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"WIDENING THE USE OF EUROPEAN SOLAR THERMAL TECHNOLOGIES IN MEDITERRANEAN COUNTRIES FOLLOWING THE SUCCESSFUL MODEL OF GREECE AND CYPRUS. PART B: I, F, RO, BG, TR"

Bulgarian Solar Thermal Market and Technology Assessment Report

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Acronyms and Abbreviations

DHW	Domestic Hot Water
R&D	Research and Development
RES	Renewable Energy Sources
TPF	Third Party Financing
Toe	Ton oil equivalent
BGL	Bulgarian leva
EEA	Energy Efficiency Agency
EE	Energy Efficiency
SCER	State Commission on Energy Regulation
CLSENES	Central Laboratory on Solar Energy and New Energy Sources
BAS	Bulgarian Academy of Sciences
SHW	Solar Hot Water
WCB	Water Conveying Boiler

1. Introduction

The aim of this Market and Technology Assessment of Bulgaria is to contribute to the analysis of the market potential for wider application of solar thermal technologies in Bulgaria and to disclose the opportunities for further development and implementation of solar thermal technologies.

For development of the utilization of solar energy potential, mainly for thermal energy (daily needs hot water and heating) it is necessary that wide and reliable information regarding the possibilities for utilization of solar technologies and their prices is provided. This information is necessary not only to designers and builders, but it has to reach and draw the attention of the consumers, at first place.

The experience of the Member States mostly applying solar thermal technologies (Greece, Germany and Austria) shows that for the rapid development of the solar collector market, the following prerequisites are necessary:

- Motivation, mainly financial stimuli. In Bulgaria, in the supplements to the Energy and Energy Efficiency Act, it is foreseen that the investments for installations for utilization of RES, including solar collectors, are recognized as expenditures.

- Developed trade network. Here, the main point is competition for achieving of lower prices of installations, i.e. of the primary investments.

- Developed servicing network (consultations, installations, maintenance).

- Provisions at the time of design and construction of buildings for the use of solar thermal systems.

The main reason for the slow penetration of solar thermal systems is in the high initial investment expenditures. Solar collectors are comparatively expensive in the country. The high price is determined not by their complexity, but by the lack of market security. Production of solar collectors and elements is not in economically optimal series. This does not allow automation of production and respectively lower prices.

The present report presents the country's specifications and its solar potential so that comparison could be appreciated on this basis.

The current situation on the Bulgarian solar market is studied. Background and historical information are followed by a description of the technologies currently used for SHW.

A market analysis includes the role of the market actors and a comparison with electricity (competing energy).

The development and the perspectives of the Bulgarian solar thermal market are adequately assessed.

The effects of further incentives, motivations and new regulatory frameworks are evaluated and certain conclusion are presented.

2. Country specifications – Solar Potential

2.1 Environmental conditions – the Bulgarian climate

The Republic of Bulgaria is located in the southeastern part of Europe on the Balkan peninsula. The country borders on Greece and Turkey to the south, the former Yugoslav Republic of Macedonia and Serbia to the west, Romania to the north and the Black Sea to the east. The country has a population of around 7.9 million and covers a territory of 110 912 $(km)^2$.

Map 2.1. Map of Bulgaria

The climate in Bulgaria is temperate with four distinctive seasons and varies with altitude and location. The climate in Northern Bulgaria is moderate continental, while the climate in Southern Bulgaria is intermediate continental tending to Mediterranean. The climate in the regions with an altitude of 1900 – 2000m above sea level is mountainous and along the Black Sea cost is maritime. The Black Sea coast features a milder winter as opposed to the harsher winter conditions in the central north plains.

Table 2.1 presents the average monthly temperatures for various Bulgarian cities, situated in the north, the west, the south and the east part of Bulgaria. The same temperatures are shown in Figure 2.1.

Table 2.1. Average monthly temperature (°C) in various Bulgarian cities

Month / Town	Pleven	Sofia	Pazardzhik	Varna
January	2,5	1,5	2,5	4,1
February	5,3	8	4,4	4,2
March	4,8	2,9	4,7	4,9
April	14,7	13,1	14,3	13,2
May	16,9	14,7	17,0	15,8
June	22,4	20,0	21,9	21,1
July	24,1	22,2	24,2	22,7
August	24,5	22,1	23,7	23,8
September	16,7	15,1	16,9	17,8
October	12,8	11,6	12,9	14,4
November	3,5	3,7	5,3	6,8
December	-3,1	-3,7	-0,9	0,8
Average annual value	**12,1**	**10,6**	**12,2**	**12,5**

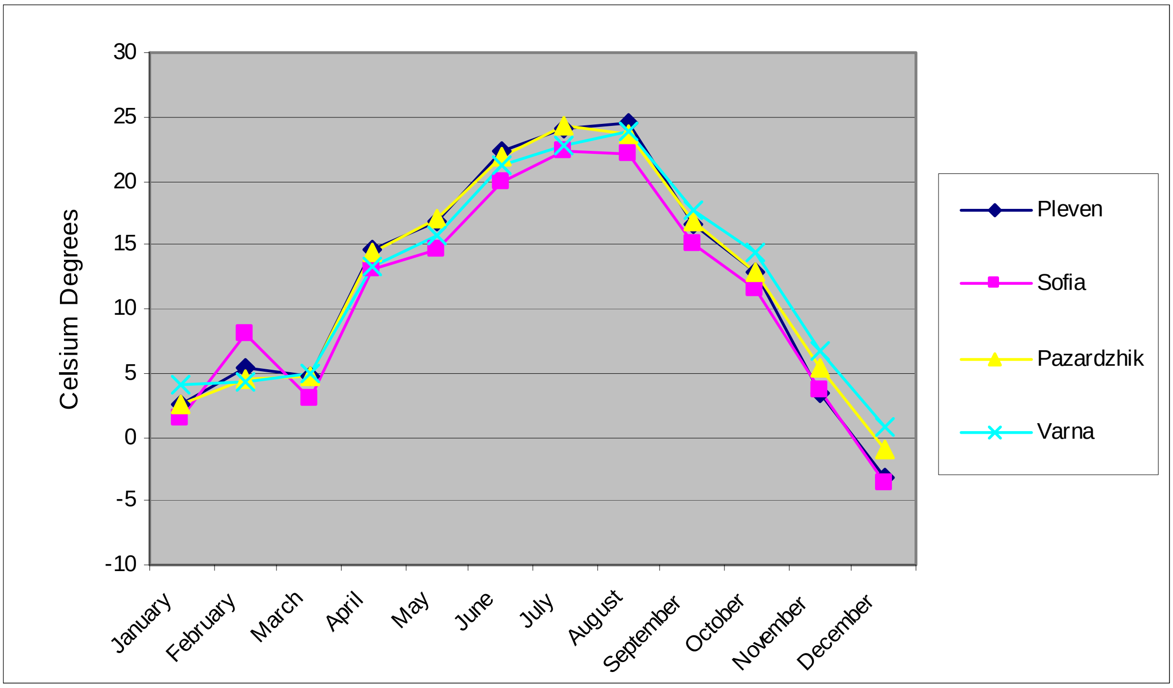
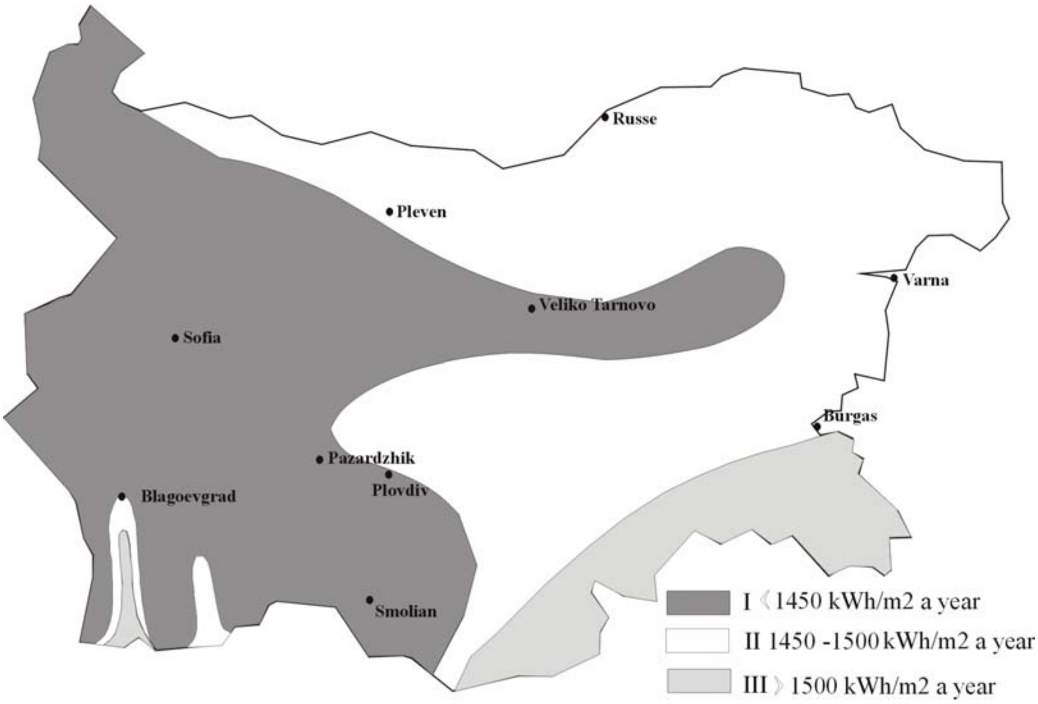


Figure 2.1. Average monthly temperature in four Bulgarian cities

2.2. Solar radiation

In Bulgaria the average annual period of sunshine is about 2.100 hours, in some of its regions it may reach 2.500 hours (i.e. the range is from 1.450 to 1.600 kWh/m² annually).

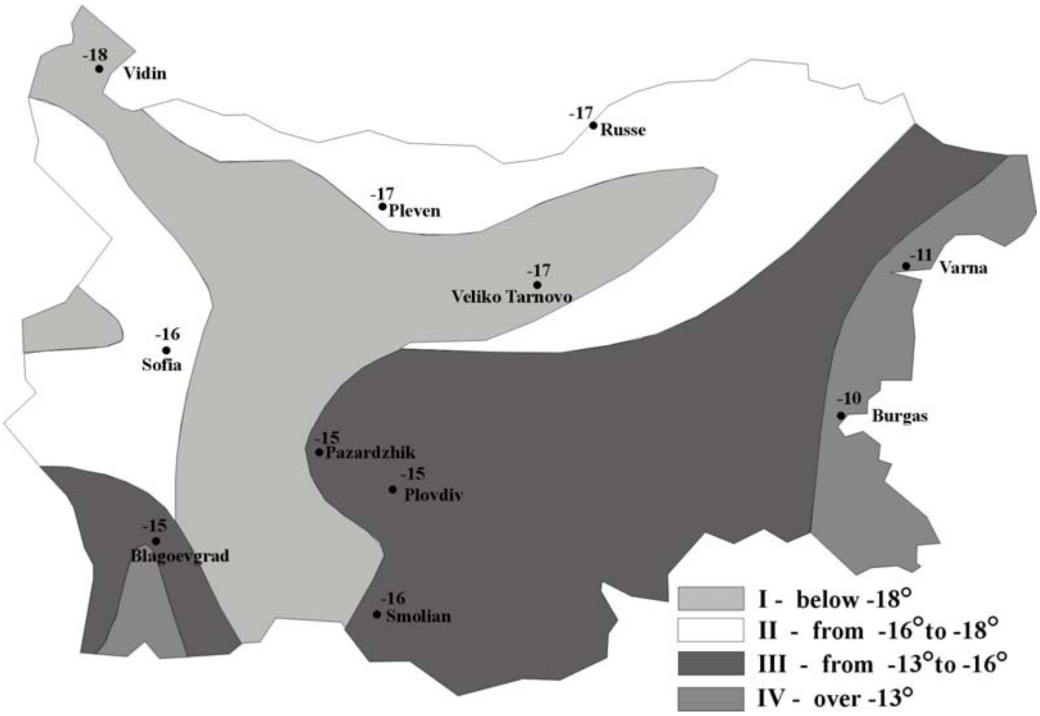


Map 2.2 Solar energy zones in Bulgaria; annual distribution of total solar radiation.

