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# A CONSTRUCTIVE SOLUTION FOR A SOLAR COLLECTOR WITH ALUMINUM ABSORBER

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**Abstract:**
The paper presents a constructive solution of a solar collector made of a series of aluminum lamellas, placed in aluminum thermo-isolated box. The shape and the profile of lamella make the collector absorber original, and its design has a number of advantages compared to the usual technical solutions. A significant effort has been made to find the geometric profile of ribbed lamella, which would meet all the requirements, starting from design, production and assembly, to high thermal and electric power characteristics. The surface protection was made by way of special procedure of electrochemical protection, thus obtaining a high quality selective surface of absorber. The collector is intended for conversion of solar into thermal energy, and its vast application is possible in heating of sanitary or technological water in boilers, reservoirs, pools, etc.
**Keywords:**
Solar radiation, solar collector, absorber, aluminum lamella, heat conversion

## 1. INTRODUCTION

Solar energy, as an energy source is gaining in importance daily. There are several reasons for that, some of them are that solar energy is free and easily accessible to everyone, it is ecologically clean and does not pollute the environment. It is inexhaustible for both the present and future generations, and falls in the group of renewable energy sources. The reason why it has not been exploited sufficiently so far can certainly be found in its "dispersion", that is to say, its relatively low density compared to conventional sources, and in the fact that for its "capturing" and conversion relatively big solar surface should be installed which, already at the beginning, requires significant investment from an investor. This is why this investment is a privilege of well-off individuals and countries, which however, after a relatively short repayment period, provides free of charge and clean energy throughout its useful life. The ways of "capturing" solar energy are diverse. This paper focuses on an innovated technical solution of a solar collector designed for heat conversion, that is to say, primarily for hot water preparation. Photovoltage collectors that perform conversion of solar into electric energy also have a significant role as far as application is concerned, but they will not be discussed in this paper.

## 2. CONDITIONS AND POSSIBILITIES FOR USING SOLAR ENERGY

The power of the radiation of the Sun on the surface of the Earth is within the range of 1000 $W/m^2$[2], which depends on a number of factors, latitude, position and the surroundings of the facility being radiated, cloudiness, etc. The time period during which solar energy can be efficiently and effectively used in our climatic area is from March through October and especially during the summer months when the abundance of the Sun is great and ranges from 1100–1500 $kWh/m^2$/year (Figures 1. and 2.).

According to the PVGIS database, the average yearly global irradiation on horizontal plane in Europe is 1096 $kWh/m^2$/year. If we consider only built up areas, than the average is 1130 $kWh/m^2$/year. To better see the geographical distribution, the colors in the legend were modified to see the deviations from the value of 1000 $kWh/m^2$/year.

