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PROVINCIAL SECRETARIAT FOR ENERGY AND MINERAL RESOURCES

STUDY ON THE ESTIMATION OF OVERALL SOLAR POTENTIAL - SOLAR ATLAS AND THE POSSIBILITY OF "PRODUCTION" AND USE OF SOLAR ENERGY ON THE TERRITORY OF AP VOJVODINA

- *SHORT ABSTRACT*-

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The energy of solar radiation which comes to the Earth yearly is around 170 times bigger than the energy contained in the overall reserves of coal in the world. The capacity of solar radiation on Earth is, according to some estimations, around 14.000 times bigger than the overall energy consumed by human kind today. The power of solar radiation that falls onto the Earth is around 175.000 TW. What kind of a potential is that shows also the fact that entire world energy consumption has the power of closely 13 TW! The energy of solar radiation that reaches the Earth's surface, meaning potentially usable solar radiation, is around 1,9 x 10^8 TWh (190 million of TWh) yearly. This energy is around 170 times bigger than the energy of entire coal reserves in the world and compared to the needs of human kind for energy, that is 1,3 x 10^5 TWh (130 thousand TWh) yearly, we come to a derivational fact that the solar energy that reaches the Earth during only 6 hours is enough to satisfy all needs in the world on annual level. To get a better insight for these values, an average household in some of the most developed countries in the world spends yearly around 10.000 kWh of electricity, and it would take 100.000 years to spend 1 TWh. Around 37 % of global demand for energy is satisfied with production of electricity which in 2008 was around 17. 000 TWh.

Concerning that the Sun's energy, from the technical-exploitation point - is energy resource of renewable feature (transformed solar energy which is conducted from the solar energy collectors (SEC), is permanently being in the process of renewal, in the conditions of radiating solar energy), we cannot speak of an energy resource as in other cases of non-renewable sources of energy. This resource depends on insolational conditions, size and characteristics of SEC (previously listed factors) and the time span of exposure to RSE of radiating solar energy.

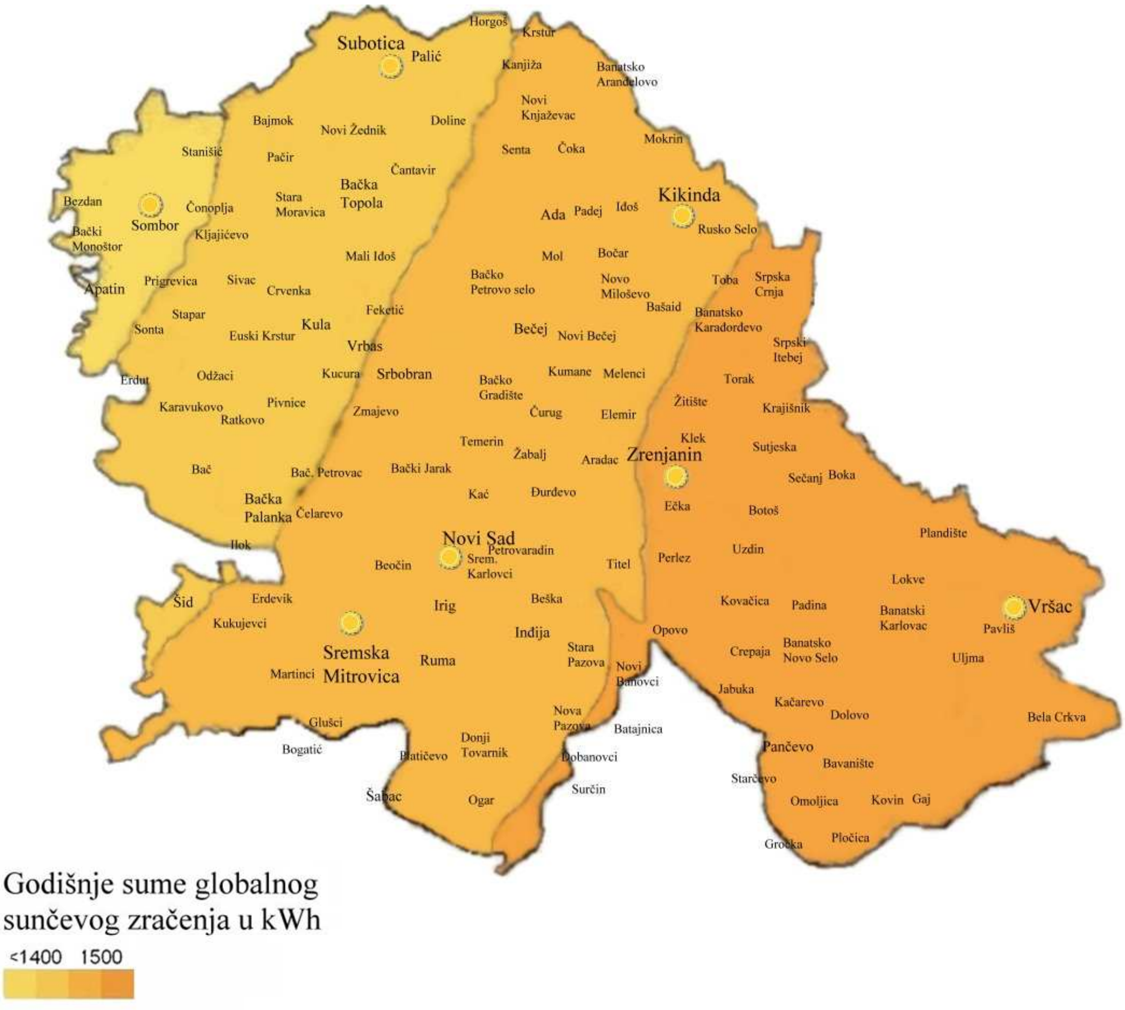
Of radiation from the Sun radiating on the Earth, whose power density reaches the values from 970 to 1.030 [W/m^2] - the useful radiation quantity on the unit of free orientated area, depends on its orientation (should be oriented towards south), on its angle (it is preferred to have Sun beams reaching the receiver at the angle closest to normal (direct), so the radiation - the density of the power can be bigger), on the construction and energetic characteristics of the solar energy receiver, part of the day, part of the year, time of insolation, atmospheric conditions and other. The power of solar radiation changes during day, month and year. Its value depends on geographical position, conditions of the atmosphere and other.

The number of sunny hours in Serbia goes in average from a bit less of 2.000 hours (in the North) to more than 2.300 (in the South). It is a larger value than in the most European countries, but the solar potential is not used. The potential of solar energy presents 16,7% of overall usable potential of Renewable Energy Sources (RES) in Serbia. The energy potential of solar radiation is for about 30% bigger in Serbia than in Central Europe. The average daily energy of global radiation for a flat surface during winter period goes from 1,0 kWh/m^2 i the North and 1,7 kWh/m^2 in the South, and during summer season between 5,4 kWh/m^2 in the North and 6,9 kWh/m^2 in the South. The most favorable areas in Serbia record a great number of sunny hours, and the yearly ratio of real irradiation and overall possible irradiation is close to 50%. Serbia has one of the best solar resources in Europe. Solar radiation in average is bigger for about 40% of the European average. The lowest measured values of solar radiation in Serbia could be compared to the highest values in the countries leading in the use of solar radiation, such as

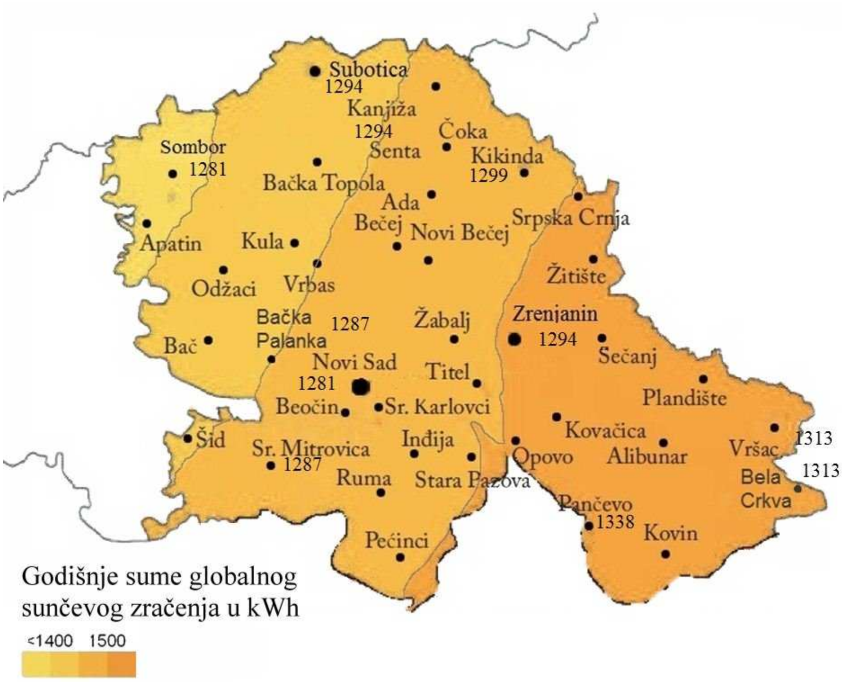
Germany and Austria. For comparison, the average value of solar radiation for the German territory is around 1.000 kWh/m^2 , while for Serbia it is 1.400 kWh/m^2.