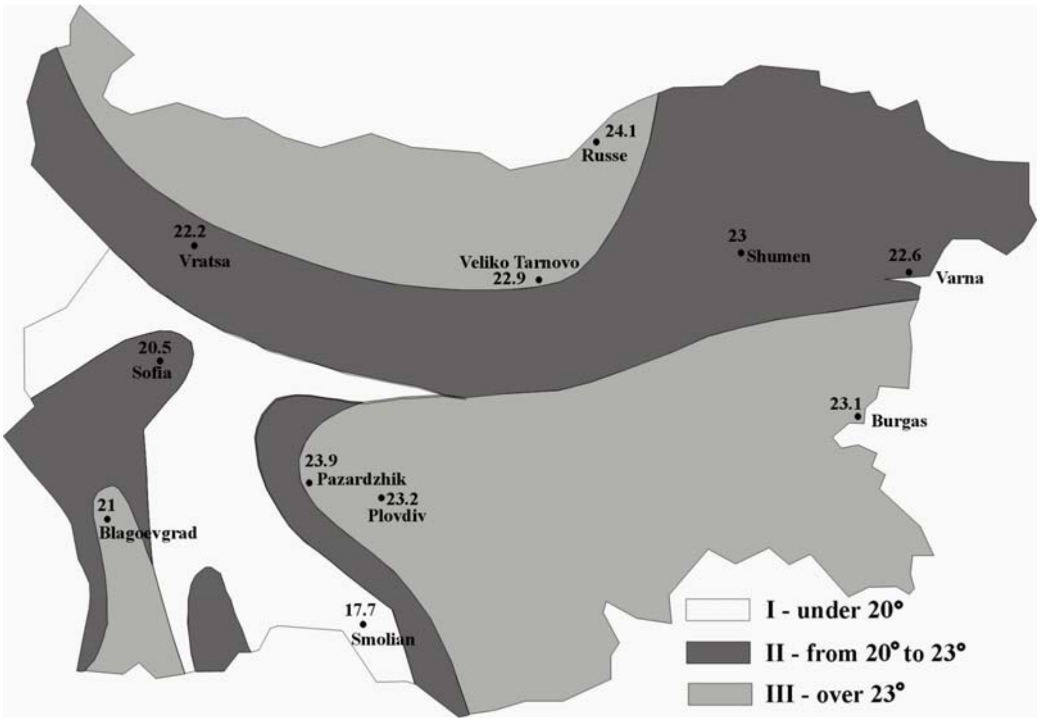
The air temperature characteristic of the climate is a result from the solar radiation intensity and depends on the amount of thermal energy, radiated from the surface of the earth during its 24-hour and annual cycles. The solar monthly radiation changes during the year from 41-52 kWh/m^2 in January till 200-238 kWh/m^2 in July. Annually, on horizontal surface, for different sites, the total solar radiation varies between 1400 kWh/m^2 and 1674 kWh/m^2. This energy is coming mainly during the summer and spring seasons, particularly during the average weather conditions. Map 2.2 presents the solar energy zones in Bulgaria

The capacity of space heating systems depends on the temperatures for the respective region (N.B. the lowest winter temperatures). The Map 2.3 presents the four zones of Bulgaria of different minimal temperatures. It does not identify, however, regions with specific climatic conditions, or mountainous regions with altitude more than 1000 m.

Significant for solar systems is not the highest temperatures, but the average summer temperatures. The Map 2.4 shows the territorial distribution of the average 24-hour summer temperatures in Bulgaria.



Map 2.3 Calculated temperature in °C - zoning according to minimal temperatures.



Map 2.4 Average summer temperatures per 24 hours – territorial distribution.

The average annual temperature in the country is 10,5 °C. In winter, the average temperature in the country is about 0 °C. The lowest temperature –38,3 °C was measured in 1947. The average monthly temperatures for the capital city of Sofia range from –3,7°C in December to 28,2°C in August.

3. Current Situation

3.1 Solar Technologies & The Bulgarian Solar Thermal Market

3.1.1. Historical evolution of the solar thermal market in Bulgaria

The climatic conditions and the high rates of solar radiation in the Balkan countries are ideal for the exploitation of solar energy for thermal energy production. Although individual solar collectors, mainly in households, have started entering the market, the application of solar technologies in the hotel industry, especially in Bulgaria, remains still modest. The potential for thermal production by solar energy in the hotel sector still remains mostly unexploited although there is a significant potential for introduction of solar thermal technologies.

The theoretical solar energy resource in Bulgaria is many times the country's national energy demand. The theoretical solar potential in Bulgaria is $13x10^9$ toe/year. Taking into account the technical constraints on the use of solar energy (such as land use, energy demand and technical performance), the technical potential for solar heating is $246x10^3$ toe/year. For solar electric technologies, the technical potential is $52x10^3$ toe/year. Yearly, $161x10^3$ toe/year could be used for hot water production in the country. Solar-thermal collectors for hot water production can be used almost everywhere in the villages and the towns, in the hotels, holiday houses, camping, etc. particularly during the period from April to October when the solar radiation is higher.

The technical potential for the solar energy is distributed as shown in Table 3.1:

Table 3.1 Technical solar potential in Bulgaria

Solar energy resource	10^3 toe/year	%
Photo voltaic panels	52	21
Active solar thermal energy systems	161	66
Passive solar thermal energy systems	33	13
Total	**246**	**100**

The largest part (66%) of the technical solar potential in Bulgaria belongs to the active solar thermal energy systems, which are mostly applied until now. Bulgaria was the leader in Eastern Europe in design and production of solar thermal installations.

Since 1977 a large scale program has been implemented in Bulgaria for designing, production and implementation of 50.000 m^2 solar collectors. These collectors had various solar applications, such as:
- solar domestic hot water systems for hotels and holiday facilities, mainly at the Black Sea coast,
- solar systems for industry,
- other.

During the period 1977-1990 a lot of efforts have been made in the research and development area and an important human potential and infrastructure have been used to this purpose.

For the last 15 years many development and demonstration programs have been implemented, which covered practically all renewable energy sources, including solar thermal ones.

However, the low quality of the equipment and the installations made in Bulgaria, and the lack of maintenance in many of the early installations resulted in a dissatisfaction, creating for a moment an additional barrier to further solar energy utilization.

The R&D activities, manufacturing and installation have almost stopped since 1990 because of the economy reformation and the resulting difficult economic situation.

It should be mentioned, however, that in the transition period the prices of the main energy source, which is utilized for obtaining of DHW in the tertiary sector, in the service sector and in some industrial sectors, is electrical energy. The price of the electrical energy in the last decades has increased many times. This led to a change in the psychology of the population and to a change in its attitude toward RES, including to a demand for possibilities for utilization of solar energy.

At the present moment, in Bulgaria there are several producers of flat plate solar collectors. There are also distributors of Greek, German, English, Turkish, Chinese, Israeli and other solar systems. The collectors are flat plate and vacuum-tube, as well.

The market of solar thermal systems in Bulgaria started to develop at good rates. Of great importance, at this still early stage on this market, is the correct and professional sizing, implementation and maintenance.

3.1.2. Solar water-heating technologies

3.1.2.1. Classification of systems and principles of operation

Generally, solar systems for water heating can be classified according to three elements:

- type of circulation of the heat transfer fluid from the collectors to accumulators (hot water storage tanks) and vice versa;
- manner of heat transfer from the working fluid to accumulator and vice versa;
- number and type of consumers.

According to the first criterion, they fall into two categories: gravity systems (thermosiphons) and pump circulation systems. According to the second criterion they fall into two categories: direct systems (open loop) and indirect systems (closed loop, through a heat exchanger) by giving out heat to the accumulator (hot water storage tank, boiler). According to the third criterion, they fall again into two categories: individual (domestic systems) and multiple-consumer collectors (large systems).

Direct pump systems

Direct pump systems consist of solar collectors, hot water accumulators and pumps. A simplified system is shown in Figure 3.1.

Principle of Operation: Cold water in the accumulator is sucked from its lowest point through a pump and passed on to the solar collectors, where it is heated. The heated water returns to the accumulator again. In this way the upper part of the accumulator begins to fill up with hot water. The lower part remains slightly colder. The main characteristic for this system is that water is directly heated in the solar collector.

Advantages: The systems are simpler from a technical point of view. No heat exchanger is required

Disadvantages: The systems (accumulators, collectors, pipe-lines, etc.) are made of material in line with the requirements of potable water. Direct systems are not automatically protected from freezing weather conditions. Deposits might block the absorber tubes in areas with hard water (constant decrease in the efficiency of the solar hot water system).

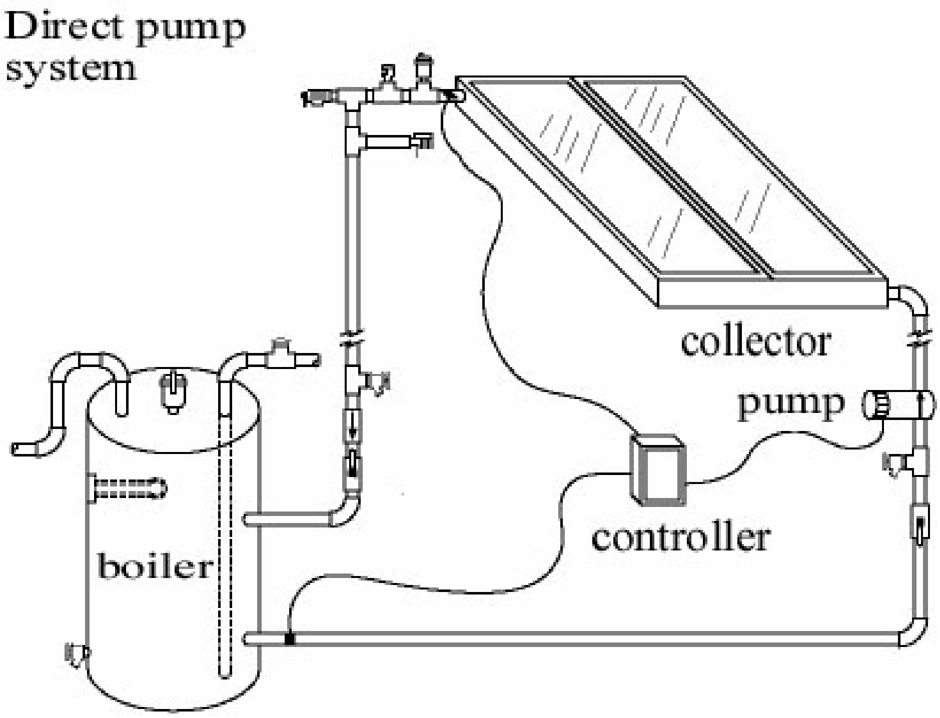


Figure 3.1 Direct solar water heating system with pump.

Indirect pump systems

Indirect pump systems consist of solar collectors, heat exchanger (external or internal with respect to the accumulator), hot water accumulator and pump. A simplified system is shown in Figure 3.2

Principle of operation: The heat transfer fluid, heated in the collectors, flows through the heat exchanger in the boiler and gives out the heat to the water for consumption.

