INTENSITY OF INCIDENTAL LIGHT AND SOLAR ENERGY POTENTIAL OF THE BALKAN REGION

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Abstract: Energy from the sunlight is more than sufficient to meet the increasing demand in the world. Within a year, solar energy that reaches the earth is 10,000 times greater than the energy necessary to meet the needs of the entire population of our planet. About 37 % of world energy demand meets the production of electric energy (approximately about 16.000 TWh in 2001. year). If this energy is generated by photovoltaic systems with modest annual output of 100 kWh per square meter, there would be an indispensable required area of 150 x 150 km² for accumulation of solar energy. A large part of the absorption area could be placed on the roofs and walls of buildings, so it would not require additional land area.

Keywords: solar energy, albedo, radiation.

1. INTRODUCTION

Reflection (or scattering) of incident light from the surface is called albedo (an abbreviation from the Latin word "albedo" which means whiteness). Refers to the percentage of radiation from Earth reflected back into space, the value of 0 (black areas that do not reflect anything) to 1 (white surface that reflects all the radiation). The average annual value of the Earth is 0:29 to 12:31 (or 29% -31%), while usually in the range of 0.1-0.4. Marked with A, α, ρSW, ρ, it determines [1-7]:

$$\alpha = \frac{I_r}{I_i} \tag{1}$$

I_r intensities of reflected light, I_i the intensity of incident light. However, the basis of reflection depends on the wavelength of the incident beam. As 99% of the sun radiation is in the 0.2 µm-2.5 µm, the equation (1) takes the form:

$$\rho_{SW} = \frac{\int_{\lambda=0}^{\infty} \rho_\lambda G_\lambda d\lambda}{\int_{\lambda=0}^{\infty} G_\lambda d\lambda} \approx \frac{\int_{\lambda=0.2\,\mu m}^{2.5\,\mu m} \rho_\lambda G_\lambda d\lambda}{\int_{\lambda=0.2\,\mu m}^{2.5\,\mu m} G_\lambda d\lambda} \tag{2}$$

where ρ_λ is the spectral distribution of albedo, and G_λ the spectral density of irradiation.

The three types of albedo are defined as: Astronomical, Terrestrial and "Single scattering" albedo (dotted scattering). Astronomical albedo is determined for celestial bodies; there are two types of astronomical albedo: Bond's albedo and Normal albedo. Normal albedo or normal reflection is defined as a measure of relative brightness of illuminated surface and analyzed vertically i.e. from the direction of light sources. The subtypes of normal albedo are: visual albedo (refers only to the visible part of the spectrum) and the geometric albedo (the ratio between the brightness of the object and Lambertiana's surface with the same cross section, which is the ideal projector for all wavelengths). Bond's albedo (American astronomer George Born) is defined as the ratio of total-global radiation reaching the observed surface and the radiation which is reflected or scattered in all directions (it is important for energy balance of the planet). Planet Earth has a geometric albedo 0.367, while Bond's albedo is 0.29.

”Single scattering” albedo is defined as the ratio of scattering efficiency and total attenuation coefficient. It was usually defined for small scattering particles of electromagnetic radiation.
Terrestrial albedo refers to the scattering/reflection on the surface of the planet. In many analysis and calculations for a given zenith angle θi, terrestrial albedo is shown as the sum of two components: direct-semispheric reflection for the zenith angle θ_i (direct effect of radiation on the reflected), $\rho_b(\theta_i)$, and bi-semispheric reflection (indirect effect of radion on reflected), ρ_d. Thus, defined albedo stands:

$$\rho = (1 - D)\rho_b(\theta_i) + D\rho_d \qquad (3)$$

D is the proportion of diffuse illumination, and it is defined as the ratio of diffuse reflected and diffuse incident light, both sizes of sloped surface in one hour or a day.

It depends on the anisotropy surface and atmospheric conditions, time of day, of the year. In Figure 1, the dependence of albedo on the type of surface is shown. Its value is greatly affected by human activity [1-7].