The number of sunny hours in Vojvodina goes from a bit less than 2.000 hours (western part) up to 2.100 hours (eastern part). According to "*Valentin Energie Software -TSol Pro 4.5*" the average annual value of global radiation for horizontal surface is between 1.294 kWh/m^2 on the north of Vojvodina and 1.350 kWh/m^2 on the south of Vojvodina, and 1.281 kWh/m^2 on the west and up to 1.294 kWh/m^2 on the east of Vojvodina. This shows that on the same source, the average yearly value of sun radiation over a horizontal area for the territory of AP Vojvodina is around 1.300 kWh/m^2.

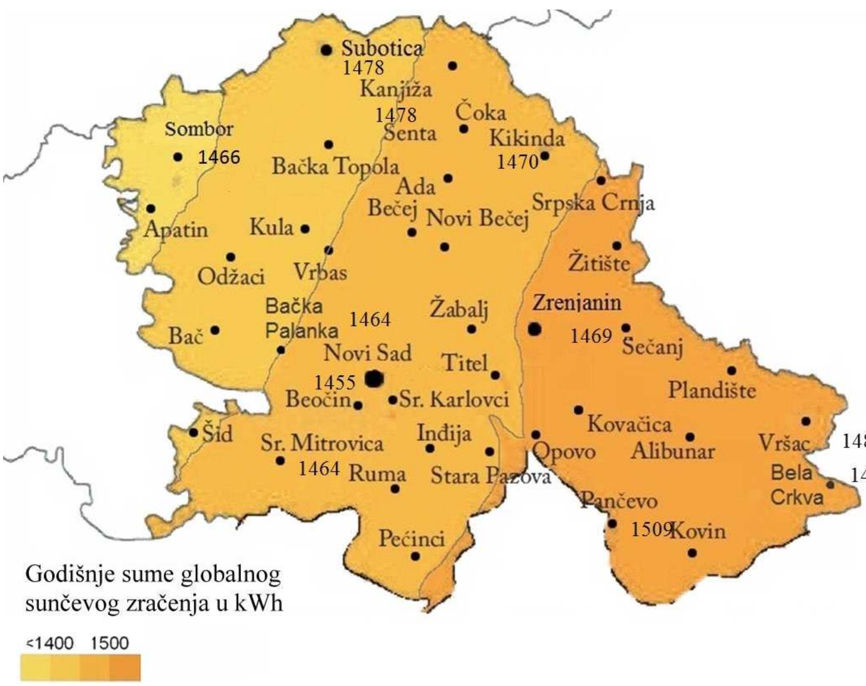
The average daily energy of global solar radiation on horizontal surface at the territory of Vojvodina goes from 1,0 – 1,4 kWh/m^2 during January, and from 6,0 - 6,3 kWh/m^2 during July. At the territory of Vojvodina, the annual average of daily solar radiation energy on the surface leaned towards south under the angle of 30° results with 4,0-4,6 kWh/m^2.



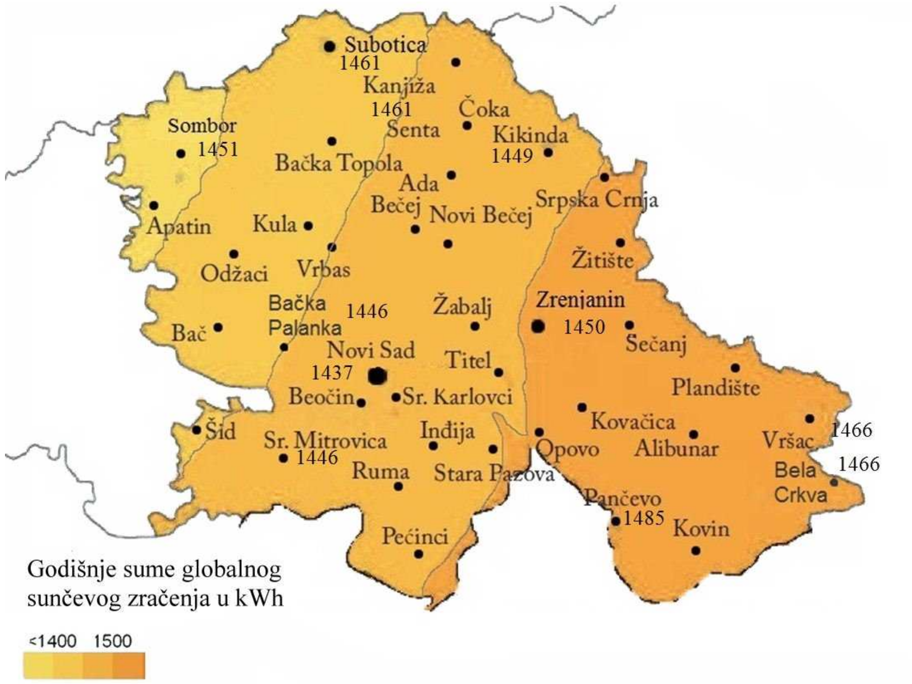
Solar chart of AP Vojvodina with irradiation zones during, a year in kWh/m^2



Yearly average of daily global energy radiation (in kWh/m²) on horizontal surface (0⁰) for Vojvodina



Yearly average of daily global energy radiation (in kWh/m²) on a surface at the angle of 30⁰ for Vojvodina



Yearly average of daily global energy radiation (in kWh/m^2) on a surface at the angle of 45^0 for Vojvodina

The average daily energy of global radiation on even surface during winter period goes from 1,0 kWh/m^2 on the north of Vojvodina to 1,45 kWh/m^2 on the south of Vojvodina (December - January) and up to 3,55 (March), and during summer period between 5,70 kWh/m^2 on the north and 6.85 kWh/m^2 on the south (June - August). According to meteorological measuring made in the span of 30 years in ex Yugoslavia, the values of radiating energy on some horizontal surface are larger from estimation values (according to *Valentin Energie Software -TSol Pro 4.5*) for about 9 to 12%.

In the conditions of irradiation in Vojvodina - depending on the season and atmospheric conditions - the intensity of global radiation in afternoon hours can vary from 200 do 1.000 W/m^2. The relation of direct and diffuse radiation depends on geographical and microclimatic conditions. Diffuse radiation on the level of average for entire year makes 40-60% of global radiation, where during winter this participation is bigger.

Solar energy collector, is put under a certain angle and oriented to the south in the aim of getting maximum energy effects. Due to the relative position of the Sun to the place where the receiving surface is located and its changing positions in the course of a day, month and year, it is necessary to provide the immovable receivers with the right orientation and the maximum exposure of the receiving surface to the Sun, and by this to achieve better energy result. But if accommodating conditions do not permit ideal south orientation, it is not necessary to insist on them, it is possible to position the same into a slightly turned position (towards south), without a big energy loss. In that way, for example, for places in Vojvodina, the deviation of solar collector from ideal south orientation of 15 to 30^0 lessens the quantity of radiation energy for about 5 to 10 % (respectively).

For the territory of Vojvodina a suitable angle for some south oriented surface (of solar collector) for the maximum "catch" of solar radiation during the whole year, is an angle of around 40 to 45^0, and for solar collectors that are mainly used during warmer periods of year (late spring, summer and early autumn), that is when better effects are expected in that period, the optimal angle is around 30^0. For solar collectors where better energy effects are expected in a colder year period (late autumn, winter and early spring) the optimum angle of solar collectors is around 60^0. So, for example, for a surface laid at the angle of 30^0 the annual value of radiated energy is bigger for about 13-14% - in comparison to horizontal surface.

From the energy sector point of view, solar radiation presents a resource that is available for use and the substitution of considerate quantities of conventional energy forms. Its limited use is caused by technological and economical problems. It is a huge energy source with which demand for the energy can be covered for a very long time. Solar energy that reaches the Earth's surface during only 6 hours is enough to meet entire world needs on annual level.

Since the angle covered by the Sun's ray with its horizontal projection changes during day, month and year - the optimum angle of static receiving surface presents compromise solution according to which this angle suits medium angle for a certain period of exploitation during a year. In table 3.5 the dependence of the angle of receiving surface - the solar energy receiver (in relation to the horizontal surface) from the season for achieving maximum energy effect on the static receiving surface in that specific period is given. For the territory of AP Vojvodina, a suitable angle of some south oriented surface (solar collector) for the maximum "catch" of solar radiation during the whole year equals the angle of around 40 to 45^0, and for solar collectors that are mainly used during warmer seasons (late spring, summer and early autumn), that is when better effects are expected in that period, the optimal angle is around 30^0. For solar collectors where better energy effects are expected in a colder year period (late autumn, winter and early spring) the optimum angle of solar collectors is around 60^0. So, for example, for a surface laid at the angle of 30^0 the annual value of radiated energy is bigger for about 13-14% - in comparison to horizontal surface. For a surface at the angle of 45^0 annual value of irradiated energy is bigger for about 12 to 13% - in comparison to horizontal surface.