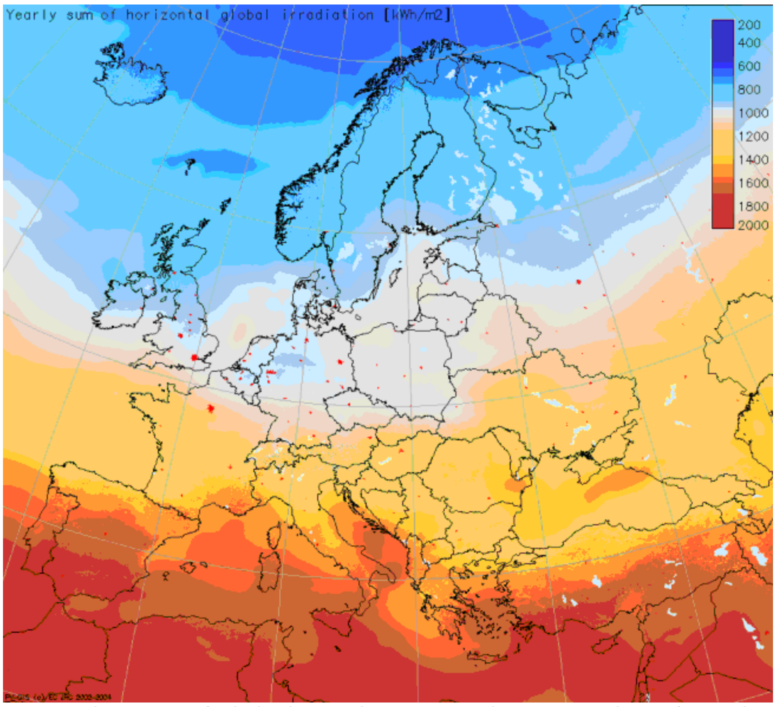


Figure 1. Yearly sum of global irradiation on horizontal surface [kWh/m²]

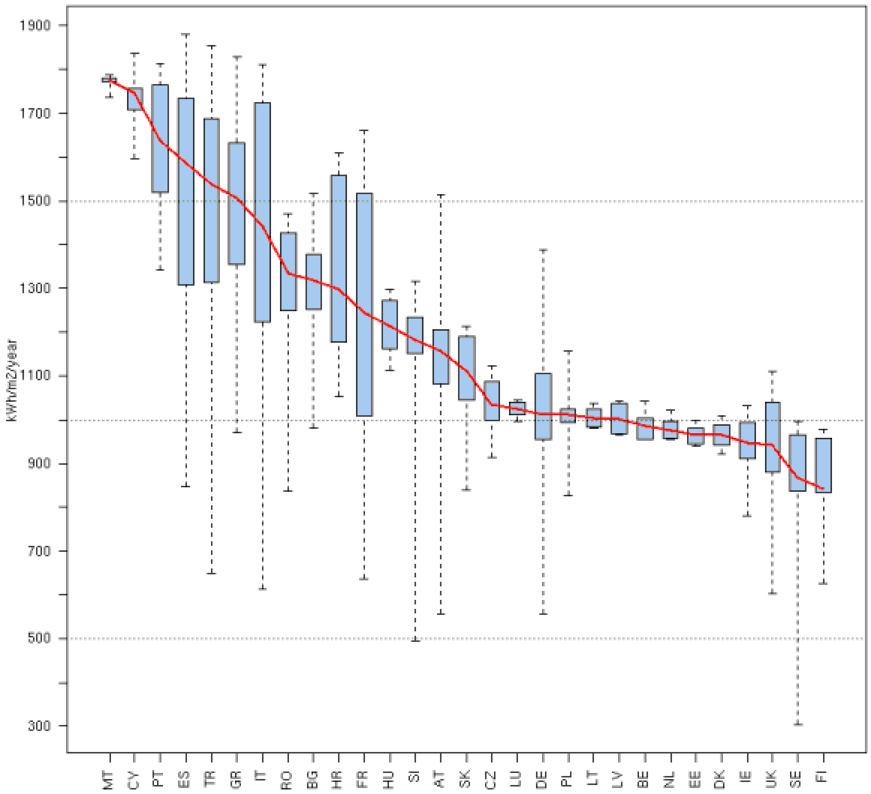


Figure 2. Global horizontal irradiation in EU25 countries [kWh/m²/year]

This time period coincides with naturally increased needs for water consumption due to bigger individual consumption, the summer season of bathing in outdoor pools, etc. That fact inevitably leads to the idea and the need for more intensive utilization of free and ecologically clean solar energy during that period, which can be efficiently solved by using solar collectors. The collectors have already found their place and application and are present in a number of different versions and technical solutions.

From the point of view of transformation technology, solar receivers, as devices that serve for capturing that is to say, receiving the energy of radiation of the Sun, can be divided into two basic groups, more precisely:

- collectors designed for thermal conversion, during which the energy of the Sun is directly converted to heat; their most frequent application is in heating systems and preparation of hot water for consumption;
- photovoltage panels designed for direct conversion of solar into electric energy which makes their use exceed the domain of thermal and technical systems and this is the reason for their much wider application in other fields too.