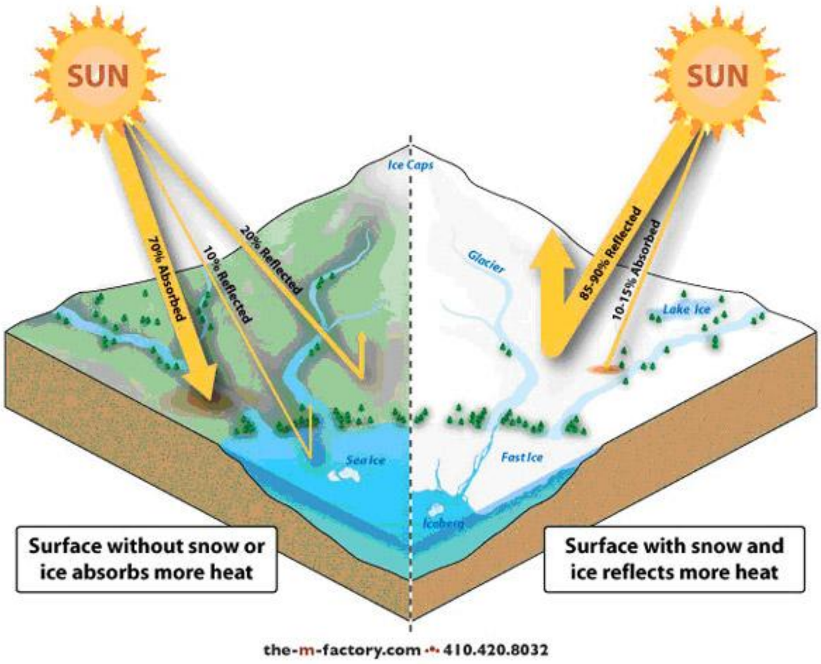

Figure 1. The dependence of Albedo from the reflective surface [1-7]

Changes in the value of the Earth’s albedo affect the average temperature of the planet. The decrease of albedo results in an increased absorption of Solar energy, wherein the temperature on the surface is being increased („temperature feedback“). For such a precise analysis, the satellite recording albedo is used. Thus follows the process of global warming of the Earth (eg, Terra and Aqua satellites of NASA). It is also possible to measure the reflection from other celestial bodies, and thus determine an astronomical albedo.
It is the best to measure the albedo (Albedometer instrument) for a given location and based on this, design the solar systems. Today, an attempt is being made to find the dependence of albedo with temperature, by means of elevation (or complementary zenith angle) [1-7].
In the table 1, there are given the values of albedo for some types of surfaces.

Table 1.

Type of area	Albedo
Fresh asphalt	0.04
Aged asphalt	0.12
Coniferous forets (in summer)	0.08-0.15
Deciduous forest	0.15-0.18
Pure land	0.17
Green grass (July-August)	0.25
Desert sand	0.40
New concrete	0.55
Ocean ice	0.50-0.70
Fresh snow	0.80-0.90
Soot	0.02
Charcoal	0.04
Volcanic ash	0.06
Basalt	0.10
Granite	0.30-0.35
Quartz	0.54
Blue stone	0.57
Sulphur	0.85
Magnesium oxide	≈1.00
Cereals	0.18-0.25
Snow, dried, aged	0.45-0.70
Ice, glacier	0.20-0.40
Ice, sea	0.30-0.45
Clouds, thin	0.30-0.50
Clouds, thick	0.60-0.90
Snow, melted	0.70
Ice, melted	0.65
Tundra	0.20
Arctic Ocean	0.07
Wet grass	0.28-0.32
Lawns	0.18-0.23
Fallow field	0.26
Macadam	0.18
Pure cement	0.55
Savannah	0.16-0.21
Steppe	0.20
Moist black soil	0.08
Dry black soil	0.13
Dry sand	0.35
Evergreen forest with snow	0.12-0.30
Black concrete	0.09
Uncoloured concrete	0.35
Light brick	0.40
Dark read brick	0.26
Matt white colour	0.70
Bright white colour	0.25
Dark gray colour	0.09
Black oil paint	0.09
Red oil paint	0.26

2. SOLAR CONSTANT AND QUANTITY OF SOLAR ENERGY

Irradiation and insolation are often considered with the terms of the same notion, but there is a difference. It derives from the generality of irradiation in relation to insolation.

The total irradiation is defined as the amount of incoming energy radiated by any source and any wavelength, not only visible light (visible light is only a part of the spectrum of electromagnetic radiation), which in unit time falls normal per unit area. When referring to solar radiation, it's called the solar irradiation or insolation. This radiation in the local time domain is almost constant, varying the thousandth part of that, a few watts of power per day. When it reaches the outer limits of Earth's atmosphere, then irradiation is defined as the solar constant (1367 W/m2). Earlier, this size, at the edge of the atmosphere, was called the "radiation flux". It's going to be measured by the devices positioned on satellites. Irradiation is a more general term of the insulation. There are two sizes of "Irradiance" and "Irradiation" which can be translated as: Irradiation. Their difference is the physical unit: The first is the power per unit of surface W / m ², while other energy per unit of surface is J/m². During the day, when analyzing the intensity of the visible part of the spectrum, analogous irradiation for a given range of wavelengths is defined as an additional size of illumination ("Illuminance" - brightness) with the unit of measure lm/m² (lumens per square meter) or lx (lux).

Irradiation, when viewed outside the atmosphere, depends on the observed point in space from the surface of the sun. It can be determined on the basis of the radiation from the Sun (Figure 2) [1-7].