The receiving surfaces that are located north of the Equator (on northern hemisphere), and that have a certain angle in relation to horizontal line, should be oriented towards south. Static surface, oriented so, can receive the most energy during day, because each different surface of the same size and under the same angle, whose projection of normal onto horizontal surface is not strictly oriented towards south - receives less energy during the day. If this variation is larger, the received energy is less. Orienting the surfaces (collectors) of solar installations in southern Europe, in order to be used whole year round, is most suitable when directed to south under the angles of closely 35 to 45°. This angle can be less if we want to use the system more during summer season or more if we want to use the same system during winter more. Naturally, the best orientation is the South, with maximum of varying of 45° to east or west.

Solar energy can have a significant place in energy sector of a country because it presents renewable and inexhaustible energy resource. Not the same attention to renewable energy resources is paid everywhere in the world. We can freely say that relatively small number of countries - the ones most developed - pays more attention to this issue. It is interesting that the energy technologies based on the use of solar radiation are being developed the most in technologically and economically powerful countries. There are several reasons, from which the most important are strategic, economical and ecological factors.

Solar energy is, ecologically seen, clean energy whose energy technologies in application do not pollute the environment. It presents a resource that each country has available, without being import-dependant. It is especially significant fact that the plants for solar energy use can be constructed immediately next to the consumers - without significant investments into infrastructure. With technical means solar energy simply is transformed directly into heat and, directly or indirectly, into electricity, which enables fast application in all energy processes. The use of solar energy in all segments of energy consumption is in significant increase in many countries of the world today.

Solar energy provides various possibilities for application. Contemporary solar systems provide the use of solar energy during whole year. These systems can satisfy up to 35% of all demand in North and Central Europe, more than 50% south of the Alps, and even up to 70% in the south of Europe. At the same time, the emission of poisonous gases into the atmosphere is considerably lowered, which makes a good argument for the use of solar energy. From practical solar energy use point of view, important is the quantity of energy that reaches some surface during a day. This quantity depends on the latitude, season, orientation of receiving surface and meteorological conditions. The first three factors are of geometrical character and there are calculation methods of their precise determining. However, meteorological conditions are a variable factor and reliable data can be reached only by measuring during many years. For the use of solar energy data on middle daily sum according to months of a year, as well as data on average temperatures for the same periods are important. A great role in the use of solar energy have the shape, the size of the buildings, orientation, materials used and other. Also the environment is important, if there are shades from other buildings and other.

By passing a Directive on Measures of Encouragement for Energy Production by Using Renewable Sources of Energy, with the decision of the government of Republic of Serbia, pre-conditions to start more intensive use of transformed solar energy in households and economy of Serbia and Vojvodina province have been established. The aim of this study is to thoroughly check energy and exploitation possibilities of the solar energy use in all areas of energy consumption of Vojvodina, and to present relevant framework for decision-making on the application of these technologies to potential investors.

The use of RES and with them of solar energy, contributes to more efficient use of our own potentials in producing energy, decrease of "green-house effect" emissions, decrease of the import of fossil fuels, development of local industry and creating new jobs.

By analyzing the data on solar radiation, it has been confirmed that the change of integral radiation during time does not derogate more than ±1,5%. Scatter, or the concentration of air molecules of water steam and particles of dust and smoke in the atmosphere affects decrease of solar radiation throughput on the Earth's surface. The absorption of radiation energy in the atmosphere is defined in the function of water steam content and optical air mass. Optical air mass is determined by the length of the radiation trajectory through the atmosphere, where vertical trajectory is taken for a unit of mass. By measuring and calculations, it has been determined that, due to the rays' reflection from the atmosphere and absorption in the atmosphere, with normal angle of radiation and small content of water steam, dust and smoke, the intensity of radiation is decreased. Due to that, solar radiation that reaches surface of the Earth (in our area), is from 970 [W/m^2] - in summer and 1.030 [W/m^2] - in winter. Most often in the calculations a middle value of power of [W/m^2] is used. The change of distance between the Sun and the Earth during the course of a year influences the change in values of radiation that reaches the upper layers of the atmosphere. This change is included in the limits of variations of ±3%. Evident and scientifically determined fact, according to which the strength of solar radiation on Earth (in our area) during winter is even more than 5,8% from the strength of radiation in summer, can be seen in previously mentioned. This increase of radiation strength is based on the fact that the Sun, for northern hemisphere, is closer to the Earth during winter than in summer, for around 3%. The overall effects of radiation energy are still bigger in summer in certain areas - due to the longer trajectory of the Sun over the skies (longer days).

The Sun, as a source of energy, has very stable effect and intensity of radiation until it reaches the Earth's atmosphere. The decrease of this radiation in the Earth's atmosphere under the most favorable conditions goes within limits of 23,9 to 28,3%. But, except for yearly, monthly and daily changes of the intensity of solar radiation on a certain surface of the Earth, the changes appear depending on meteorological conditions of the atmosphere, as well as the angle of arriving rays onto the Earth, or the surface they reach.

In geographical conditions of Vojvodina, the energy that reaches a horizontal surface of 1 m^2 creates values of minimum 1.350 to maximum - 1.500 kWh/yearly. This is equal to the quantity of heating energy, that is possible to get by burning approximately 160-180 m^3 of natural gas.

Having in mind that the Sun's energy, from the technical-exploitation point - is energy resource of renewable feature (transformed solar energy which is conducted from the receiver of solar energy (RSE), is permanently being in the process of renewal, in the conditions of radiating solar energy), we cannot speak of an energy resource as in other cases of non-renewable sources of energy. This resource depends on insolational conditions, size and characteristics of SEC (previously listed factors) and the time span of exposure of RSE to radiating solar energy.

Of radiation from the Sun radiating on the Earth, whose power density reaches the values from 970 to 1.030 [W/m^2] - the useful radiation quantity on the unit of free orientated area depends on its orientation (should be oriented towards south), on its angle (it is preferred to have sun beams reaching the receiver at the angle closest to normal (direct), so the radiation - the density of the power can be bigger), on the construction and energetic characteristics of the solar energy receiver, part of the day, part of the year, time of insolation, atmospheric conditions and other.

The energy of radiation that reaches some surface on the Earth depends mainly from the duration of sunshine. Insolation depends on the latitude and season. The difference in time from dawn till sunset gives the time of insolation duration to which horizontal and uncovered surface is exposed. This for Serbia equals to around 15 h - in summer and 9h-in winter. Real duration of insolation is significantly shorter due to the appearance of clouds and fog, and also depending on the conditions of atmospheric pollution at the monitored area. It differs for surfaces that are set horizontally, vertically, or at a certain angle relating to the surface of the Earth. Energy inflow of solar radiation is not proportional to insolation duration. Meaning that a part of the energy is lost by going through the atmosphere due to oxygen, ozone and CO_2 absorption. The loss is greater as the Sun is closer to the horizon. Next to that, radiation energy scatters in its passage through the atmosphere, and the biggest loss happens immediately after the sunset. So, the overall radiation that reaches the Earth's surface consists of immediate - direct and indirect - diffuse radiation, which is a part of scattered radiation energy. Because of all this the strength of radiation that reaches some surface, and which could be energy useful, considerably varies during the day, and its changes depend on the season and the position of the radiated surface.

Very often the energy of radiation is presented as the energy that reaches the surface of the Earth during the day, of course during the time of insolation. This energy depends on the conditions of cloudiness and features of the atmosphere, but it is also necessary to know the potential radiation energy. It is the maximum energy that reaches the surface through dry and wet atmosphere. It depends on the latitude and altitude and it goes less as altitude decreases and latitude increases. At the latitude of 43 degrees the potential energy equals around 2.500 kWh/m^2 yearly, and at the latitude of 46 degrees of around 2.400 kWh/m^2 yearly.

For a spectator from the Earth, two angles define the position of the Sun. Solar altitude angle is the angle between the Sun and horizon. During day it varies between 0 and 90^0. The zenith angle and solar altitude angle added equal 90^0 . Solar azimuth is the angle in horizontal line between reference direction (north) and the Sun. This angle varies between –180 and $+180^0$.

For calculating solar installations, the systems for receiving solar radiation, the significant influence has so called "solar window". Solar window is the surface of sky amidst the Sun's trajectory in summer and winter solstice for a certain location. The knowledge of a solar window for a specific city is important for the right positioning and directing of solar collector in order to get optimum energy characteristics, and to avoid shades from trees and other buildings.