Advantages: The use of a heat exchanger allows the use of a separate (from the hot water) heat transfer fluid to carry heat from the solar collectors to the storage tank. The use of inhibitory additives provides flexibility for the selection of absorber materials. The use of antifreeze additives can reliably protect the solar system from freezing weather conditions.

Disadvantages: The system includes a heat exchanger, which means some additional cost and possibly some small reduction in the thermal efficiency.

There is another indirect system where the heat exchanger is outside from the accumulator.

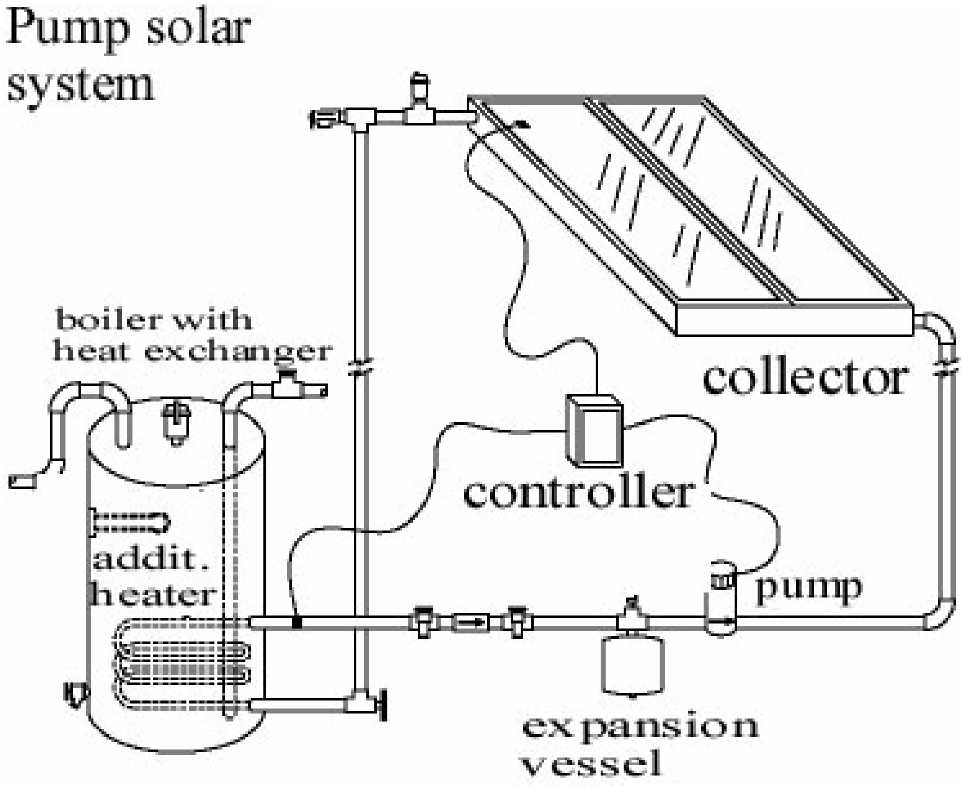


Figure 3.2 Indirect solar water heating system with pump. The heat exchanger is inside the boiler

Direct gravity systems (thermosiphons, open loop)

Direct gravity systems comprise of a water accumulator and a collector, however without a circulation pump. For the functioning of the system it is absolutely necessary to mount the accumulator higher than the level of the installed collectors. A typical thermosiphon system is shown in Figure 3.3

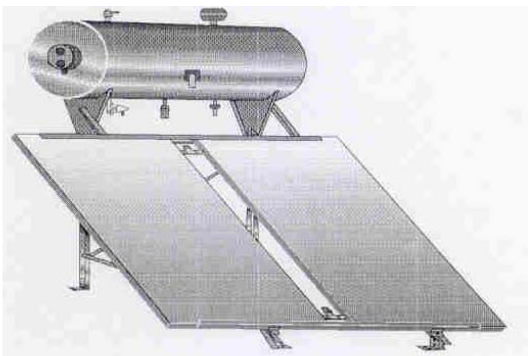


Figure 3.3 Thermosiphon system for solar water heating (direct or indirect system).

Principle of operation: In this case the circulation of the heating fluid (water) is automatic and it is based on the fact that there is a difference in density between the heated water (in the collectors) and the cold water (in the accumulator).

Advantages: No extra energy is necessary (there are no pump units). It functions in an independent mode. Practically, from a technical point of view, this is the simplest system.

Disadvantages: The accumulator must be installed on a higher level than the collectors. The building materials of the equipment should be in line with potable water requirements. Deposits in the collector pipes and freezing weather conditions should be properly handled. The systems are made with small-area solar collectors.

Indirect gravity systems (thermosiphons, closed loop)

An indirect gravity system comprises of an accumulator with incorporated heat exchanger and collectors. The accumulator should be mounted on a higher level than the collectors. Figure 3.3 presents such a system.

Principle of operation: The same as described in "direct gravity systems".

Advantages: No extra power consumption (there is no pump). It is possible to use anti-freeze and an inhibiting substance in the collector loop.

Disadvantages: The system has a heat exchanger (additional cost, some reduction in the thermal efficiency. The systems are made with small-area solar collectors.

The solar part of a system consists of two main units – a solar collector and a heat accumulator (hot water storage tank), which are discussed next in this report.

3.1.2.2. Solar collector

The collector is designed to absorb solar energy and to transform it into heat, which heats the fluid flowing through the collector. The collectors are mounted either on open ground or on the roof and should receive solar energy during the whole day.

There exist three types of collectors for heating of hot water: Flat-plate collectors, Evacuated tube and Concentrating collectors.

- ***Flat plate collectors*** could be manufactured from different materials like copper, aluminum, iron or plastic. They usually have black surface, painted or selective, laid on through galvanization or evaporations in vacuum. The selective collectors have slightly better heat absorption qualities and greatly reduced losses. The insulation of the collectors is important, because it decreases the losses to environment. Most of the collectors are covered with glass or other transparent material.

  The solar energy passes through the transparent cover and heats up the absorber of the collector. In the in-built tubes in the absorber circulates water or special heat transfer fluid. The heat carrier could move thanks to the gravity or with the help of a pump.

Flat plate collectors are an economical choice and reach moderate temperatures of about 80°C. Because of their relatively high heat loss coefficient, higher temperatures could hardly be achieved.

Flat plate collectors are the most common in Bulgaria. This is due to their lower price and simpler manufacturing technology. They require also small maintenance.

- ***Vacuum tube collectors*** have absorbers, which are mounted in a glass tube, from which the air is evacuated and vacuum is created. Like the flat plate collectors, the solar energy heats up the liquid in the absorber and it is transferred to the domestic water. There are two methods of this process:

  - The solar fluid circulates in an ordinary tube, built-in in the absorber like the flat plate collectors. The only difference is that the collector is insulated from the environment via vacuum.

  - The integrated in the absorber heat tube transfers the useful heat while using the principles known in the refrigerator techniques – evaporation of the heat carrier at low temperatures (around 20°C – 30°C) and condensation of the vapors in condensers contacting with the built-in in the collector heat exchangers. This is the most effective transfer of heat energy and it is 20.000 – 30.000 times better than the heat carrying characteristics of silver. Such a collector is shown in Figure 3.4

  Usually, evacuated tube collectors are set in systems, whose production of hot water is necessary all the year around. They operate effectively even at temperatures below zero

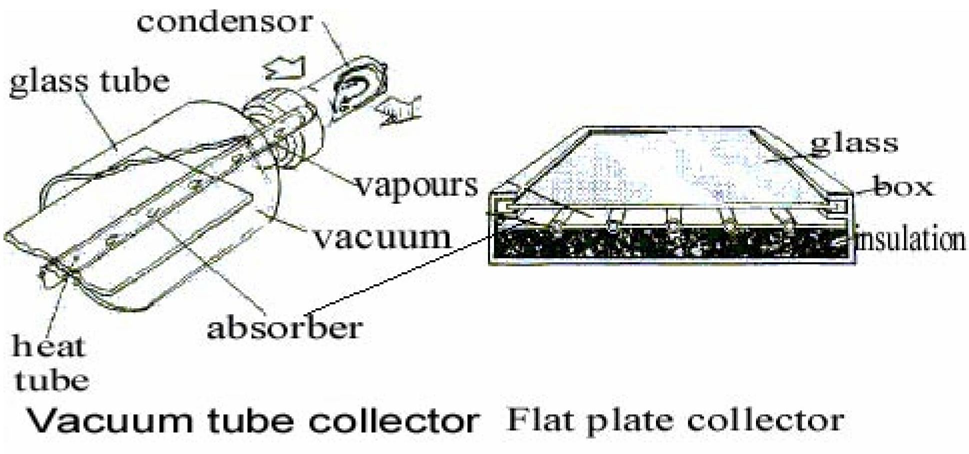


Figure 3.4 Types of collectors i.e. flat plate and vacuum tube.

- ***Concentrating collectors*** concentrate optically the solar radiation to a small target or receiver where it is transformed into heat. A mechanism for tracking the sun is usually used. Thermal losses are reduced when the area that is heated is smaller. Therefore concentrating collectors are associated with high temperatures.

3.1.2.3. Heat storage equipment

The water, heated by the collector, reaches the storage tanks, which have the function to retain for some time the heat obtained from the sun. Heat storage tanks are mounted separately. Heat storage tanks are produced by a number of companies in Bulgaria. Need for corrosion protection at the temperatures developed by the solar system ($80^oC - 95^oC$)

3.1.2.4. Codes and Standards

The state policy in Bulgaria supports and promotes the utilization of renewable energy sources (RES). In the draft project for a new Energy Law, in article 2 section 5 is stated that this act ensures conditions for ***"stable development of heat and power production out of renewable, environment friendly energy resources"***. Moreover, the production of solar systems in Bulgaria has started since 1977. Despite that fact, up to the present moment, there are no authorized laboratories for quality control of the produced equipment and respectively the standards have not been applied.

At the present moment, the Central Laboratory on Solar Energy and New Energy Sources to the Bulgarian Academy of Sciences implements a project of the European Union, according to which a test laboratory is being created (one stand) for testing of solar collectors in real conditions according to the European standards.

The European Commission has funded the technical work for the development of the following main three standards, which will be applied in Bulgaria:

- ISO 9806-1 Test methods for solar collectors – Part 1: Thermal Performance of Glazed Liquid Heating Collectors;
- ISO 9806-2 Test methods for solar collectors – Part 2: Qualification test procedures;
- ISO 9459-2 Solar heating – Domestic Water Heating Systems – Part 2.

In addition, the following four European Standards are under consideration (they are very close associated with the previously mentioned ISO standards):

- EN 12975-1 Thermal solar systems and components – Collectors – Part 1: General requirements;
- EN12975-2 Thermal solar systems and components –Collectors – Part 2: Test methods;
- EN 12976-1 Thermal solar systems and components – Factory made systems – Part 1: General requirements;
- EN 12976-2 Thermal solar systems and components – Factory made systems – Part 2: Test methods.

The exported solar collectors, produced in our country, are tested in the respective laboratories abroad.

3.1.3. Market information

3.1.3.1. General information

The main conclusions are very characteristic and significant for the solar thermal installation market in the country. The main factors influencing it are as follows:

- The installation of 50.000 m^2 solar collectors for the period 1977-90 was made in the framework of a governmental program and was financed by the government, local authorities, etc.;

- This policy was not related with the market penetration of solar thermal installations for households, small hotels, etc.;

- The low energy prices of the fuels and electricity at that time and incompetiveness of the price of a solar energy;

- Since 1990, Bulgaria is in transition and major part of the tourism facilities and industrial enterprises have been privatized or undergoing this procedure. This is one of the reasons for the poor maintenance, leading to the present bad status of the installations;

  In the tourist facilities, 54% of the installations are still operational, but for the industrial sector only 8% are still in operation.

