0,5 at solar installation with 80 collectors.

"Tervel" Hotel. Solar installation with flat solar collectors operational during the tourist season. Installations with 75 to 175 collectors have been investigated. The annual coverage factor reaches 0,523 at solar installation with 125 collectors.

4. INVESTMENT AND OPERATIONAL PARAMETERS OF SOLAR THERMAL INSTALLATIONS

The economic analyses are aimed at comparing alternative solutions and choosing the most profitable variant for a solar installation. There are three methods used for the economic evaluation: pay-back period, profit during the life-time and benefit-cost ratio (BCR), used in the economic appraisal. These methods assure reliable quantative assessments of investment efficiency.

The main parameters, ased as a basis for the economic analysis, are :

Electricity price - 0.09 Lv./kWh; annual electricity inflation – 10.0 %; economic appraisal life-time – 20 years; initial investment – 100 %; annual loan interest - 7.0 %; loan repayment period – 5 years; discount rate - 7.0 %; operation and maintenance costs - 1.0 %; annual inflation of operation and maintenance costs - 7.0 %; tax for building improvements - 0.5 %; annual tax inflation - 7.0 %; salvage

value– 50 %; price for unit area of flat collectors - 260 $/m^2 .

The final results of the technical and economic parameters of the investigated variants for the hotels "Kaliakra", "Dobrotitsa" and "Tervel" are shown on the folowing table.

The following variants have been accepted as most economically viable: "Kaliakra" Hotel - Variant К-1 with 150 solar collectors; "Dobrotitsa" Hotel – Variant Д-1 with 100 flat solar collectors; "Tervel" Hotel - Variant Т-1 with 100 flat solar collectors.

Economic indiactors for the hotels "Kaliakra", "Dobrotitsa" and "Tervel"

Hotel	Variant	Type of solar colectors	Technical parameters				Economic indicators				
			Energy			Coverage factor	Investments	Fuel savings value	Pay-back period	Profit (LCS)	(BCR)
			Consumption	Yeild of solar installation	Supplementary source						
		Number	GJ/year	*GJ/year*	*GJ/year*		USD	USD	Years	USD	
Kaliakra	К-1	150	1016.8	534.8	482	0.525	78000	8279	9.4	164126	2.1
	К-2	100	1016.8	380.8	636	0.375	52000	5904	8.8	121245	2.3
	К-3	200	1016.8	665.8	351	0,651	104000	10316	10	196658	1.9
Dobrotitsa	Д-1	100	504.5	332.5	172	0.659	52000	5152	10	98150	1.9
	Д-2	80	504,5	281.5	223	0.557	41600	4356	9,6	85711	2.1
	Д-3	120	504.5	377,5	127	0,748	62400	5850	10,6	107555	1.7
Tervel	Т-1	100	826.9	360,6	466.3	0.436	52000	5028	10.3	94345	1.6
	Т-2	125	826.9	432.8	394,1	0.523	65000	6036	10.7	110261	1.5
	Т-3	200	826.9	498.7	328,2	0.603	78000	6955	11.2	123464	1.4

5. SENSITIVITY ASSESSMENT

The influence of the variable economic parameters on the investment efficiency and on the fluctuations of the profit during the life-time (LCS) has been investigated.

The following parameters influence has been investigated: initial investment; loan interest for installation construction; energy prices increase. Similar results have been obtained also for the other investigated systems. The results show that for all of them the factor LCS remains positive and there is no risk for the investment when the economic parameters vary within the limits [-50÷50] %.

6. SUMMARISED ECONOMIC ASSESSMENT

The investigation results show that solar energy utilisation for domestic hot water

production is economically profitable. For all systems a satisfactory coverage factors has been reached and the ratio BCR is greater than 1. The variation of the parameters influencing the LCS factor is not risky for the investment. Indisputably solar energy could be alternative energy source, which utilisation alongside with the economic efficiency has also positive environmental effect. The price of the collectors and elements for solar energy use has reached real market levels. Due to this fact the solar energy installation pay-back period is realtively high – in this case varies from 5,1 to 11,2 years.

The influenece of invetsment variation on LCS factor has been assessed. For this purpose the initial investment and the loan interest have been changed within the limits [0÷-50] %. This leads to significant increase of savings for the life-time period, and respectively in improving the rest of the criteria for efficiency assessment of the investment (pay-back period, BCR).

7. CONCLUSION.

The possibilities for solar energy utilisation for hot water production in the hotels "Dobrotitsa", "Kaliakra" and "Tervel" in Albena Resort has been investigated. A multi-factor simulation assessment of the energy charachterics of solar installations has been done. The choice of the optimum variants was done based on economic analysis for forecasting the investment and operational costs and the profit during the installation life-time. It is proved that the climatic conditions in the complex make economically viable hot water production from solar installations. The variations of profit have been investigated at different investment parameters. Prerequisites for environmental protection within Albena resort are being created.