The strength of solar radiation varies during day, month and year. Its value depends on geographical position, conditions of the atmosphere and other. All this points to a great variability of solar radiation strength. Still, these changes are slight (less than for example the change of the strength of the wind), and they can be foreseen with bigger or smaller exactness, because the rhythm of these phenomena is familiar (dawn and dusk). The intensity of available radiation we cannot predict utterly precisely. As a source of energy, solar radiation is more suitable than - for example the wind - concerning the predictability of the phenomenon, but it is less suitable because there is no radiation at night and it is less intense during winter when energy consumption is bigger. Plants can function only during daily cycles, which does not coincide completely with the rhythm of energy demand. Additional plants have to be built, or to ensure the accumulation of energy, by which the providing of consumers would be secured even at night or in worse conditions of insolation.

The greatest participation in getting the energy via solar collectors have direct and diffuse radiation, whose intensity changes during the year, depending on the change of seasons. naturally the most of solar energy is achieved during summer months when the intensity is the strongest. The maximum of solar radiation happens in June, and minimum at the end of December and beginning of January. During the duration of a day generally, the biggest radiation reaches the Earth at noon when the position of the Sun in the skies is the highest and the trajectory of passing solar radiation through the atmosphere is the shortest.

Technologies for using the energy of solar radiation are based on two main principles which are:

- the use of heating effect of solar radiation, where the energy of solar radiation is transformed into heat at the absorber of solar energy collector (heating SEC). In these types of SEC an average degree of the transformational efficiency of radiated solar energy into useful redirected heat - is from 35 to 55% and

- on the use of photoelectric effects, where the Sun's light is directly transformed into electricity in photovoltaic receiver of solar radiation - photoelectric SEC. With these types of SEC, the irradiated energy is transformed into usefully conducted electricity with efficiency of 10 to 20% - depending on the type and construction, exploitation and insolation conditions.

Flat low-temperature receivers of solar radiation are technically the simplest receivers from the aspect of construction (production), and the working temperatures of up to do 100 [°C] (with so called "idleness" and up to maximum 180 [°C]) are achieved. Also the heat is redirected from SEC with air, water or some other liquid derived on the basis of "anti-freeze" (working medium) - and delivered to the consumer - directly or indirectly through exchanger of heat and heating units.

Solar energy systems that are based on the application of SEC of these characteristics, are used mainly for preparation of hot sanitary and technological water, in the processes of drying various agricultural and industrial products, for heating the space and other heating processes where working temperatures go up to 100 [°C]. In the conditions of Vojvodina solar collectors are the most suitable for heating water in all processes, facilities, especially in households. The average surface of a commercial collector type is around two square meters and about two collectors are necessary for water heating in a smaller household.

Special technology for the use of heating effect of solar radiation present so called "passive solar systems" by which the heating for facilities inside houses and other structures is provided, and where the receiver of solar energy is derived on the basis of integration of the heated object and the receiver of solar energy.

Systems that concentrate solar radiation are based on catching solar radiation from a bigger surface with suitable mirrors (parabolic, hyperbolic, parabolic-cylindrical, flat - heliostat systems and other) and reflecting - with significant degree of concentration (increase of the power density) on the right absorber where temperatures of 200 to thousand degrees Celsius are created. This is one of the reasons why the use of flat collectors for low-temperature applications are more suitable than concentrating ones, which can make use only from direct radiation.

With solar combined systems (with larger number of solar collectors) in certain measure the heating of facilities during autumn and spring months is provided. In this way, with optimum planned plant - installation, solar energy can provide 20 to 30 (40)% of overall energy need of the building, depending on how well it is insulated and what degree of heating we aim to. With specially designed buildings - houses, with application of combined heating the energy demands of the building of up to 50 to 90% can be covered.

This resource depends on insolational conditions, size and characteristics of SEC (previously mentioned factors) and the exposure time to SEC - from one square meter of SEC around 500 do 800 (kWh) of heating energy can be achieved yearly, which is closely equivalent to heating energy that is achieved from 50 to 80 liters of distillate oil.

In winter period, in our area, overall energy effect of solar radiation is less than in summer, but still efficient enough for use. So, for example, from commercial types of solar collectors, in heating season, it can be produced - per square meter and per day - energy of (depending on the month and location) 1,2 to 3,0 [kWh]. This means that RSE for 30 days in a month can give to a consumer of heating from 36 to 90 [kWh] per one square meter of the collector. RSE whose surface is ten times larger can provide from 360 to 900 [kWh] of energy monthly, and a collector of 30 [m^2] - from 1.800 do 2.700 [kWh] monthly - which is from the aspect of the need for heating already a considerable quantity of heat.

In the heating season it is possible to achieve solar radiation of around 360 [kWh] of heating energy from one square meter of SEC, that is to say around 11.000 [kWh] from the surface of 30 [m^2].

Since the temperature of warmth in solar collector (with recommended speeds of current) in winter period goes mostly from 40 to 60 - maximum 80 [°C], it is clear that with the systems of central hot-water heating in the period of lowest temperatures, they can not be used as necessary. But if external conditions are more favorable, that is, when external temperature is around 0 [°C] and more, the possibility for using the heat from SEC is larger. Then boiler installation functions mostly with the temperatures of 60/45 [°C].

This means that the best effects for heating family houses and apartments can be achieved in transitional periods. Even this contribution is very significant. If in the system of hot-water heating, under-floor heating with floor panel is applied, which functions with lower temperatures, the effects of warming will be even better. The best effects are achieved by applying air system of heating. Energy effects of solar systems with heating houses or apartments depend on more factors, among which the right and optimum planning has the top role. Thermal characteristics of under-floor heating directly influence the quantity of heating loss, and with this the needs for heating energy.

Vacuum pipe solar collectors, for its specific construction, basically present a special subgroup of solar collectors. The are consisted of several vacuum pipes with the absorber inside, where the system - collector is formed by connecting separate elements of vacuum pipes with its own absorber, arranged in a line - forming a unit collector of measures similar to a flat collector. Vacuum collector consists of 15 to 30 vacuum pipes that are connected to the exchanger of heat through which runs a fluid being in the heating process. The price of such collectors - vacuum pipe - is for around 50% higher than of the classic collectors. Because of this, they are recommended for facilities where there is a constant need for hot water, especially where bigger quantities of hot water are needed.

In residential buildings there are two types of solar heating energy systems: the ones used specifically for water heating and those which next to it provide general heating (combined systems). Solar/thermal energy systems for consumable water heating are designed in such a manner to have dominant role during the warmer part of a year for consumable water heating. During winter season hot water is provided with boilers that usually function on electricity or indirectly from conventional heating system in the building, and during sunny days it is supported by thermal energy system. This means that around 60% of yearly needed energy for heating consumable water can be achieved by solar thermal energy systems.

With solar combined systems (with larger number of solar collectors) in certain measure the heating of facilities during autumn and spring months is provided. In this way, with optimum planned plant - installation, solar energy can provide 20 to 30 (40)% of overall energy need of the building, depending on how well it is insulated and what degree of heating we aim to. With specially designed buildings - houses, with application of combined heating the energy demands of the building of up to 50 to 90% can be covered.

It is necessary to know that solar system is one of the options for preparing sanitary hot water and support for heating the space, and justification and the pay off exist, thanks to achieved savings, in comparison to classical sources of heat. Classical boiler or other source of heat in a family house or some other building we consider as necessary investment, due to which we do not consider its pay off, because it is not possible. Contrary to that, solar systems bring significant cost-cuts thanks to which. after starting investment , we use attained energy for free so to speak. The life span for quality systems is 25-30 years (except the boiler for drinking water and circulation pumps), and that is the reason why solar collectors are good investment for the future, and less dependent on the price rises of classical fuels. Still, it is not possible to generally establish the time for payback of the investment of solar system, because it depends on many factors, as for example the type and manufacturer of the collector and accessories, the way of preparation sanitary water and heating till present, the price of heating, natural gas or other fuels and similar. Without the support of a foreign country the time for pay off is rather long in order to build, simultaneously with solar systems, modern, more efficient practical systems. Thinking about investing into solar collectors is, because of that, most suitable with replacing or reconstructing the obsolete and inefficient, or rather expensive heating systems (e.g. electrical heating), as well as in the case of new building.

Heating solar systems are mostly used for heating sanitary water, heating technological water , water in pools and other. It is possible to use them also as a support to heating various facilities - houses, halls and other, but this application is more suitable for buildings that use low temperature systems of heating (under-floor, ceiling or wall) and that are well insulated, meaning that their temperature losses are on the level of low energy buildings. In climatic conditions of Vojvodina the application of solar technologies is combined with other sources of heating for providing enough quantity of heat in the conditions of less insolation or absence of insolation (in the evenings, mornings, at night, in winter etc.). The water for the needs of heating, heated by solar collectors can be also used in systems of central heating or central heating provision (CHP). Generally viewed, solar energy can cover 50 -70 % of yearly needs for the energy for heating water in households, in summers and transitional periods,so to say, entirely, while during winter it is enough for pre-heating of cold drinking water. Except in the field of apartment building and family houses building, public infrastructural institutional buildings (hospitals, sanatoriums, schools, hotels), present further potential sphere in application of solar heating plants. Good application of solar installation can be found with heating open and closed swimming pools, small buildings of power-maintenance services, public institutional buildings (customs, military installations and other), restaurants, agricultural companies and especially for the heating of consumable water in agricultural industry, food industry and other.