- Major part of the existing installations requires repair. The main problems are the corrosion of steel collector frame and the absorber coatings, lack of frost protection, broken glasses, etc.

3.1.3.2. Bulgarian solar collectors during the period 1977-90

The first Bulgarian solar thermal collectors were of panel type radiators with area of 2 m^2. The next step of design was the flat plate collectors with area of 1,46 and 1,76 m^2. The first Bulgarian solar collector was designed and produced in 1977. The state enterprise "New Energy Sources" (NES) was in a position to solve technical problems related to research, design, testing, manufacturing and assembling of solar thermal installations. NES implemented a large-scale governmental program for designing, manufacturing and installation of 50.000 m^2 solar collectors. These collectors were installed during 1977-90 mainly in tourist facilities for hot water supply at the Black Sea coast and the industry for domestic hot water preparation. Figures 3.5 and 3.6 present the regional distribution of these solar thermal installations and the installed capacity of solar collectors.

Detailed surveys had been conducted, reviewing the present condition of the various elements of solar collectors and installations. Three administrative regions are investigated – Plovdiv, Sofia and Burgas. These regions are taken as representative for all installations as the majority of solar systems have been installed there. Totally 102 installations are included in the investigation, which represents a share of 58,6 % of all installations. Totally 79 installations are investigated in Burgas region, that represent the share of 68.7% of the installations there. Totally 23 installations are investigated in the regions of Plovdiv and Sofia, that represent the share of 39 % of all installations there.

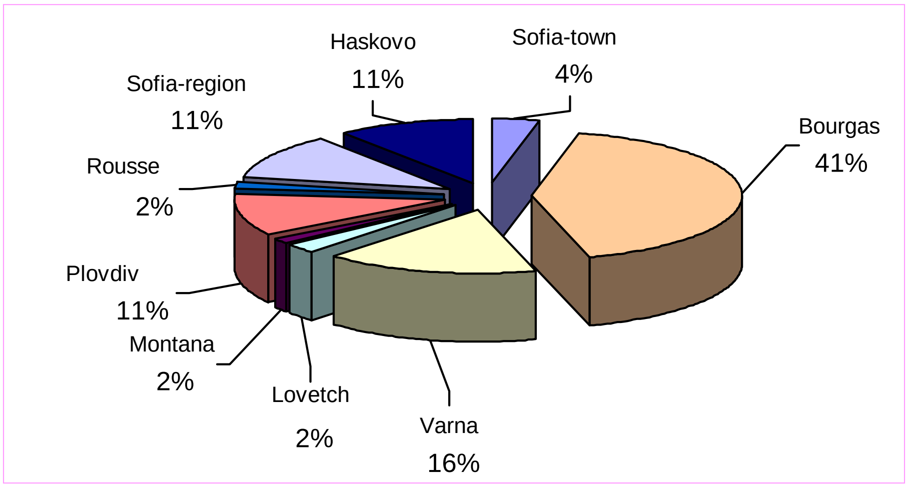


Figure 3.5 Regional distribution of the solar thermal installations (1977-1990).

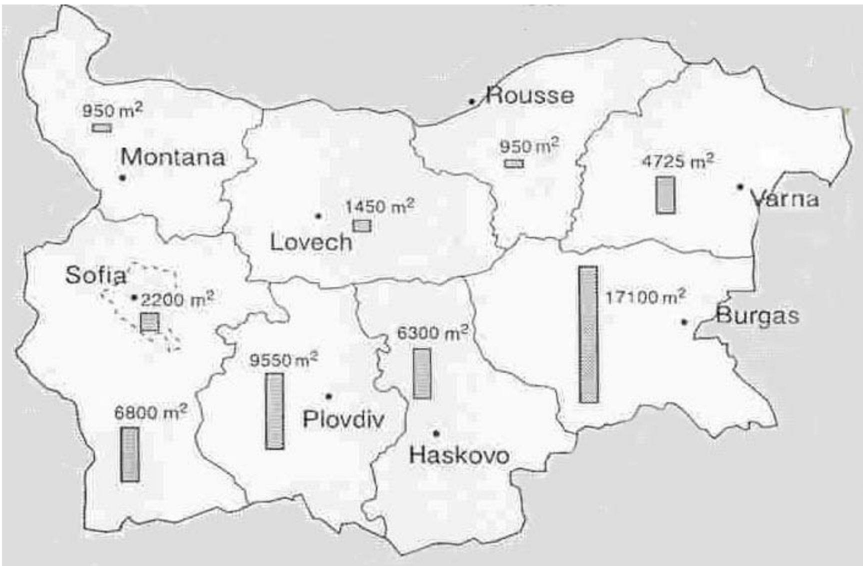


Figure. 3.6 Installed capacity of solar collectors (1977-1990)

Sectors (Figures 3.7 and 3.8)

The Figures 3.7 and 3.8 give us an overview of sectors where the solar systems were installed in Burgas, Plovdiv and Sofia regions and the reason why they are divided into two big groups according to the sector service. The first group of installations (represented by Burgas region) mounted in Black sea region has to meet the sanitary needs of the tourist industry mainly and the rest of the country (represented by Plovdiv and Sofia regions) has to meet sanitary needs in industry or public activity.

As it could be seen 53 % of the installations in Burgas region are installed in vacation complexes, 22% in camping, 9% in restaurants (canteen), 8% in hotels, 4% in sanatoriums and 4 % in others (swimming pools).

The majority of the installations (44%) in Plovdiv and Sofia regions are installed in industrial enterprises for sanitary needs, 35% for public needs, 9% -in baths, 4% in hotels, 4 % in vacation complexes, 4 % in restaurants.

Status of the installations per branch (Figures 3.9 and 3.10))

From the Figures 3.9 and 3.10, for Burgas region, we can observe that 30 % of the installations mounted in vacation complexes, 8 % in camping, 7 % in hotels, 5 % in sanatoriums, 3 % in restaurants, 2 % in swimming pools are still working.

Working installations in Plovdiv and Sofia regions are a very small amount in different branches: 4 % in industry, 4 % in bathes, 4 % in publics.

Some part of the installations is in working conditions, but they are shut down, because of the administrative changes – privatization, change of the owners, lack of work, no needs for hot water supply, shut down factories, lack of service for the installations and some other reasons.

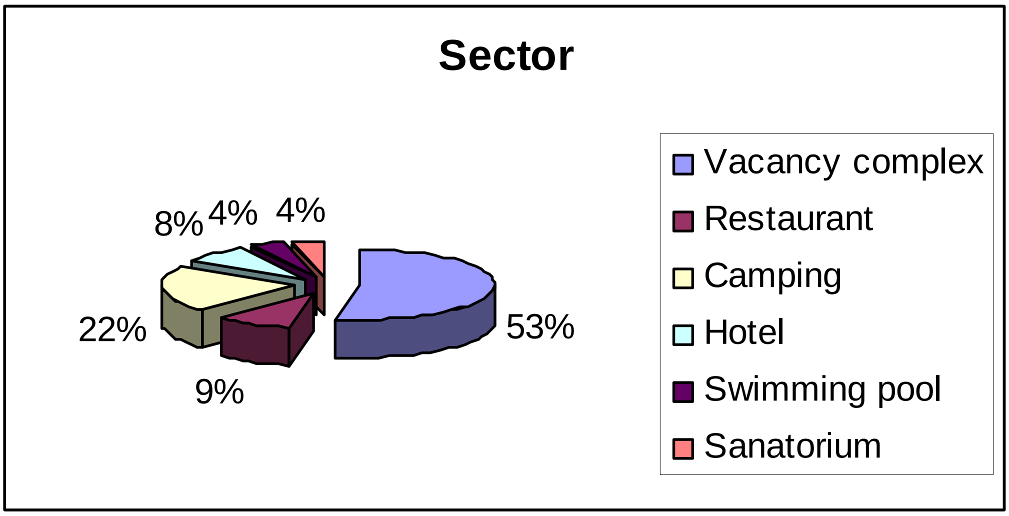


Figure 3.7. In Burgas region solar systems are used mainly by tourist facilities (1977-1990).

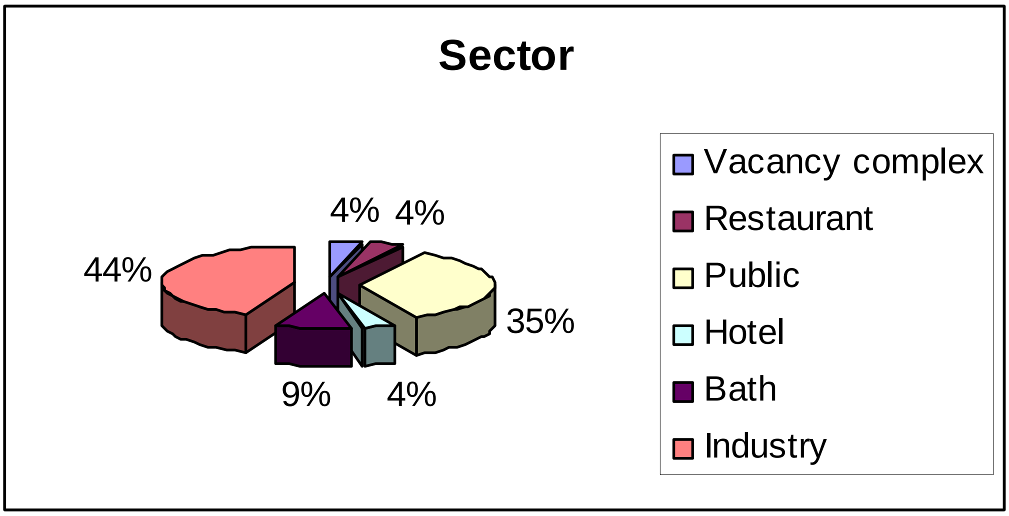


Figure 3.8 In Plovdiv and Sofia region solar systems are mainly used by the industry and in public buildings (1977-1990).