Of a number of collectors, i.e. systems, designed for thermal conversion, it is important to point out flat low-temperature receivers of solar energy, primarily because these systems are the cheapest and the simplest, and can easily find mass application, and thus produce significant economic and ecological effects.

There was a considerable number of producers of low-temperature solar panels of various types in the territory of former Yugoslavia; their production mostly stopped. However, the new producers with new solutions have been emerging. They are aware of the need and importance of using „free" energy, especially having in mind that energy, being a strategically important resource is becoming more and more expensive every day. In addition to that, in recent years there has been a major change in overall attitude toward preserving the environment, and this has also been given a legal form in many countries and international organizations. The fact that classic energy sources, like coal and oil, are inevitably polluters, and that they incur additional expenses in terms of maintenance of the systems within permitted limitations of work, leaves more and more space for utilization of alternative, ecologically clean systems that use free energy of the Sun, the wind, etc. This context was borne in mind while designing this technical solution of low-temperature flat solar collector (Figure 3). The aim was to achieve the biggest possible level of efficiency of heat conversion, decreasing the weight and the price, to accomplish longer duration of the device, as well as the simplest possible installation and operation.

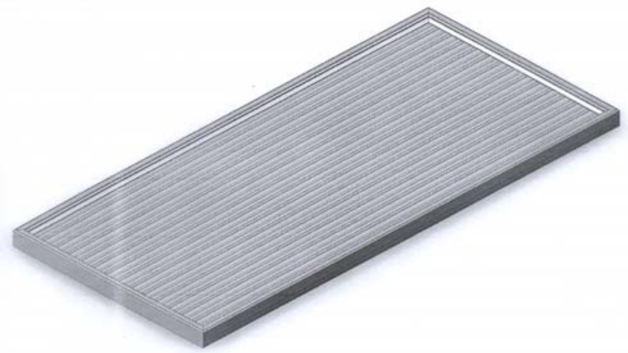

Figure 3. Solar collector

## 3. TECHNICAL AND GEOMETRIC CHARACTERISTICS OF THE ABSORBER

Having in mind that the absorber (Figures 4. and 5.) is the basic and the most important part of any solar receiver, it should be paid special attention during its constructive design. The efficiency of the entire device mostly depends on the absorber, but during the design process itself attention should be paid to technological possibility of making and installation of the elements, mass, price as well as to other factors.

Figure 4. The layout of the lamella of solar absorber

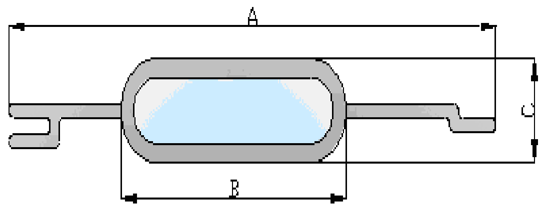


Figure 5. Lamella of absorber (cross-section)

In connection with that, aluminum was chosen as a material for making the absorber (i.e. aluminum alloy). It is significantly lighter than copper, material normally used for making this type of solar collectors. Weight is certainly something that should be taken into account, not only because of the price, but primarily because of the load on the roof structure, which can be significant, especially if a considerable number of collectors are placed on the roof, and having in that this type of load is frequently overlooked by civil engineers. Besides its being lighter, aluminum is also much cheaper material than copper and has good technical characteristics in the sense of heat conducting, the possibility of applying appropriate long-term surface protection, all of which provides the ground for expectation that this type of product can last longer.

The idea around the construction of the absorber itself was to assemble it of elements – lamellas, which are actually a substitute for usual classic collector pipes. The internal cross-section of the lamella through which the medium flows has a shape of a stretched circle; on the external cross-section two ribs from the left and the right side can be seen. The main task of the ribs is to directly conduct the collected energy of radiation from the surface which they cover to the medium.