The production of photovoltaic mechanisms doubles every year with average growth of 48% since 2002, so that this line of industry shows the biggest development in the world, in comparison with the rest of energy technology lines. From the economic aspect the price of the electricity derived from solar energy is continuously falling as a result of technological enhancements and growth of mass production, while it is expected that the fossil fuels will become significantly expensive in the near future. At this time for Serbia - Vojvodina, it is more justified to encourage the use of energy from solar radiation for the production of heating and electricity for households, industry and some agricultural works because of smaller investments. Encouragement and building of larger solar power plants on the basis of photovoltaic systems is justified as well. This policy would, among the rest, be useful for the development of domestic economy as well as the employment of people in the field of clean energies. But viewed long-term, the future of converting solar radiation is in PV technology and its integration with other branches of technology, which is in accordance with the attitudes, plans and current condition in the European Union and other economically leading countries of the world. Due to this, only mechanisms and systems based on photovoltaic conversion of solar energy and suitable program, plans and possibilities for use and development in Serbia and Vojvodina, are being discussed.

From economical perspective, on the basis of independent comparative tests, the most efficient are systems for heating sanitary hot water. This is confirmed also by comparative tests done for monitored and tested houses. In this comparison, mainly attained power was taken into consideration (yearly saved energy, the degree of usability, the quantity of hot water), also work and maintenance, ecological aspect and energy amortization, safety and simplicity of assembling. From comparative tests we can conclude that great investment costs are 2 to 3 times bigger with combined systems than with the systems anticipated just for the heating of sanitary water. With the support for heating the space, it has some economical cost-effectiveness but only with low-temperature heating systems (e.g. under-floor heating) and houses with small heat losses.

Four reasons why Serbia should enlarge the application of solar energy is:

- Over 55% of overall energy is used in households in Serbia in the form of electrical energy, from which a great part for heating the sanitary water.
- Cost-cutting for heating sanitary water of around 60 to 70 percent is achieved yearly, which leads to unloading the house budget.
- The employment in the process of research, production, assembling and maintenance of solar equipment is raised.
- By achieving considerate application of solar energy we get closer to suggestions of the European Union on the use of renewable energy resources where the Sun has a large role.

Researches and commercial application in the area of technologies for the use of solar energy in the processes of heating and producing electricity have as a result in the previous decades enough indicators and practical experiences - so it could be said that these technologies, mainly, have outgrown basic research and experimental phase, and have achieved significant degree of practical application and commercial maturity. Of course, this does not mean that further researches in the direction of conquering new, more efficient, more technologically advanced and more efficient solutions, suitable for wider and further application in practice in everyday life and work, are not needed - as well as the systems reliable enough and efficient enough in the sense of use in various processes of heating (water, space and other), pre-drying and drying (of agricultural and industrial products), production of electricity for everyday use and similar. It can be concluded that the world solar industry, even today, has available reliable technologies and long-standing experience of practical application. In this sense the systems for the use of solar energy for various lower temperature processes (to 100 ^{0}C) are acceptably reliable, efficient and commercially mature. That, above all, relates to the use of heating effect with lower-temperature conversion of solar radiation into heat - for the needs of sanitary water heating for the consumption (in all segments of use - from households, tourist facilities, establishment buildings to industry), technical water (in agro-industrial and industrial processes) and other.

The use of lower-temperature solar plants (solar collectors) in the processes of pre-drying or drying of agricultural products or in industry - of industrial products (processes that demand working temperatures of up to 100 ^{0}C) is practically applicable - whether directly - by pre-heating of the drying agents (air and other gases) - in air collectors, or indirectly - by solar collectors with liquid working medium. It must not be forgotten that low-temperature solar systems (collectors) provide preheating in high-temperature processes. Because in all processes - whether they are low or high-temperature - the heating is done from some lower temperatures (temperature of the environment) to some, technologically needed temperatures.

When we consider medium-temperature solar systems (concentrating systems with a line center) with working temperatures over 100 ^{0}C - mostly with temperatures from 200 do 300 ^{0}C - their application in practice is also long-lasting. However, these systems are less present, although they are technically and technologically mature - they reached sustainable and reliable technical level. Smaller presence in practice is conditioned by lower demand (lower presence in practice), when their usual working temperatures are in question. As it is listed in the description of technological solutions , these systems are based on curved reflecting surfaces - mirrors (parabolic cylindrical or similar - so called "baths" which have the need (for bigger efficiency and effectiveness in work) turning (following the height and daily movements of the Sun in the skies) mainly on one axis. Also, important is the fact that these systems cannot technically "cover" diffused solar radiation that is often dominant in winter period, and it is also significant in other periods of year (with cloudy skies). Important is also the request for reflecting surfaces (mirrors) of these types of collectors to be clean - with high degree of rays reflecting on the central zone where the absorber RSE is positioned. This means, no matter the technological maturity of these receiving systems, and considerate practical experiences, and past experimental phase - these systems cannot be considered as dominant for broader application in practice, except in specific cases when - the absence of conventional infrastructure provides the application of these systems - for production of electricity or mechanical works.

Concentrating and heliostat systems have also been in use for a long period - as a support to production of electricity - and this almost - as an experimental phase. Relatively small number of completed plants in the world, with power of 5 so 50 MW - and that in the areas with high value of yearly insolation and high percent of part of direct radiation in global (smaller percentage of diffuse radiation during year) are one of the important pre-conditions for successful techno-economical exploitation of these systems. This system with a large number of flat mirrors - heliostats - computer directed - which (each) has to have a possibility of permanent turning of two axes, so they could follow the change of Sun's position during day (height and daily pace) - present more complex system. Having as well in mind that the keeping reflecting surfaces - mirrors clean and with unchangeable reflecting characteristics - additionally endangers the system parameters. World experiences and suggestions predict - recommend the building of heliostat solar power plants in the areas where they produce over 1.600 kWh per square meter - of yearly radiated solar energy. Vojvodina with its 1.200 to 1.400 kWhm^2 – does not, today, fall into the group of territories suitable for application of these types of solar power plants. However, these recommendations do not exclude the building of these systems on the territories with less insolation - but the period of paying off the system is in this case longer - which raises the specific price of produced electricity. These types of power plants fall into more complex types, with relatively small number of constructed plants in the world, with bigger starting investment (3 to 5 euros/W of installed power), more complex system of directing, maintenance and other. Having in mind exploitation characteristics as well, and impossibility of catching diffuse solar radiation that significantly participates in global radiation - and on territories such as Vojvodina - importantly affects smaller justification for building these types of power plants in Vojvodina.

Systems for photoelectrical (photo-power) conversion of solar radiation into electricity are far more suitable for broader use in practice. This also relates to smaller systems with accumulators of electrical power where electricity is stored (in other words the excess of produced electricity) during the day - when there is not enough solar radiation (night and day - in cases of extreme cloudiness). Solar systems where produced electricity is kept in accumulators, consists of solar cells, regulator for charging the accumulator and accumulator. With this system an inverter for converting direct current into alternating current is also added. The second type of the system is based on joining the photo-voltage system - via converting the inverting system - directly to power network (without the accumulator of electricity). Solar systems for producing electricity that are joined to the city's network, consist of solar cells (modules), converters of direct into alternating power (inverters) and electricity meter.

Thise system, on the contrary to the power plants with concentrating mirrors, can use also diffuse radiation for producing electricity. (The quantity of produced electricity with diffuse radiation is of course less from the one produced during direct exposure to solar radiation. The advantage of these types of solar power plants is in the possibility of type building of systems with high and low power. These are simple systems (usually built without the possibility of changing the angle or turning.) And as static systems work efficiently and reliably enough. They are easy to manage and maintain. The price per Watt of installed power for these power plants goes from 2 to 3 Euros. Today in the world, commercial power plants of this type are common and work, where limits per exposure to the Sun and intensity of solar radiation mainly do not exist (for average conditions). Since photo voltage systems produce direct transformation of solar radiation into electricity - these systems do not have (static) movable mechanical subsystems that are important for function and maintenance.

The conditions of installation and other conditions for areas in Vojvodina are suitable for building and exploitation of these kinds of plants. These are systems that, through up till present researches and exploitation reached full maturity and needed reliability in work. Further researches connected with the enhancement of energy efficiency and lowering the initial costs for photovoltaic panels are continuing, where the application of the reached technical solutions does not present a problem.

Having previously mentioned in mind, and in the framework of this study - presented and explained - it can be concluded that for the needs of various energy consumers in Vojvodina, today application is, recommended, compatible and reliable enough and techno-economically (and ecologically) justified for:

1. Low temperature solar systems (with flat thermal collectors) in the processes of heating sanitary and technical water for consumption in households, institutions, tourism industry, health care, industry and everywhere where there the need for heating (or pre-heating) of various fluids exists.

2. Photo voltage conversion systems for producing electricity - from small power (mini-plants) to middle and larger power.