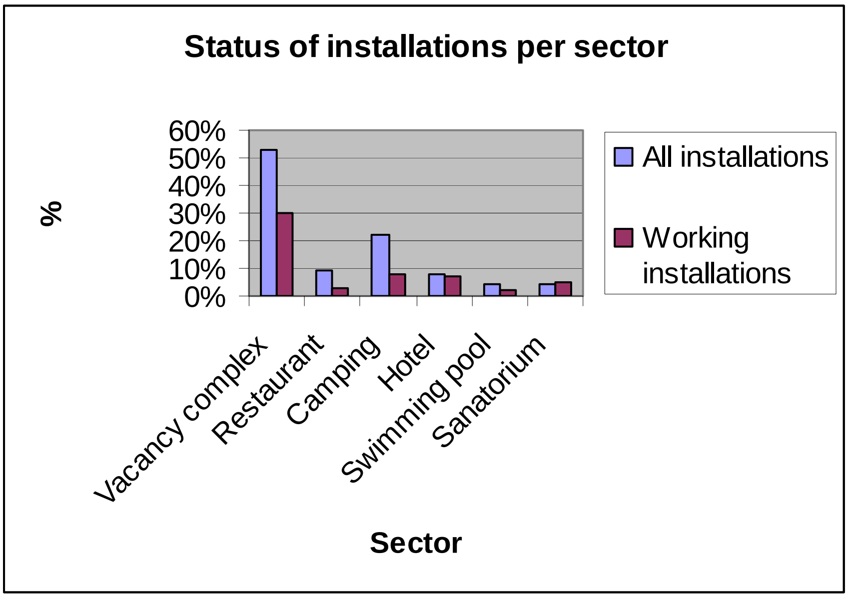


Figure 3.9 Tourist sector at the Black sea region(Burgas) has better economic conditions – therefore more maintenance has been done and a higher percentage of solar systems are in operation (1977-1990)

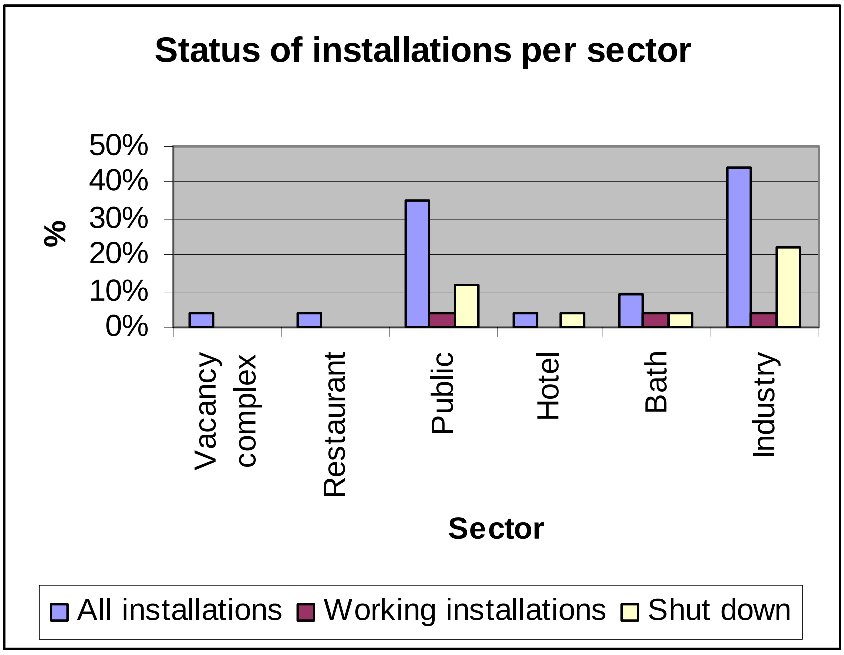


Figure 3.10 The Solar systems in Plovdiv and Sofia regions are mainly installed in the industry and public sector. Due to the bad economic situation a lot of systems are out of operation (1977-1990).

3.1.3.3. Demonstration projects on solar thermal utilization

During the last years, many demonstration projects have been implemented under various programs on solar thermal utilization in Bulgaria.

Sofia Energy Centre took part in the implementation of energy efficient solar system in the kindergarten “Alen Mak” in the town of Veliko Tarnovo (1998), for domestic hot water production and hot water supply for the swimming pool.

Other demonstration projects [solar thermal installations for various types of buildings (blocks of flats, houses, restaurants, pizzerias, etc)] – have also been realized by Sofia Energy Centre.

Within the PHARE program, different solar thermal demo projects have been implemented in Southern and Northern Bulgaria.

Table 3.2 presents technical data and financial and ecological benefits of three projects in hospitals in Southern Bulgaria.

Table 3.2 Financial, technical and ecological data and results for solar systems in hospitals in three Bulgarian cities

No	Parameters	Unit	Stara Zagora	Radnevo	Krumovgrad
1.	**Investments**	EUR	116.970	62.190	34.005
2.	**Fuel savings-diesel**	t/year	38,0	19,1	10,5
3.	**Cost savings**[1]	EUR/year	22.941	11.531	6.339
4.	**Simple pay-back period**	Years	5,1	5,4	5,4
5.	**Solar collectors-area**	m^2	405	210	110
6.	**Accumulation volume**	L	7.000	5.000	3.500
7.	**Hot water consumption incl. distribution losses**	MWh/y	352	198	92
8.	**Measured production**	$kWh/m^2/y$	501	550	572
9.	**Measured production**[2]	MWh/y	203	116	63
10.	**Solar collector cover summer/winter**	%	100/25	100/25	100/32
11.	**Reduced CO_2 emissions**	t/year	71,01	40,44	22,03
12.	**Reduced SO_2 emissions**	t/year	0,48	0,27	0,15
13.	**Reduced NO_x emissions**	t/year	1,44	0,82	0,45
14.	**Particles**	t/year	0,10	0,05	0,03

Table 3.3 presents five solar thermal demo-projects in Northern Bulgaria. The first three of them were of flat plate solar water collectors (made in Bulgaria) – installation for hot water with pumped circulation.

[1] 1 ton diesel costs 1180,8 lv = 603,7 Euro/ton
[2] boiler efficiency close to 50 %

For the project by ZEMUS enterprise, two solar systems have been designed, each comprising of two groups of four modules. Each module comprised of a solar collector and a boiler, working in a gravitation regime.

The fifth project is solar dryer for the wood processing enterprise and is integrated in the roof.

Table 3.3 Financial and technical data for the five solar projects

No	Parameters	Unit	Kindergarten "Eugenia Kissimova" Veliko Tarnovo*	"ELIOT" Ltd. Veliko Tarnovo	Sanatorium in Ovcha mogila village	ZEMUS Ltd.	EMOS – Solar Dryer
1.	**Investments**	EUR	5.561	5.561	4.661	5.702	5.000**
2.	**Fuel savings**	t/year	1,6	1,8	1,1	1,2	6,5
3.	**Cost savings**	EUR/year	966	1.087	664	724	3.924
4.	**Simple pay-back period**	Years	5,8	5,1	7,0	7,9	1,3
5.	**Solar collectors-area**	m^2	21	21	15	13	100
6.	**Accumulation volume**	l	1.500	1.500	1.200	640	-
7.	**Measured production**	$kWh/m^2/y$	400	432	401	462	-
9.	**Measured production**	MWh/y	8,4	9,1	6,0	6,0	-
10.	**Solar cover summer/winter**	%	54/0	56/0	52/0	34/0	100/0

3.1.3.4. The solar collector market at present

The majority of installed solar collectors during the last years in public buildings and in industrial enterprises are implemented under different programs, as it was mentioned above. The annual market of solar collectors for household systems is rather low, because a great part of the population currently faces enormous financial problems and the people being worried about their energy bills do not dispose of finance to invest in solar systems. A big part (90%) of the sales of solar systems belong to those who build new houses or new private hotels.

The technologies applied for solar thermal energy conversion are the same as the ones applied in other European countries.

* The savings for the five demo-projects are for the session April – October instead of a whole year.

** The total investments are 36 840 EUR for the whole construction of the solar dryers. The investment only for the transparent part and its construction, i.e. the solar part, is 5 000 EUR.

The solar thermal installations, implement under different programs, were mainly for:

- Hot water in public buildings (hospitals, kindergartens, etc.), in domestic and tourist sector;
- Solar dryers in the wood processing and agricultural products industries.

Market sectors:

The following main market sectors are distinguished now:

- Hotels and holiday sector;
- Individual private houses;
- Swimming pools – public and private;
- Industry – for wood processing and agricultural products.

Bulgarian hotel and holiday sector:

In 1999 the capacity of accommodation facilities in Bulgaria was about 117.000 beds, from which about 100.000 beds in the hotels with more than 30 beds, 6.000 beds in camping sites and 11.000 beds at Mountain chalets (see Table 3.4).

Table 3.4 Accommodation facilities in Bulgaria

Year	Hotels			Camping sites			Mountain chalets		
	No	Beds	Bed nights x 10^3	No	Beds	Bed nights x 10^3	No	Beds	Bed nights x 10^3
1997	461	97.974	23.236	33	8.220	1.336	207	13.394	4.234
1999	505	99.538	23.240	25	6.073	1.041	167	11.004	3.931

The most important resorts for tourism are the sea resorts Sunny Beach, Albena, Golden Sands, etc. From the mountain resorts, the most important are Pamporovo, Borovets and Bansko.

The greatest part of the hotels, particularly in the regions at the Black Sea coast, has no space heating. The climate is moderate and most of the hotels are closed in the winter. Domestic hot water (DHW) is the most important energy consuming sector in the hotels. Usually, domestic hot water is heated by means of electricity and takes the greatest share of a hotel's electricity consumption.

The average electricity consumption obtained from a number of hotels is 3,3 kWh/overnight. DHW accounts for 45-55% of the total electricity consumption or 1,7 kWh/overnight.

As an example could be illustrated the hotel "Zora" in Sunny Beach (see Photo 3.1). The hotel has 17 rooms and 2 apartments with 38 beds in total, and is operational during 5 months – from 1st May till 30th September. During June, July and August the occupancy is 100 %.

The installation of 16 solar collectors is mounted on the roof and is South-oriented. The solar collectors are Bulgarian production made by “New Energy Sources” company, in the town of Razgrad. They are of flat plate type, with aluminum absorber and with an area of 1,7 m^2. The collectors are connected through a pump to two boilers of 1.000 litres each, and each boiler has an auxiliary electrical heater with 7,5 kW capacity.

The temperature of cold water is 12^{o}C. The solar collectors heat it to 45 ^{o}C, and it is fed to the boilers where it is additionally heated to 60 ^{o}C, i.e. the solar collectors supply 70 % of the required heating of the necessary domestic hot water of the hotel, which is about 3.000 litres/day.

Photo 3.1 Hotel “Zora” in Sunny Beach, equipped with a solar system (27m^2/2000l)

<u>*Individual private houses:*</u>

Taking into consideration the climatic conditions in Bulgaria it could be assumed that 1m^2 of collector area could adopt 500 to 850 KWh/year.

Domestic hot water for the tertiary sector is obtained mainly with electrical boilers. The constant increase of the price of electrical energy results in demand of alternative energy sources, including utilization of solar collectors for DHW. At the present moment, an increase is observed in introduction of solar collectors, and especially in new individual private houses.

Below is given an example for individual house in the village of Bistritza, near by Sofia, in the mountain of Vitosha, at 1.100 meters above the sea level (see Photo 3.2). The house is inhabited all the year around by a four-member family.

Photo 3.2 A private house in Bistritsa (near Sofia) with a pumped solar system ($3,6m^2$/120l)

Two collectors are installed, each of them with an area of 1,8 m^2 and an area of the absorber 1,6 m^2. The collectors have an aluminum absorber with eight tubes and mineral wool insulation. Their weight is 31 kg each. The boiler has a capacity of 120 l.

The price of one collector is 115 Euro and the price of the whole installation is 950 Euro.

With calculated, for this collector and the given location of the house, 400 kWh/year for $1m^2$ area of the absorber and assumed 0,14 lv./kWh, we obtain an annual economy of 1280 kWh or 179 lv. and a simple pay-back period of 10,6 years.

3.1.3.5. Forecast for the solar thermal utilization

The estimated market potential at present is around 5.000 m^2 of collectors per year.

There are five enterprises in Bulgaria, which produce solar collectors. There are a number of small sized companies producing solar collectors but these are not equipped with technological lines, and most of the solar collectors feature various design defects. It would be more beneficial to import at least the absorbers and the rest to be produced and assembled in Bulgaria.

There are also many distributors of different types of solar collectors (Greek, German, French, etc.).

There is no laboratory in Bulgaria for testing solar collectors, therefore no quality certificate can be granted for collectors made in Bulgaria. At present, as it was mentioned, a test laboratory (one stand) is being constructed for testing of solar collectors.

At present, solar water heating is not financially competitive with oil or electric heating (due to the subsidized sales price of electricity and district heating). When electricity prices reach the international prices, solar water heating will become financially viable. Therefore the market potential for solar water heating is large. A market potential of 1 million m^2 is forecast by 2020, providing more than 10% of the country's water heating demand. This market would support a number of small companies.