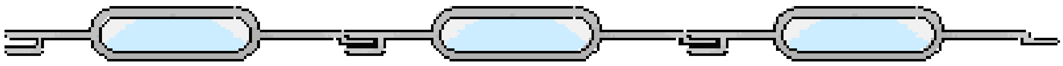

Figure 6. Connected absorber lamellas (cross-section)

The edge of the rib is adjusted and shaped for fitting into and connecting with the adjacent rib (Figure 6.), so that after assembling all necessary ribs the final surface of the absorber is obtained, of a slightly wavy shape, but of quite satisfactory external appearance. In this way the laying of the cover upper sheet metal board has been avoided, which is in classic pipe collectors usually placed over the pipes and which serves as an absorber, but first of all as a mask - curtain. That role has been assumed here by lamellas. In this way, there is one less position in the assembly, and better conditions for transfer of heat to the medium are created by avoiding the contact resistances that inevitably appear with classic collectors on the place of contact of the upper board and the pipe. In this case the beams fall directly on the lamellas in which water flows.

Two aluminum collector pipes that have a role of a distributer, that is to say collector of the medium (most frequently water with addition of an anti-freeze agent), are connected from the upper and lower side of the lamella, thus ensuring circulation of the medium through the collector. However, if more than one passage through the same collector needs to be provided, then not all the lamellas are connected with a single collector pipe, but only a certain number of lamellas, whereby the medium is returned back through the collector by the subsequent same number of lamellas thus making more passages through the collector. This can be done thanks to the fact that the number of lamellas installed in one collector is not limited, nor is their length which is obtained by cutting lamellas to the desired length from the finished profile. This ensures the projected speed of circulation through the collector, and an influence is made on the ratio of heat transmission from the wall to the fluid, as well as on the overall circulation resistance, output temperature of the fluid, etc. Also, the frame of the collector box does not limit forming of the size of the collector, because the frame itself is formed according to the requirements of the collector dimensions from custom-made Al profiles. Therefore, during designing of a concrete solar system (e.g. water heating for the needs of hotels, multistorey buildings, pools, etc.), it is easy to form a collector of certain dimensions adjusted to that specific requirement.

The surface protection of the absorber itself has a key role in absorption of the radiation of the Sun; having said that, it is necessary to achieve the goal of the biggest possible absorption and the smallest possible emission and reflection of radiated energy on the surface of the absorber. A selective coating was applied by way of an electrochemical process; it was kept during a certain time period in the solution of exactly determined concentration in order to obtain a coating of necessary chemical composition and thickness. Besides good absorption characteristics, this coating also shows good persistence during the exploitation conditions, unlike classic coatings that most frequently peel and decay with time. The selection of the process itself of applying and achieving the best selective coating has been done in accordance with the diagram in Figure 7 [3], which shows dependence of emissivity on thickness of oxide coatings formed in solutions of different acids.

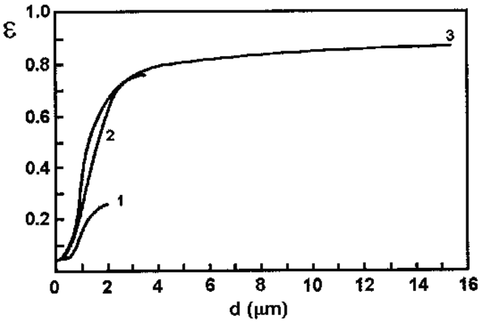


Figure 7. Emissivity depending on thickness of oxide coating made in solution of 1. phosphorous, 2. chrome and 3. sulphur acid

Protection of the box-frame of the absorber has also been done by way of electrochemical protection with parameters that underline more permanent resistance to atmospheric influences.