In the field of heating conversion of solar radiation there are several roads open for developing, research and innovation. The development in the are of thermal use of solar energy is not so connected with the expensive equipment, which is the case with photovoltaic conversion. Systems for concentrating solar radiation, hybrid systems (combination of heating and photo-voltage conversion), air collectors, integration of existing, or new components, into buildings, application in distillation and desalinization of water, pasteurization in food industry, drying in agriculture and storing heating energy - are just one part of the program which is possible to develop by available potentials in Vojvodina. The present policy, connected to the decision about granting significant monetary means for recovery and development of science in Serbia, points to the opportunity for a part (at least 1%) of these means to be spent for applicable solutions in the area of renewable energy resources, where special attention should be paid to solar energy.

To make the use of solar energy more intense in Vojvodina, there should be a favorable business climate for the development of domestic solar equipment industry, on the basis of our own research and development. In present conditions it is even possible to produce the equipment of suitable quality and of lower prices in comparison to imported one.

It is necessary to set as a goal to have all needs for heating water up to 80°C in residential buildings and industrial processes met by using solar energy. In this way the building industry would be encouraged to deal more seriously with this source of energy. It is also necessary to encourage developmental and innovational activities in technology and solar equipment production, which will bring domestic industry to bigger efficiency and lower prices. In this we must also not forget continuous promoting, advertising of the use of solar energy, where a big role should be played by NGOs and media.

Vojvodina has available resources of solar energy on a level quite above the European average, with favorable season schedule. Its efficient and long-term use is necessary to be elaborated in the shortest period coming. To intensify the use of solar energy in Vojvodina, a favorable climate for the development of domestic industry should be created. In present conditions as well, equipment of suitable quality could be produced in small batches and of a suitable price, less than of that from the import.

The application of solar energy presents good way to lower the consumption of electricity everywhere where it is possible. No matter the starting investment into solar installation is relatively high (almost 500 euros for one kW of installed power), it pays off to invest because it will have safe and certain market. If in this price we calculate everything that simultaneously accessorize well planned and organized work, such as research, development, production, marketing, creating professional, scientific and production staff, conquering new technologies, export of the biggest part of production, raising the employment in basic and following fields of work - then the price is quite lower, and a positive energy and economy effect is reached. In the period from 1975 to 1990, in Sebia and Yugoslavia, the atmosphere of research, development and application of solar energy was created. In that period several producers of solar collectors and accessorizing gear existed. Numerous and big systems for heating sanitary water were built, and that mostly in hotels on Adriatic coast and tourist centers. Today in Vojvodina there are two producers of solar heat collectors and several importers of entire systems. Installation of the equipment for solar heating of sanitary water is based on the individual feeling of the investor to make in his/her home or company something that is natural and normal, to use what comes to the roof for free, and also that to be completely pure.

Entirely viewed, in Vojvodina, the application of solar energy for heating sanitary water or space is largely negligible. The same can be said for other areas of possible application. The reasons for existing condition in Vojvodina are: ignorance about the application of renewable sources of energy, small amount of information on the plans and conditions in Europe, about our future obligations in the circles of decision-makers, as well as in population being uninformed of the possibilities of applying solar energy, the price of the equipment, energy and financial effects. Also, the problem lies in very low material standard of Serbia's population, as well as in relatively low price of electricity, which automatically leads to the fact that electricity is not being rationally spent. The production of domestic equipment is expensive due to import dependence for materials and small, not formed yet, market.

Solar energy can have a significant place in energy industry of one country because it represents a renewable and inexhaustible energy resource. Not the same attention is paid to renewable resources in different parts of the world. It can be freely said that a very small number of countries deal with this issue - those developed ones. It is interesting that energy technologies, based on the use of solar energy, are being mostly developed in technologically and economically powerful countries. For this there are several reasons, of which, the most important ones are strategic, economic and ecological factors.

Solar energy is ecologically viewed clean energy whose energy technologies do not pollute the environment. It presents the resource that each country has available - without import dependence.
Huge savings of conventional energy could be achieved if each household would have at least one unit of solar collector by which sanitary consumable water would be heated.

Seen in electro-energetic system of a state, it would represent quite load shedding. Especially interesting group of heating energy consumers are numerous industrial, tourist, sporting, medical, military and other facilities. It is known that these facilities spend considerable quantities of energy, derived by burning solid, liquid and gas fuels for heating. This can be easily achieved by using very simple systems for using solar energy.

Solar energy is very attractive and economically justified for use, even with the heating of households, industrial and other facilities.

Technologies for using the thermal energy of solar radiation are based the use of heating effect of solar radiation, where the energy of solar radiation is transformed into heat at the absorber of solar energy receiver (heating SEC). In these types of SEC an average degree of the transformational efficiency of radiated solar energy into useful redirected heat - is from 35 to 55% .

The receivers of solar energy that are based on transforming energy of solar radiation into heat, according to the construction type, are divided on:

- flat low-temperature SEC,
- medium-temperature (systems with lower degree of solar radiation concentration) and

high-temperature SEC (systems with higher degree of concentrating solar radiation).

Not less important is the economical effect of the development of new industries of manufacturers and providers of technologies in the area of renewable energy sources. On the basis of European Federation study on the use of solar energy (ESTIF) the use of solar energy has incomparably more advantages in functioning in comparison to fossil and nuclear energy. On 1.000 GWh of delivered primary energy there are 90 new jobs in energy sector based on coals, 72 jobs in nuclear energy sector and even 3.960 jobs in solar energy sector. Creating projects, making, installing and maintaining solar systems, which differ from others, since the energy source is not centralized on one place, but provides opportunities for work in all the regions, is included in this number. So, if we think about limited storages of brown coal, renewable sources of energy are the only domestic, basic, energy sources for the future. By using renewable sources of energy Serbia can get tens of thousands new jobs for qualified personnel, and in the future it will not be afraid or become someone else's cheap labor in other parts of the world.

By using solar energy natural sources are being preserved on our planet. The overuse of fossil fuels such as raw oil, coal or natural gas brings serious problems concerning our environment firstly. Global warming and climate changes have become reality, and that is the reason to lean towards broader use of "clean' technologies, among which, unquestionably is the use of heating solar energy. By using solar energy noxious substances do not end up in the air, and there is no greenhouse effect, which cause gradual warming of the atmosphere like in the case of burning classical types of fuels.

Photovoltaic systems are various: They can be size smaller than a coin and larger than a football pitch and they can provide energy for any appliance, from a clock to entire settlements. With simple handling, these factors make them especially attractive for wide range of applications. Recent growth of PV cells production with low prices opened a large number of new markets with a large number of various applications. Applications such as lighting, telecommunications, cooling, water pumps, as well as providing electricity for entire settlements, especially in remote areas, showed as competitive and profitable in comparison to already-existing technologies.

In the area of heat conversion of solar radiation, several roads for development, research and innovation have been opened. The development in the area of thermal use of solar energy is not so connected with the expensive equipment as it is the case with photovoltaic conversion. Systems for concentrating solar radiation, hybrid systems (combination of heating and photo-voltage conversion), air collectors, integration of existing or new components into buildings, the application in distillation and desalination of water, pasteurization in food industry, drying in agriculture and storage of heating energy - are just one part of the program which is possible to develop in Serbia with available potentials. Present policy connected to the decision about granting significant monetary means for recovery and development of science in Serbia points to the opportunity for a part (at least 1%) of these means to be spent on applicable solutions in the area of renewable energy resources, where special attention should be paid to solar energy.

From economical perspective, on the basis of independent comparative tests, the most efficient are systems for heating sanitary hot water. This is confirmed also by comparative tests done for monitored and tested houses. In this comparison, mainly attained power was taken into consideration (yearly saved energy, the degree of usability, the quantity of hot water), also work and maintenance, ecological aspect and energy amortization, safety and simplicity of assembling. From comparative tests we can conclude that great investment costs are 2 to 3 times bigger with combined systems than with the systems anticipated just for the heating of sanitary water. With the support for heating the space it has some economical pay off but only with low-temperature heating systems (e.g. under-floor heating) and houses with small heat loss.

Although in winter time energy effect of solar radiation is lower than in summer, it is still very significant for the use of solar heating in houses, as a support to some other energy on the system of central heating, where it can cover around 45% of free heating energy for houses and around 75% for heating of sanitary water. The best effect using solar energy for solar heating of family houses and other residential and business spaces can be achieved in transitional periods with energy efficient heating systems, under-floor and wall heating systems, with low-temperature heating systems. Still, due to variability of radiating power of solar radiation during the day, month and year, the installation of solar heating that would provide entire house heating during the whole winter season cannot be implemented, and that is the reason why solar systems for solar heating are combined with some of different sources of energy where some other form of energy is used: liquid fuel, gas, electricity, solid fuel and similar.