The Bulgarian National Programs for RES foresee for the perspectives for development of RES to reach a relative share of 8 % from the total energy balance by the year 2010. The execution of the National RES Program will lead to the realization of more than 920 small investment projects.

3.2. Economic data

3.2.1. Economic cost of solar applications

The first 30 large-scale solar installations had full governmental subsidy in the period before 1990. They were designed and produced by the Energy Technical Institute of Bulgaria promoting governmental policy for solar hot water production in the country. The rest of the installations are subsidized by communities, factories, ministries or local authorities. It is necessary to underline that real market of solar installations did not exist at the period 1977-90.

As a whole the national renewable energy program supported mainly by hot water consumers like tourist centers, vacation complexes, holiday houses, pioneer camping, hotels, industry services to meet sanitary needs. This policy was not connected with the market penetration of solar installations to meet sanitary needs of the households, small hotels, houses, etc.

At present, on the Bulgarian market, the cost of solar thermal systems varies in a wide range. The cost depends mainly on the type of collector, whether it is flat plate or vacuum tube, and in which country it is manufactured.

The cost of the Bulgarian solar collectors is only 100-150 Euro/m^2 and 250-290 Euro/m^2 for the entire systems, depending on the technology used and installations applied. With the electricity prices projected to reach the international levels and relatively constant oil prices, the price of the solar heating systems is expected to become competitive.

The allocation of the cost by a system component of a solar thermal system equipped with Bulgarian produced elements in percentage is as shown in Table 3.5

The main benefit, for the state from implementation of solar thermal systems, is that they replace a substantial amount of electricity and are environmentally friendly.

Table 3.5 Allocation of cost by system component
(Bulgarian produced elements)

Cost Component	Cost (%)
Design	4
Solar collectors	55
Hot water storage tank	13
Connecting pipes + valves	10
Support stand	8
Installation	10
Total	100

3.2.2. Economic performance of solar water heating applications

Domestic Systems

Solar thermal systems for domestic needs are utilized mainly in single-family houses. Their utilization in blocks of flats in Bulgaria has not been implemented so far. Usually, solar thermal systems are utilized mainly for summer houses and villas along the seacoast or in the mountains for DHW in the period April – October. In this case flat plate collectors and simpler systems are implemented.

The simple pay-back period varies between 3 and 8 years, calculated at an average accepted price for the electricity, at the moment, of 0.07 Euro/kWh. Shorter pay-backs could be expected when the electricity costs get higher.

The vacuum tube collectors, up to the present moment have not been implemented in the domestic sector.

Large systems

Large solar systems for DHW in Bulgaria are implemented generally in the hotel sector.

To give a general overview of the economic viability of solar water heating applications, the economical models for two hotels in Bulgaria (hotel “Ambassador” – Sofia; hotel “Rhodopi” – Sunny Beach) are presented, as the hotel sector is the one, where solar thermal technologies are mostly applied, nowadays.

Hotel “Ambassador” – Sofia

The application projected for the “Ambassador” hotel is intended for hot water supply and storage, where the base water heating system is electricity operating.

The site conditions are as follows:

- Annual solar radiation (tilted surface) – 1,25 MWh/m^2 ;
- Annual average temperature – 10^{o}C;
- Desired load temperature – 60^{o}C;
- Hot water use – 3000 l/day;
- Energy demand for 12 months analyzed – 63,72 MWh;

System characteristics:

Solar collector

- Collector type – evacuated;
- Area per collector – 3 m^2 ;
- Number of collectors / total area of collectors – 15/45 m^2 ;

Storage

- Ratio of storage capacity to collector area – 100 l/m^2 ;
- Storage capacity – 4.500 l;

Balance of system

- Heat exchanger / antifreeze protection – yes;
- Heat exchanger effectiveness – 85 %;
- Pipe diameter – 25mm;
- Pumping power per collector area – 5 W/m^2 ;
- Piping and solar tank losses – 3 %;
- Losses due to snow and dirt – 1 %;

Annual energy production

- Pumping energy (electricity) – 0,55 MWh;
- Specific yield – 688 kWh/m^2 ;
- System efficiency – 55 %;
- Solar fraction for 12 months – 49 %;
- Renewable energy delivered – 30,94 MWh;

The initial cost of the investment comes up to EUR 42.014 (i.e. 934Euro/m^2), where the renewable energy equipment (solar collectors, solar loop piping materials, circulating pumps, heat exchanger, storage tanks, transportation and electronics) form 88,5 % of the cost, 5,2 % is the share of the balance of the system (collector support structure, plumbing and control, collector installation, solar loop installation, auxiliary equipment installation and transportation). The rest 6,3 of the initial cost is formed by the feasibility study, project management and engineering, training and contingencies costs.

The project life is estimated to be 25 years, where the years to positive cash flow are 8,8 and the simple payback is 14 years. The annual life-cycle savings are EUR 9.418 with profitability index 5,60. The total annual costs come up to EUR 346 and the total annual heating energy savings or income are EUR 3.352.

Hotel "Rhodopi" – Sunny Beach

The application projected for the "Rhodopi" hotel is intended for hot water supply and storage, where the base water heating system is electricity operating.

The site conditions are as follows:

- Annual solar radiation (tilted surface) – 1,55 MWh/m^2 ;
- Annual average temperature – 14^{o}C;
- Desired load temperature – 60^{o}C;
- Hot water use – 7000 l/day;
- Energy demand for 5.2 months analyzed – 56,28 MWh;

System characteristics:

Solar collector

- Collector type – glazed;
- Area per collector – 1,85 m^2 ;
- Number of collectors / total area of collectors – 47/87 m^2 ;

Storage

- Ratio of storage capacity to collector area – 80 l/m^2 ;
- Storage capacity – 6.956 l;

Balance of system

- Heat exchanger / antifreeze protection – yes;
- Heat exchanger effectiveness – 85 %;
- Pipe diameter – 38 mm;
- Pumping power per collector area – 5 W/m^2 ;
- Piping and solar tank losses – 2 %;

Annual energy production

- Pumping energy (electricity) – 0,50 MWh;
- Specific yield – 413 kWh/m^2 ;
- System efficiency – 48 %;
- Solar fraction for 5,2 months – 64 %;
- Renewable energy delivered – 35,92 MWh;

The initial cost of the investment comes up to EUR 12.600 (i.e.145Euro/m^2), where the renewable energy equipment (solar collectors, solar loop piping materials, circulating pumps, heat exchanger, storage tanks, transportation and electronics) form 76,8 % of the cost, 13,5 % is the share of the balance of the system (collector support structure, plumbing and control, collector installation, solar loop installation, auxiliary equipment installation and transportation). The rest 9,7 % of the initial cost is formed by the feasibility study, project management and engineering, training and contingencies costs.

The project life is estimated to be 25 years, where the years to positive cash flow are 4,6 and the simple payback is 5,2 years. The annual life-cycle savings are EUR 8.275 with profitability index 32,83. The annual costs come up to EUR 2.340 and the annual heating energy savings or income is EUR 12.600.

Another example of the economic viability is the solar installation of 66 collectors (2 m^2 each), arranged in 6 rows, 11 collectors in each row, installed **in the hostel "St. Vassilii Veliki", the city of Plovdiv**, where 200 persons live. The installation is implemented in the framework of the 5-year programme (1997 - 2001) of the Greek Government for assistance to the neighbouring countries. The project comes up to EUR 67.000 and the annual savings are estimated at 45.000 lv. or 23.000 Euro, i.e. the pay-back period is 2,9 years.

3.3. Investment framework and incentives

3.3.1. Incentives employed in the past and goals achieved.

Till 1990 Bulgaria was a socialist country and a member of the Council for Economical Mutual Aid and had a centralized planned economy. Beside that, Bulgaria got energy sources (natural gas, oil, electrical energy and coal) from the former Soviet Union at exclusively low prices, for coverage of the energy balance. The low price of the energy sources was a main prerequisite for non-utilization of the energy from Renewable Energy Sources and for the low energy efficiency.

As a country with centralized planned economy, the former State Committee of Science and Technical Development created a program for centralized introduction of RES on the base of state subsidies, and not on the principle of market penetration. For solar thermal installations the program foresaw 50.000 m^2 of collectors, which were produced and installed. For the implementation of this objective a Scientific Industrial Laboratory on Solar Energy and Other Renewable Energy Sources (NAPOLOC) was established in July 1977.

The first Bulgarian made solar collector was designed and produced by the NAPOLOC Laboratory in 1977. A number of scientific and technical investigations were developed by the Laboratory. It was reconstructed in 1979 as the scientific-industrial works "New Energy Sources" with three subdivisions situated in Sofia, Plovdiv and Burgas.

At the beginning of 1980 the works "New Energy Sources" executed governmental program for design, production and montage of 5.000 m^2 solar collector's area per year. Till 1990, 50.000 m^2 of solar collectors were produced and installed.

The distribution of the solar collectors was described (by sectors and regions) in the previous chapters, as well as the state of their operational conditions.

Regarding the incentives, which had to have been in force in this past period, could be mentioned that they had not existed, as the whole economy (industry, agriculture, services and so on) was state, and for the residential building sector (domestic hot water and heating), which had been more than 95% private, the solar collectors had not been of interest as the energy sources had had a symbolic price.

3.3.2. Incentives employed at present

- The project for a new Energy Law (which was adopted by the National Assembly in 2003) foresees "Sustainable development of electrical and thermal energy generation from RES in the interest of environmental protection".
    - For the realization of the above, however, the respective normative documents are necessary;
    - Appropriate financial stimuli are necessary.
- An Energy Efficiency Law has also been adopted. Different incentives are foreseen in this law, which are with regard to the energy efficiency as well as to RES, including solar thermal applications.

3.4. Major market actors

The major market actors on the solar thermal market in Bulgaria are as follows:

3.4.1. Governmental agencies

3.4.1.1. Ministry of Energy and Energy Resources

The Ministry of Energy and Energy Resources is responsible for the sustainable development of the electrical and heat energy generation from renewable energy sources in the interest of environmental protection.

3.4.1.2. Energy Efficiency Agency

The Energy Efficiency Agency is under the authority of the Ministry of Energy and Energy Resources.

The short-term priorities of the Energy Efficiency Agency (EEA) foresee the preparation of:

- National program for renewable energy sources (RES);
- Specialized (sectorial) national programs on RES;
- Annual investment programs.

The Energy Efficiency Agency coordinates also the activities on RES with ministries, local governments, non-governmental organizations and different commercial and specialized firms and professional organizations.

The EEA participates also in:

- Foundation of regional centers on EE and RES;
- Initiation, organization and support for realization of projects on EE and RES;
- Other activities connected with promotion and wide introduction of RES utilization, including Energy Thermal Applications.

3.4.1.3. State Commission on Energy Regulation (SCER)

The State Commission on Energy Regulation is an independent specialized state body. One of the main objectives of SCER is to supervise competition and pricing in the energy market and protect the customers and the public interests, and the environment. Through regulation of the prices of the electrical and heat energy as well as of the liquid fuels and the natural gas, and besides the price of RES, the implementation of RES including Solar Thermal Energy is promoted.

3.4.2 R&D Centers

3.4.2.1. Central Laboratory on Solar Energy and New Energy Sources (CLSENES) to the Bulgarian Academy of Sciences (BAS)

The Central Laboratory on Solar Energy and New Energy Sources was founded in 1975. The main topic is Scientific Studies and Consulting. The laboratory was approved as a leader in photovoltaic researches in Bulgaria.