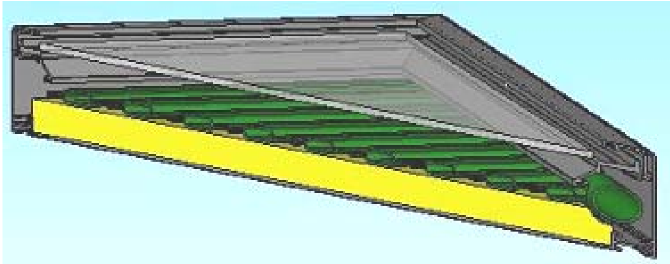

Figure 8. Cross-section of solar collector

Thermal isolation and protection of the absorber (Figure 8) against external influences has been done in the aluminum box which is isolated with polyurethane foam from the bottom side, and from the upper side with one glass board. Dimensions of the box, as well as of the thermal isolation and the glass board are reduced to minimum, having in mind that the operation of this absorber is preferred during the summer time as well as the transitional period when maximum energy effects are obtained.

## 4. INSTALLATION AND USE OF THE COLLECTOR

The collector has been designed for assembling in classic solar installations for preparing hot water in individual or joint containers for several consumers, for supplementary heating of the facilities, as a support to classic heating system, for supplementary heating of water in outdoor or indoor swimming pools, etc.

The hot water container should also be equipped with the pipe heater through which exchange of heat from the fluid-carrier of the heat to the consumer hot water is carried out. Besides standard components, the pump, the expansion receptacles and the pipe installations, there should be also automation installed in the system that will perform regulation of processes, that is to say, start and end of circulation, in order to prevent the loss of already accumulated heat in the container and increase the efficiency of the entire system. If there are more collectors installed in the system, their connecting can be done in a series, in parallel or in a combined manner, depending on the requirement of the project itself. The support structure is being adapted and delivered depending on the characteristics of the place of installation (gable roof, flat surface, etc.).

Figure 9. [1] presents a diagram for rough selection of size, i.e. number of solar collectors and hot water containers.

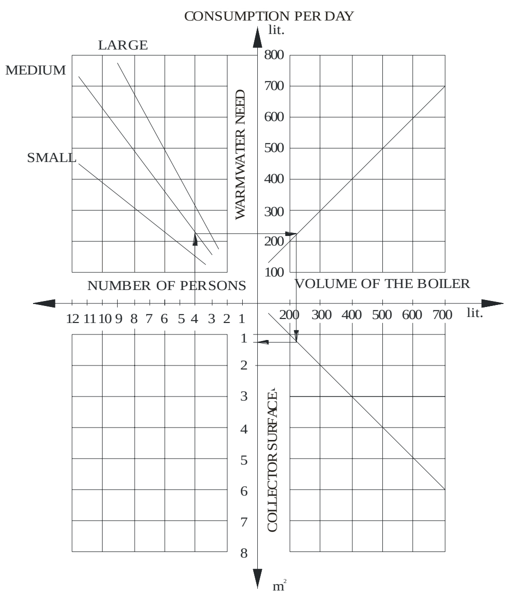


Figure 9. Determining the size of the boiler and the collector depending on the size of the household

## 5. CONCLUSION

The paper presents an original technical solution of a solar energy receiver, designed for heat conversion, which can be effectively used for preparation of hot water in boilers, containers, pools, etc. A solar receiver of high technological and energy performances is obtained through significantly adjusted geometric shape of the absorber, quality surface protection and simple assembly of pre-fabricated elements. This is more than enough as a reason for the beginning of serious application this ecologically clean system in our area of, which ensures capturing and the use of abundant and free of charge heat of the Sun. In this way significant savings in the consumption of expensive conventional fuels will be achieved, especially having in mind that those fuels are polluters of the environment that is already to a large degree jeopardized and the protection of which will have to be intensively implemented in all countries in the world, on the basis of both current and future International treaties. Bearing in mind that these standards are to a large degree already in effect in EU countries, their application in our country is also expected, as well as the significant support to these projects by the Government. This solution also helps achieve considerable financial effects and savings compared to the utilization of conventional energy resources.

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