Solar systems bring significant savings thanks to which derived energy is, so to say, used for free, after the pay off of the starting investment. The life span for quality systems is 25-30 years (except for the boiler for drinking water and circulation pumps), and that is the reason why solar collectors are good investment for the future and less dependent on the price rises of classical fuels. Still, it is not possible to generally establish the time for pay back of the investment for solar system, because it depends on many factors, as for example the type and manufacturer of the collector and accessories, the way of preparation sanitary water and heating till present, the price of heating, natural gas or other fuels and similar. Without the support of a foreign country the time for pay off is rather long in order to build, simultaneously with solar systems, modern, more efficient practical systems. Thinking about investing into solar collectors is, because of that, most suitable with replacing or reconstructing the obsolete and inefficient, or rather expensive heating systems (e.g. electrical heating) as well as in the case of new construction.

The application of solar energy with thermal conversion is used in practice for:

- Heating of sanitary water in houses, apartments, hotels, hostels, students dormitories, retirement homes, kindergartens, restaurants, sporting facilities and everywhere where the need for sanitary water heating exists.

- Central or individual heating of sanitary water for settlements that are connected to the distribution of hot water from city heating plants in the periods when they do not work.
- Heating swimming pools in the houses and sporting/recreational centers.
- Heating water or other fluids in industrial processes.
- Heating greenhouses (glass or plastic) in agriculture.
- Pre-drying and drying of agricultural and industrial products.
- Distillation of water for industrial purposes.
- Heating facilities as additional means in the periods when there are not enough sunny days.
- Producing electricity on the basis of heat conversion of solar radiation (steam turbines).
- In processes of space cooling.

Over 55% of overall energy is used in households in Serbia in the form of electrical energy, from which a great part for heating the sanitary water. By using solar energy we can achieve the cost-cutting for warming sanitary water of around 60 to 70 percent yearly.

According to the results of research done by European association "INTERATOM", the price of heating water for a household with flat solar collectors - in areas where there are more than 1,600 sunny hours yearly (and that is entire Europe), even today it is 1:1 in comparison with other systems of water heating.

As an illustration, with a simple calculation of the time for paying off the investment, an example that suits one part and way of preparing sanitary hot water in a family house, can serve the purpose. Needed investments are 15 - 25 EUR/m^{2}" 900 do 1.500 EUR respectively, per household. Lower values relate to cheap solar collectors and simpler installations, and higher to more expensive systems with complex installations with heat-exchangers, system for emergency circulation of working fluid and automatic regulation of work.

The effects with heating consumable sanitary water in the period from April till October, from the aspect of coverage are 80% out of needed energy, and in the period from October till April, this coverage is 30%.

In the case of constructing basic solar system - installation designated for sanitary consumable water heating with two solar collectors and water tank (heat accumulator - boiler) with capacity of 200 liters of water, around 60% of electricity consumption for water heating can be saved up yearly. Energy gain in this case with average solar collector, unit surface of about 2 m^2 goes from 700 to 900 kWh/m^2 yearly (for two solar collectors 2.800 to 3.600 kWh yearly). The price of such a basic solar installation (with assembly) goes in the limits from 1.500 to 2.000 euros maximum. According to present prices of electricity, the value of invested means would pay back in 10 to 12 years. But it is less likely that the price of electricity will not rise in the following years, and due to that, the period of pay off will not be longer than five years. Some of the analyses related to the evaluation of the electricity price rise indicate the probability that the period for pay off will be even shorter - three to five years. Most certified systems has a life span of 25-30 years, so after the completion of the 10th year from the assembly, the solar system will, so to say, prepare hot water for free in the following 15 to 20 (25) years.

This means that the best effects for heating family houses and apartments can be achieved in transitional periods. Even this contribution is very significant. If in the system of hot-water heating, under-floor heating with floor panel is applied, which functions with lower temperatures, the effects of warming will be even better. The best effects are achieved by applying air system of heating. Energy effects of solar systems with heating houses or apartments depend on more factors, among which the right and optimum planning has the top role. Thermal characteristics of under-floor heating directly influence the quantity of heating loss, and with this the needs for heating energy.

Efficiency of transformation of the system for heating sanitary water, from collector to solar boiler, in classical collector types, goes from 35 to 55%.

Lower values relate to solar collectors of worse quality constructional and thermo-insulation features and lower values of absorption and especially of emitting heat from absorber's surface. For this group of collectors fit the collectors whose absorbers do not have selective characteristics, so their value of coefficient of radiation emission is close to value (above 0,9), of the coefficient of radiation absorption. The type and number of transparent saps.

Solar collectors have higher starting efficiency (in the conditions of equality of external temperature and the temperature of the absorber - fluid in the absorber) from working efficiency. Starting (zero) efficiency does not influence the quality estimation of efficiency of some type of solar collector. For this evaluation the feature of the efficiency curve, or curve (equation) of the dependency of collector's energy efficiency from the relation of difference of characteristic fluid/absorber temperatures and the environment - and solar radiation. The most important characteristic for the selection of solar collector from the point of its efficiency is the efficiency that relates for realistic functioning of solar collector.

During a year from 1 m^2 around 900 kWh of thermal energy can be received. Vacuum thermal collectors are feature by greater efficiency that especially shows in colder periods. This efficiency is based on much better thermal insulation of the absorber which is situated in glass pipe from which the air is pumped out. The overall efficiency of a system for heating sanitary water with vacuum collectors is on a year level for about 40% bigger in comparison to the system with flat panel collectors.

In practice the most often application have solar installations that as a working medium use some liquid or air. These two types of installations, basically function in similar manner, only the components of the system and working medium in them differ. With installations that use liquid working medium, the thermal carrier can be water, water mixed with some sort of anti-freeze or a liquid on the basis of anti-freeze (propylene glycol) that is created for application in solar installations. In this kind of installation the liquid that was heated in water solar energy receivers is most often suppressed through the pipe-line towards heat exchanger. Sanitary consumable or technical water is heated there, while the heat exchanger can be derived with a bigger capacity, so that the exchange and accumulation of heat in water mass is done simultaneously (combined boiler - heat exchanger). But, with the bigger installations, the heat exchanger and the storage of hot water are usually separate, so there is the need for emergency circulation of heated water from the heat exchanger into the heat storage - which is done by circulation pump - through pipe-line of so called secondary, consumable circle of installation.

For an average household these systems have usually two solar collectors (around 4 m^2) with liquid working medium that circulates in primary - solar circle. The heat from solar collectors - via heated working liquid - is transmitted to sanitary consumable water - via (in presented variant) exchanging pipe bundle that is situated in the lower zone of thermal accumulation boiler with sanitary water. The working fluid is, in climate territories with low (below 0^0C) temperatures during winter (as is the case of Vojvodina), created on the basis of anti-freeze - propylene glycol or other nonfreezing and nontoxic fluids, in order freezing not to happen. For the case given in this example so called "solar boiler" - the thermal accumulator usually has the capacity of about 200 to 300 liters. Water circulation is provided by circulation pump of primary circle that starts on the signal of differential thermostat - as a basic system of automatics in the installation. differential thermostat is joined to electrical conductors with thermo sensors, from which one is positioned in solar collector and another in boiler. Differential thermostat is set in a way that when the temperature of a fluid in solar collector is higher for about 5 ^{0}C from the temperature of water in the boiler - the circulation pump to start functioning. Then the heating of water is done in the boiler. As soon as the temperature difference is less than the set temperature differential -the pump is switched off in order not to get contra-effects, meaning water in boiler not to cool and solar collector not to heat, meaning not to have heat loss, heat to emit into the environment. In given example of the installation we can see that the possibility of water heating in boiler and via house heating tank is foreseen. Heating is done by water circulation from the water tank towards some other heat-exchanger (positioned in the upper part of the boiler).

Having in mind that for the needs of house heating more thermal energy is needed (larger thermal strength), this system has larger number of solar collectors. When in winter conditions the insolation is lower, and temperatures in solar installation lower (40 to 50 ^{0}C - and more), the suitable heating system is so called "panel" - under-floor and/or wall. While the temperature of solar fluid on adequate enough temperature level, the heating is done without the functioning of boiler with some conventional heating on some fuel or electricity. The automatics of the system provides easy of the installation and starting the functioning of the boiler in the situations when the temperature of solar liquid is lower than needed.

In practice they have broad application and simpler solar installations for water heating from the boiler-room in the house (conventional boiler), but only additional heating with electricity is envisaged. With these installations the pipe heat exchanger is constructed also in the lower part of the boiler, so the available heat from solar radiation would be used for heating the whole capacity of the boiler, and electrical heater is positioned in te lower part so the smaller quantity of water in the boiler would be heated. This conception demands setting the thermostat of electric heater at lower temperatures (around 40 ^{0}C) in order not to come to water overheating at the entire capacity of the boiler. As a consequence this would lead to smaller energy gain from solar radiation because the water would be previously (and faster) heated with electricity (at the point when possibility for solar energy heating would exist).