In 90s, with the change of the conditions for financing of science, as well as with the economic drop in the industry, the scientific and applied activity in the field of the thermal collectors was seriously hindered. Despite that fact, the traditions in CLSENES were preserved and partly the human resources. Stimulus for activation of the scientific and applied activity in the last years are some projects, financed by the 5th Framework Program of the European Union, and namely the project " Bulgarian Center on Solar Energy". Within the frames of this project is financed the establishment of a laboratory for testing of water collectors in real conditions. A stand is elaborated for testing and assessment of the collectors in accordance with the European standard EN 12975. In this standard are presented the requirements for testing in real (natural) conditions.

3.4.3. Regional agencies

3.4.3.1. Two Regional Energy Centers were established in 1996 by the European PHARE Program:

- Regional Energy Center in Lovetch;
- Regional Energy Center in Haskovo.

The centers operate mainly for EC programs, including for RES.

3.4.3.2. Energy Agencies under SAVE program

In Bulgaria four Energy Agencies were founded for the promotion of energy strategies, practices and local policies:

- Energy Agency of Plovdiv;
- Energy Agency of Sofia;
- Energy Agency of Stara Zagora;
- Energy Agency of Ruse.

3.4.3.3. Others

- ***Sofia Energy Centre*** is a successor of the European Community Energy Centre Sofia, which was established in 1992. The activities of the Centre are oriented, above all, toward encouragement of the application of European energy efficient and environmentally friendly technologies in Bulgaria, including those for RES.

- ***Za Zemiata*** is a NGO working in the energy field since 1995. The main topics are: anti-nuclear, waste issues, RES and energy efficiency.

- ***Club of artists "Architecture and Energy" to the Union of the Architects in Bulgaria.*** The club is working on introduction of RES and especially of Solar Thermal Applications in Buildings.

It should be mentioned that in Bulgaria there is no association of the institutions working in the field of Solar Thermal Technologies.

3.4.4. Bulgarian suppliers of solar thermal equipment

In Bulgaria, separate factories and enterprises produce flat solar collectors. There are, however, no production lines. The bigger producers of solar collectors are as follows:

New Energy Systems (NES) Ltd. – Sumen

New Energy Systems Ltd. produces flat solar collectors, which could be with an ordinary and selective absorber. They are produced in three sizes. In the Table 3.6 are presented their prices in Euro, including VAT.

Table 3.6 prices of solar collectors produced by NES Ltd (Oct. 2003).

	Size of the collector (mm)	**Area of the absorber (m^2)**	**Price in EUR**	
			Collector Standart	**Collector Selekt**
1.	770 x 2 150 x 90	1,66	146	230
2.	1 000 x 2 150 x 90	2,15	178	301
3.	1 250 x 2 150 x 90	2,70	281	352

The solar collectors are constructively designed in the following way: Special aluminum carrying profile, a top from a special thermal glass, copper absorber, insulation from mineral wool and pressed mineral wool with black face cover, and a bottom from galvanized sheet iron.

- ***Solar collector Standart***: The cover of the absorber is made from a special solar lacquer with highly absorbing surface. It is elaborated mainly for seasonal systems for DHW, as for the period April-October the solar system covers the needs of the consumer for hot water between 80 and 100 %.

- ***Solar collector Selekt***: It is elaborated for systems with all-the-year utilization of DHW. It has the following advantages: better thermal insulation, the cover of the absorber is selective – type "Tinox", this is a high-temperature cover from titanium oxide. It is characterized by highly absorbing ability 0,95 and low degree of reflection 0,05.

  The selective cover guarantees the operation of the collector in cloudy weather, with its extremely high degree of absorption of the defuse heat.

The all-the-year utilization of the collectors ***Standart*** and ***Selekt,*** according to our observations, gives advantage to the collector ***Selekt.*** It is 38% more effective than the collector ***Standart***.

The produced collectors are sold mainly on the Bulgarian market. It should be mentioned that at the present moment New Energy Systems operates at full production capacity.

KORADO – Bulgaria (Razgrad)

KORADO – Bulgaria produces solar collectors with aluminum profiled fins and copper tubes with collector area of 1,7 m^2. The simple type of installation is the self-circulating equipment (thermosiphon) with boiler of 100 l.

ECOTHERMAL ET – Burgas

ECOTHERMAL is a new private company producing solar collectors with the main parameters:

- Absorber consisting of copper tubes pressed into an aluminum profiled sheet black painted with a collector area of 1,5 m^2 ;
- Insulation – mineral wool with thickness of 40 mm and heat conductivity of 0,039 $W/m^2 K$;
- Aluminum profiled frame;
- Enameled boiler with volumes of 120l, 150l and 200l.

ECOTOP Ltd. – Sofia

ECOTOP designs complete solar systems and implements complete engineering – design, delivery, mounting and service (guarantee and beyond guarantee).

ECOTOP Ltd. has been producing a wide range of solar collectors since 1993:

A. Flat plate thermal collectors in three type sizes – 1000 x 2000; 800 x 1400 and 1000 x 1000 in two variants:

I. A steel body (frame), a steel absorber and glass cover;

II. An aluminum body and an aluminum absorber, copper pipes and a polycarbonate cover.

B. Integrated steel frame in a set with a solar accumulator – all type sizes:

I. Flat, stainless, a polycarbonate cover. The thermal accumulator is built-in in the collector.

II. Semi-cylinder, stainless steel frame, with polycarbonate cover. The thermal accumulator is built-in.

The integrated collectors do not need a boiler, pipe connections and other accessories. They are directly connected to the hot water consumers.

The annual production and sales of solar collectors varies in a wide range for the years from 1993 till 2003 in accordance with the unstable market: from 180 m^2 / year to 540 m^2 / year.

The solar collectors have a ten-year guarantee and the solar systems, according to their supplying have a two to ten-year guarantee.

The quality of the products is guaranteed with a guarantee card from the producer, a quality mark, technical passport and instructions for mounting and exploitation. All the products are tested according to their technical parameters in the testing center of ECOTOP, where they go for tests for durability and reliability.

Besides the Bulgarian collectors, the Solar Thermal Equipment market is supplied also with collectors produced in the EU member states, as well as in Turkey, Israel and China.

Below as an example are presented some distributors:

- *"ERATO Holding" Jsc. – Haskovo*

  The company offers as a distributor:

  - Vacuum solar collectors with absorber – Cu lamella with Ni selective layer and area of 0,728 m^2 . Number of ribbed tubes – 15. Working temperature up to 240°C. Price – Euro 600.
  - Flat plate collectors "MACTECH", which are made in Turkey, with an area of the absorber 1,60 m^2 and an absorber, which could be Al or Cu. The price of a single collector is respectively 115 Euro and 140 Euro.

  In 2002, ERATO Holding constructed a solar installation for DHW in holiday home "Energo" in Primorsko, which disposes of beds for 430 people and a restaurant for 650 people. The water consumption in July and August is from 2 200 to 2 500 m^3/month. The solar installation consists of two parts. In the first part are installed 47 flat-plate solar collectors with total area of the absorber of 85,5 m^2 and capacity 77 kW. In the second part are installed 45 vacuum solar collectors "Vacusol" with total area of the selective layer 34,2 m^2 and thermal capacity of 31 kW.

- *"KOVEX" – Sofia*

  The company offers vacuum tube collectors with flat and with rounded absorber with the main characteristics shown in Table 3.7:

Table 3.7 Main characteristics of collectors by KOVEX

Model	**Seido 1**	**Seido 5**
Type	Heat tube in vacuum tube collector with flat absorber	Heat tube in vacuum tube collector with rounded absorber
Absorbing surface	0,175 m^2	0,229 m^2
Weight	4,6 kg	4,7 kg
Size	Φ 100 mm x 2 000 mm	
Material for the absorbing surface	Cu – Al (copper – aluminum	
Cover	Al – N selective cover with absorbing coefficient α>0,92 and emittance ε = 0,08	
Glass material	High quality silicate glass	
Thickness of the glass	2,5 mm	
Vacuum	<10^3Pa	
Min. temperature of the environment	-25^{o}C	
Working temperature	70 - 120^{o}C	
Max. temperature of the working fluid	250^{o}C	
Resistance to hailstorm	Φ 35 mm	

The vacuum-tube collectors have the following advantages:

- Higher efficiency, especially at reduced sun-shining;
- Operates efficiently even at temperatures below zero;
- The tube construction does not detain snow, neither dust;
- Practically, the wind factor, influencing the heat release of the pipes, is missing;
- Significantly easier installation, maintenance and services;
- The natural geographical and climatic characteristics in Bulgaria, distinguishing with regions of continental climate, mountain relief, characteristic cloudiness, determine the all-the-year application of these collectors in our country.

The main barrier to their implementation is the high price 700-800 EUR/m^2 and the lack of information in Bulgaria on this technology.

The collectors are produced in China, with a license from a German Company and they are shown in Photo 3.3

Photo 3.3 Vacuum-tube collectors by KOVEX

- <u>*"APEX" Co – Sofia*</u>

APEX Co is a distributor of the English "THERMOMAX" and the Greek "MINOS", also the Dutch flat plate "AES" types of solar collectors and Bulgarian solar collectors produced by NES.

- <u>*RGS*</u>

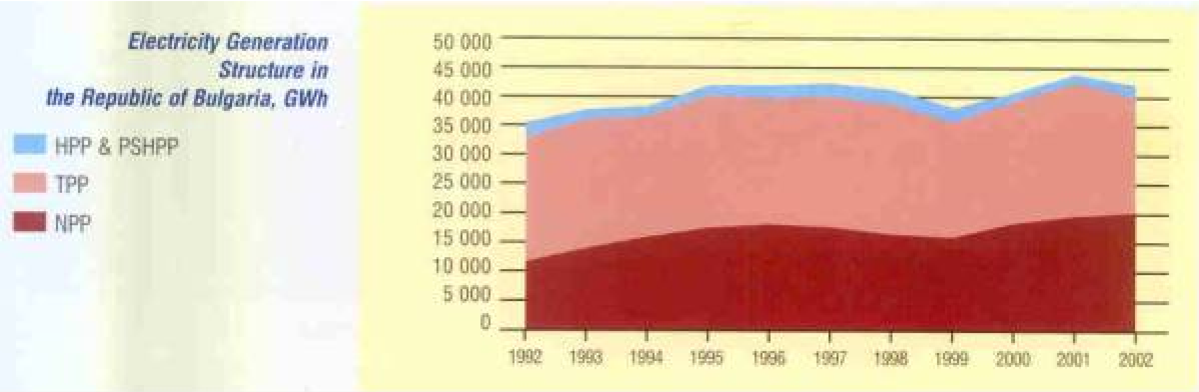
RGS is a distributor of solar collectors produced by the German company VIESSMAN – CarolSol, TuboSol and DuoSol.

3.4.5. Market competition – comparison with competitive fuels

The solar thermal energy is a sustainable and clean source of energy and can provide in Bulgaria a significant share of energy. For its utilization, however, the respective installations are needed. In the old times, barrels were painted in black for heating of water. After that are introduced the flat plate, and now the more effective vacuum solar collectors, which offer the possibility for utilization of the solar energy all the year around. From technological point of view, solar collectors and the respective installations are not complicated. Despite that fact the respective investments for installations are necessary.

In Bulgaria, domestic hot water is obtained mainly through electric boilers, i.e. the main competitor of the solar energy is the electrical energy. Here the comparison should not be measured only by the price, but also by the fact that for obtaining of 1 kWh electrical energy from conventional energy and according to the total coefficient of efficiency of the electrical energy system, about twice as much primary energy sources are necessary. For Bulgaria, the decrease of the necessary primary energy sources is of great importance, as it imports more than 70 % from them.