Compact solar boilers presents broadly applicable system for solar energy water heating. Those are compact mechanisms that consist of one, or more often two solar collectors and thermo isolated tank - boiler where the water that is being heated exists. Boilers are constructed with or without electric additional heaters. The capacities of boilers usually go from 200 to 300 liters. The equipment is positioned and affixed onto a special carrying construction and interconnected by thermo isolated pipe installation that provides thermo-siphon, natural water flow through the installation. . In practice versions where the water flow is natural are applied - by centrifugal pump. a difference from the previous type these solar boilers have to be joined to the source of electricity. Some solutions of compact solar boilers are constructed with the additional water tank, with which providing the water even in the situations when water supply from water pipes is not functioning is certain. The advantage of such systems in in their compactness, and the user gets the system that should only be connected to a cold and hot water supply. The disadvantage is that they are not envisaged for functioning in winter conditions, in conditions of low temperatures, because they are prone to water freezing and boiler or pipe cracking. In order this would not happen the system must be emtied during winter.

Usually they are used in southern areas where the temperature never goes below zero degrees or other conditions (including the conditions in Vojvodina) - during summer or in transitional periods (spring and autumn)

The use of solar energy for heating water in the pools is rather other application in the world. The installation is simply joined to the existing systems for heating water in the pools, and two main concepts are applied. According to one concept solar installation is used separately from the existing conventional installation for pool water heating and the second conception is based on connecting solar installation and conventional installation into one - sequence system. In first case those are usually simpler installations for smaller and open home swimming pools, and they usually use (and cheaper) solar collectors which are not glass-plated (and cheaper) - absorbers which are most often made out of ultraviolet stable plastic masses. In the second case, returned - colder swimming pool water is first preheated by using solar energy (via heat exchangers), and after that it is heated till the needed temperature (if this is the aim) in conventional heating system. In this case classical, glass-plated, flat solar collectors, by which better heating, even in colder weather conditions and that with - mostly larger closed swimming pools- is provided , can be used. Then the scheme of the installation is similar to the scheme of the previously presented systems for water heating in combination with conventional heat source.

The production of photovoltaic mechanisms doubles every year with average growth of 48% since 2002, so that this line of industry shows the biggest development in the world, in comparison with the rest of energy technology lines. From the economic aspect the price of the electricity derived from solar energy is continuously falling as a result of technological enhancements and growth of mass production, while it is expected that the fossil fuels will become significantly expensive in the near future. At this time for Serbia - Vojvodina, it is more justified to encourage the use of energy from solar radiation for the production of heating and electricity for households, industry and some agricultural works because of smaller investments. Encouragement and building of larger solar power plants on the basis of photovoltaic systems is justified as well. This policy would, among the rest, be useful for the development of domestic economy as well as the employment of people in the field of clean energies. But viewed long-term, the future of converting solar radiation is in PV technology and its integration with other branches of technology, which is in accordance with the attitudes, plans and current condition in the European Union and other economically leading countries of the world. Due to this, only mechanisms and systems based on photovoltaic conversion of solar energy and suitable program, plans and possibilities for use and development in Serbia and Vojvodina, are being discussed in further presentation.

According to the competent annual report "Solar Heat Worldwide", edition for 2011, on the state of solar heating with the market survey and the contribution of thermal solar energy in the world - estimated overall production and installed capacities at the end of 2010 - in the area of thermal conversion are 196 GW (with about 280.000.000 m^2 of solar collectors) - of installed power plants with annual produced thermal energy of 162 TWh. In this report a large number of countries in the world are included, from which almost all countries in Europe (except for few - including Serbia). To given data the capacities in the field of photo - electric plants with overall capacity of 38 GW installed and annually produced electricity of around 39,6 TWh should be added. Significantly smaller existing capacities relate to heliostat solar plants that are estimated power of 1,0 GW with produced electricity of around 2,4 TWh.
From all operational systems (2009.) of capacity 172.368,6 MW, on vacuum pipe collectors goes 96.539,1 MW, on glass-plated flat collectors - 54.915,5 MW, not glass-plated - swimming pool and other collectors - 19.703,9 MW and the least on air collectors - 1.210,2 MW.

From the economical point of view, the price of electricity derived from solar energy continuously is falling as a result of technological advancement and mass production growth, while it is expected for fossil fuels to become significantly more expensive in near future. At this point for Serbia - Vojvodina it is more justified to encourage the use of solar radiation energy for producing thermal and electrical energy in the domain of households, industry and some areas of agriculture because of smaller investments. This policy would, among the rest, be useful for the development of domestic economy as well employing the population in the field of clean energies. Lon-term viewed, the future of transforming solar radiation is in PV technology and its integration with other branches of technology, which is in accordance to the attitudes, plans, and also the present condition in the European Union and other economically leading countries of the world.

From economical perspective, on the basis of independent comparative tests, the most efficient are systems for heating sanitary hot water. This is confirmed also by comparative tests done for monitored and tested houses. In this comparison, mainly attained power was taken into consideration (yearly saved energy, the degree of usability, the quantity of hot water), also work and maintenance, ecological aspect and energy amortization, safety and simplicity of assembling. From comparative tests we can conclude that great investment costs are 2 to 3 times bigger with combined systems than with the systems anticipated just for the heating of sanitary water. With the support for heating the space it has some economical pay off but only with low-temperature heating systems (e.g. under-floor heating) and houses with small heat loss.

Although in winter time energy effect of solar radiation is lower than in summer, it is still very significant for the use of solar heating in houses, as a support to some other energy on the system of central heating, where it can cover around 45% of free heating energy for houses and around 75% for heating of sanitary water. The best effect using solar energy for solar heating of family houses and other residential and business spaces can be achieved in transitional periods with energy efficient heating systems, under-floor and wall heating systems, with low-temperature heating systems. Still, due to variability of radiating power of solar radiation during the day, month and year, the installation of solar heating that would provide entire house heating during the whole winter season cannot be implemented, and that is the reason why solar systems for solar heating are combined with some of different sources of energy where some other form of energy is used: liquid fuel, gas, electricity, solid fuel and similar.

Solar systems bring significant savings thanks to which derived energy is, so to say, used for free, after the pay off of the starting investment. The life span for quality systems is 25-30 years. Still, it is not possible to generally establish the time for pay back of the investment for solar system, because it depends on many factors, as for example the type and manufacturer of the collector and accessories, the way of preparation sanitary water and heating till present, the price of heating, natural gas or other fuels and similar.

Without the support of a foreign country the time for pay off is rather long in order to build, simultaneously with solar systems, modern, more efficient practical systems. Thinking about investing into solar collectors is, because of that, most suitable with replacing or reconstructing the obsolete and inefficient, or rather expensive heating systems (e.g. electrical heating) as well as in the case of new construction.

Serbia has the potential of producing energy annually - 700 to 900 and more (depending on the system efficiency, working mode and other) kWh/m^2 of solar thermal collector, which is more than in the countries that have the reputation in solar energy use. 3,3 kWh of energy could be produced in Serbia daily, and it would be used in most efficient manner in tourism, health care sectors as well as households, mainly for water heating.

Huge savings could be accomplished if every household would have at least one unit of solar collector by which sanitary consumable water would be heated. Seen in the framework of the country's electro-energy system, this would present quite a load shedding for the system.

Especially interesting group of consumers are numerous industrial, tourism, sporting, medical, military and other facilities. It is known that these facilities spend considerable amounts of electricity derived from burning solid, liquid and gas fuels for heating sanitary or technological water. This could be easily accomplished by using very simple systems for solar energy use.

Solar energy is very attractive and economically justified for use when heating of households, industrial and other facilities is in question.

Solar systems provide a considerable energy savings. In this way, for example, solar house saves 40% of the energy for heating, 80% of energy for heating consumable water. It uses significant potentials that are provided by solar roof-covers and facades, for providing additional energy. Solar systems provide:

- better energy efficiency,
- considerable energy savings,
- long-term function,
- energy result,
- through derived energy- pay off of the investment,
- favorable relation of price and performance,
- simple installation.

The application of solar energy provides bigger energy savings and lower costs.

Energy crisis and acute atmospheric and environment pollution have influenced broader possibilities of use, thermal and photoelectric effect of solar energy. In this direction the technologies have been developed, practical solutions and application of these systems designed. In winter period the overall effect of solar radiation is less that in summer, but still significant for use in the systems of heating houses - as a support to heating. In this way it is possible to cover up to 45% of thermal energy for heating houses, 70% - for heating sanitary water and up to 100% for additional heating of water in swimming pools.

Still, due to variability of radiating power of solar radiation during the day, month and year, the installation of solar heating that would provide entire house heating during the whole winter season cannot be implemented, and that is the reason why solar systems for solar heating are combined with some of different sources of energy where some other form of energy is used: liquid fuel, gas, electricity, solid fuel and similar.

It should be implemented that big consumers of energy - especially those who spend more energy per product (have bigger specific energy consumption) - have the obligation of gradual, segmental, partial introduction to the use of alternative sources of energy (solar energy included) - for their own needs. From development funds of electro industry, solar installations in the objects that have better accommodation and exploitation possibilities (refers to private sector, but also public - especially those on the budget) should be financed. This would have benefits for energy system and as an element of broader use of this energy source popularization. Ecological effects are also significant. Law on Energy should be corrected in accordance with previously mentioned.