The structure of the electrical generation in Bulgaria by types of plants in GWh is presented in Figure 3.11:



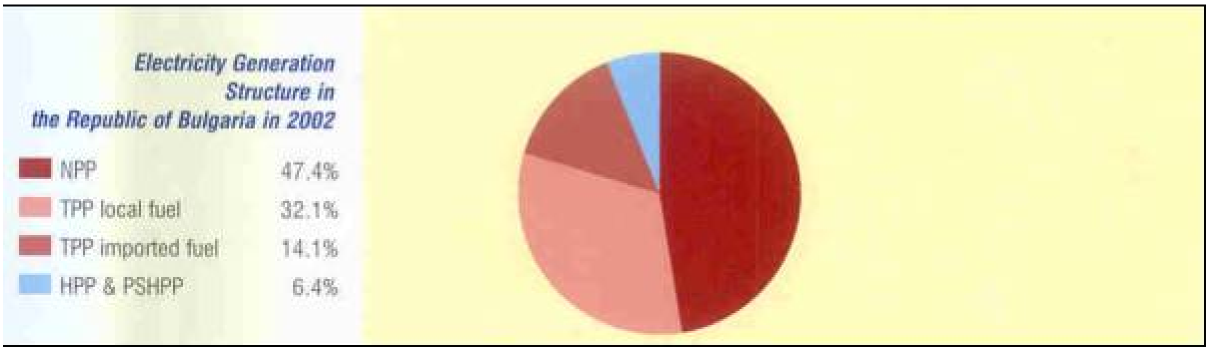


Figure 3.11 The structure of the electrical generation in Bulgaria by types of plants in GWh

The specific CO_2 emissions for the Bulgarian electrical system are about 1.250 g/kWh.

From the example of solar installation in an individual private house, with annual energy delivery of 1.280 kWh, the CO_2 emissions are reduced with 1.600 kg. Therefore the installation of solar collectors could be connected with the principle of the green certificates. That is why the state should support the introduction of solar systems.

It could be seen from the above that solar thermal energy, compared with electricity, has the advantage of being environmentally friendly. The costs for environmental and health damages caused by the use of electrical energy, also known as “external costs” have to be paid by the public, at the end. This is the main argument why solar thermal systems need to be supported by the state in the form of grants, subsidies, favorable taxation, etc.

With average price for domestic consumers from 01.07.2003 to the amount of 0,14lv./kWh (0,07 Euro/kWh) and an average price in September 2000 of 0,08 lv./kWh (0,04 Euro/kWh), it could be seen that for a period of 3 years the price of the electrical energy in Bulgaria has increased two times, i.e. the simple pay-back period of the solar thermal installations has decreased two times.

3.4.6. Market overview

To get a complete market overview on the main reasons of utilization of Solar Thermal Equipment, the following should be mentioned:

- For domestic system ensuring the needs of hot water is assumed that the necessary volume of hot water per day for one person is around 60 liters with temperature 45^{o}C. In accordance with the type of the used collector this is achieved with 1 to 2 m^2 of collector surface. When it concerns big systems like hotel, restaurant and others, calculations are made evaluating more factors like coefficient of filling in, season and etc.

  With the choice of a system and components, the geographical region is taken into account, whether the system will be used all the year around (the utilization of vacuum tube collectors is recommended).

- The monthly savings depend on the quantity of hot water, which will be used, the volume of the boiler and the price of the conventional energy, which is used for additional heating of the water. For a four-member family, the used water is around 240 liters/day, which makes in average 3.500 kWh/year or 490 lv/year, if electrical energy is used at an average price of 0,14 lv/kWh.

  A well designed system should ensure between 50% and 85% “solar contribution” or saving from the traditional bill. This makes a pure profit between 250 lv/year and 450 lv/year. Much more accurate and optimistic is the method of discount of the cash flows, which assess the inflation, the increase of the prices of the conventional fuels and electrical energy.

- Solar water heating systems are always installed with an additional source of heating. It supplies hot water in case of exhaustion, a bad day, so that there is always water in the boiler ready for use. In any case, for optimal utilization of the solar system and for more savings, the consumption of hot water should be evenly distributed in the days of the week. This would decrease the utilization of a source for additional heating.

The price of a mounted solar installation depends on the type of collectors, the type of the system and the concrete conditions of the site, but in general it is between 1.500 lv and 5.000 lv. for a four-member family installation (250 liters). Why is the difference so big? The price and the effectiveness of the system depend on some variables:

- Number of months, during which solar heated water will be used;
- Size and type of the system – thermosiphon does not require specialized automation;
- Type of collectors – the flat plate collectors operate from April till October, in comparison to the “all-the-year-around” vacuum tube collectors;
- Type of roof on which the collectors will be installed – are there any additional stands needed;
- Professional or “do it yourself” system.

The main problem for the implementation of Solar Thermal Systems is the required investments. Unfortunately, in Bulgaria the government does not offer any financial alleviation. Except for own funding, some firms offer leasing with a period equal to the one expected for pay-back of the investment, but not longer than 3 years.

Before taking the decision what type of collectors to be bought, an answer to the following main question should be given: What is the purpose of the system and how much time will it be used during the year?

With seasonal use, like bungalow, villa at the seaside or in the Balkan, a not expensive and efficient in the summer collector should be chosen. Such are the flat plate collectors with black painted absorbers. Most of the collectors used in the country are of this type. They are produced in the country or are imported from neighboring countries with significantly more favorable for their utilization climate – Greece, Turkey.

If the necessities are in a greater time period, for example they include also the transitional seasons (spring, autumn), a good choice is investment in selective flat plate collectors. In Bulgaria there is no technology and capacity for production of selective absorbers, yet. Around ten companies are known in the world, which produce such absorbers. In Bulgaria there are two importers of selective absorbers, but the produced collector, is far away from the world level for quality and does not meet the standards of the industry.

For the winter, the only collectors, which could operate in an extreme climate, even in cloudy weather, are vacuum tube collectors with heating tubes.

In Bulgaria, the most widespread vacuum tube collectors are produced by the firm THERMOMAX. Due to their advanced technology, these collectors are imported from Great Britain and have been popular in the country since 1994. There are more than 2000 installed vacuum tube collectors in Bulgaria.

The Solar Thermal Equipment market in Bulgaria is rapidly developing, but it is still in an initial phase. Apart from the professional producers in Bulgaria and the professional distributors, as well, there are a number of producers and suppliers who work unprofessionally. Of particular importance is that the clients contact an engineering company, which will not only offer delivery of the components of a Solar Thermal System, but will also design it, install it and will maintain the installations. Otherwise, the system could be not accurately sized or mounted unprofessionally and the expected effect will not be achieved.

For Bulgaria, of special importance is the way of protection of the systems against freezing. The most popular way is the utilization of propylene-glycol mixture with water. The system as a type should be executed in a way that it implements an indirect contact between the working (solar) fluid with the domestic water through heat-exchanger.

4. Development perspectives

Bulgaria has a substantial solar potential and a limited scope of its utilization. To a great extent it is due to the fact that for a long period between 1944 and 1990 the state policy applied symbolic prices of the energy sources (electricity, heat, etc.) and the development of RES utilization and therefore – of the RES industry, did not meet the required fundament to begin. The demonstration projects implemented during the last years, undoubtedly, contribute to the solar thermal applications development, but at the present moment RES hardly form 0,4% of the national energy balance. The solar collectors share in RES is only 4,5% installed capacity and 2,1% generated energy.

4.1. Barriers for implementation of solar thermal installations

The barriers for development of RES and especially for solar thermal installations are as follows:

i. Institutional barriers:

- Lack of a national program for the development of renewable energy sources and the related technologies;
- The various state institutions, although having a positive attitude towards renewables, still do not pay the necessary attention to these energy sources;
- Lack of regional and municipal structures, dealing with energy planning and utilization of RES;
- There are no authorized laboratories for quality control of the produced equipment.

ii. Financial barriers:

- There are no state funds in Bulgaria for development of RES utilization and technologies. Such a fund would support to a greater extent the implementation of various RES projects, including solar thermal installations;
- The Bulgarian commercial banks have very prudent crediting policy – high interest rate (usually over 15%) and credit guarantee more than 125%. They abstain form granting long-term credits. Currently, this burdens the small and medium size enterprises in producing solar collectors and solar thermal installations;
- In some cases, the renewable energy is still more expensive than the consumer price of heat and electricity. The pay-back period for solar thermal installations, in most of the cases, is more than 5 years.

iii. Legal framework:

- The Energy and Energy Efficiency Law (adopted in 1999) treats only generally RES. Renewables are still not considered a priority in legislation and there are no incentives for their utilization, including solar thermal installations as well.

iv. Market barriers:

- Insufficiently developed commercial network and connected to it market activities;
- Insufficient highly qualified technical service;
- Necessity of informational companies;
- Lack of an authorized laboratory for quality control of the produced equipment.

4.2. Opportunities assisting RES (including solar energy):

- The prices of conventional energy have increased many times. Nevertheless, the energy market is still not liberalized. Under the international pressure for liberalization on the energy sector, the energy prices soon will be in line with the international levels and RES will be more competitive.
- Environmental awareness is growing and RES are seen as a clean future source of energy.
- Decentralization of the state regulation and larger autonomy of the local and regional authorities lead to development of their natural resources as they see triple dividends: environmental improvement, economic development and increased employment.

5. Closing comments

Bulgaria enjoys a significant solar energy potential, which, unfortunately, up to the present moment, is almost unutilized.

The prospects for development of solar thermal installations in Bulgaria by the year 2010 are to increase to 300.000 m^2 solar collectors. The investments required are 75 million Euro. To achieve these prospects, the following should be underlined:

1. The state with its regulatory functions:

1.1. Adoption and realization of a National Strategy and a Program for Development of the Renewable Energy Sources (RES), including solar thermal systems, with view to supporting the investment process.

1.2. Legislation and normative acts:

In the project for Energy Law and in the project for Energy Efficiency Law solar thermal systems should also be included as: local energy source, energy-environmentally friendly and energy effective.

1.3. Financial stimuli, to the consumers, as well as to the producers of elements for solar thermal systems:

- Reduction of the taxes;
- Granting preferential loans (gratis period, law interest rates);
- Offering an opportunity for utilization of the respective funds (for example Energy Efficiency Fund).

1.4. Decentralization of management.

Establishment of units, at regional and municipal levels, responsible for the development and the utilization of RES.

1.5. National and regional campaigns, which are aimed at stressing on the advantages of the utilization of RES, including solar thermal products.

1.6. Standards for the main solar thermal elements.

1.7. Support for establishment and operation of laboratories for testing of elements of solar thermal systems.

2. Support the Establishment of an Association in Bulgaria for Solar Thermal Systems and the Association's Main Activities

2.1. Members of the association could be producers and importers of elements of solar thermal systems; companies, which design, install and maintain these systems; scientific and testing laboratories and others.

2.2. Research on the solar thermal systems market in Bulgaria for different sectors (dwelling buildings, public buildings, hotels, sports complex, industry and etc.), as well as for the different type of collectors (seasonal and all year utilization);

2.3. Organization of acquainting tours for members of the association, for example in Greece or in other country. Visits to producers of elements for solar thermal systems (absorbers, collectors, boilers), solar laboratories. This will contribute to the better acquaintance with the products and will create conditions for future collaborations.

2.4. Organization of information campaigns, aimed mainly at the potential users.

2.5. Assistance to local producers of elements for solar thermal systems for testing of their products in respective laboratories.

2.6. Assistance for establishment in Bulgaria of joint-venture companies for implementation of the newest technologies for production of elements for the solar thermal systems.

The RES utilization is a new philosophy in our country and requires a new way of thinking and new approach for RES development. Joint efforts are necessary, both on the part of state with its regulatory functions, and on the part of the entrepreneurs and financing institutions. Regional and national information campaigns are needed, showing the advantages of RES utilization for the energy saving and for the environment.

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