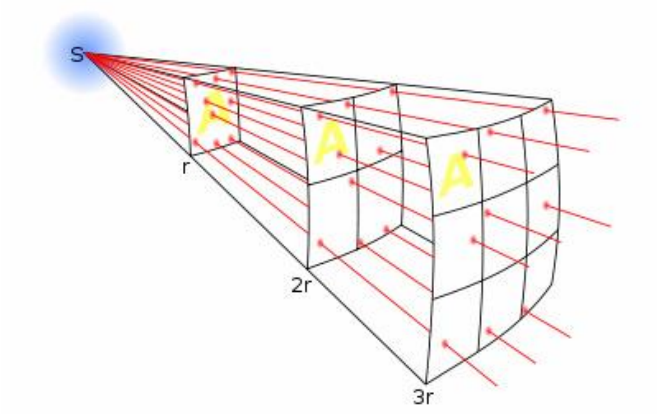

Figure 2. **Square legality of the sun radiation flux**

The power of the sun radiation is≈3.84*10^{26}W,

$$E \cdot \left(4\pi R^2\right) = 3.84 \cdot 10^{26}\, W$$

$$I = E \cdot \left(4\pi R^2\right) / \left(4\pi r^2\right) = E \cdot \left(R / r\right)^2$$

where E is the intensity of radiation in the sun, R radius of the Sun (1319 * 2 R = 106km), r the distance from the Sun where the irradiation is observed (mean distance of Earth from the Sun 1:49 * 108km). If the replacement of values occur, about 1376 W/m² is obtained, which fits well with measurements.

The amount of solar energy that passes the atmosphere and reaches the surface of the planet depends on latitude, season, time of day and weather conditions. Such radiation is called insolation or incident solar radiation. In Figure 3, there is an example of the recorded characteristics of solar radiation (global radiation) for 8 days in a year, from 275 th to 282 th day, the energy reached to the surface per unit time to the unit of surface [1-7].

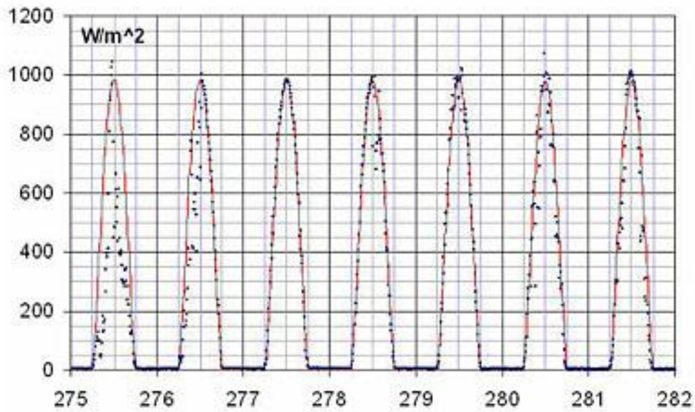

Figure 3. ***Example of changing the insolation in the next few days***

This radiation at sea level and 48.19^o of zenith angle, direct and diffuse radiation, when falling on a surface that is angled 37^o to the horizontal plane, is the intensity of 963.8 W/m² (ASTM G173-03 standard) or 1000 W/m² (CIE standard, retained from the previous conditions), called PM-1.5G. It is taken as a reference laboratory radiation of the Sun under which the panels are examined (thus allowing comparison between different types of panels to power, regardless of the technology development). Insulation can be represented as the number of sunshine hours in which time is radiation measured (measuring device heliograph) [1-7].
Maximum insolation occurs when the sun has the highest level i.e. when it has the smallest zenith angle. In the equatorial belt, the Sun is twice a year at its zenith, to Equator those are the days of equinox. For example, equator insolation during the year can be calculated as:

$$I_{Ekv} = \frac{S_a}{\pi}\left(\frac{1+e*\cos(\lambda - w)}{1-e^2}\right)^2 \cos(\delta),$$

S_a is the amount of energy that reaches from the Sun per unit time on the unit of surface at a distance **a** from the Sun, **a** are the coordinates of an elliptical solar coordinate system, **e** is the eccentricity of Earth's orbit (e=0.0167), **w** longitude of perihelion (w=282^o), **λ** the angle of the calendared day (λ=π/2 for summer solstice, λ=3π/2 for winter solstice, λ=0 for summer equinox, λ=π for autumn equinox), **δ** is declination. **S_a** is determined as:

$$S_a = S_o\sqrt{1-e^2},$$

S_o is the solar constant value 1367W/m^2

3. STANDARDS OF INCIDENT SOLAR RADIATION

As in any field, it is needful to harmonize standards for product testing and thus clearly define the quality of the same, as well as the industrial solar modules require a clear positioning of light intensity and its spectral distribution.
The reason lies more in the fact that only through well-defined excitation and obtained power it is possible to establish a common characterization of many technologies and types of solar cells. On the other hand, to make a standard solar cell and keep it in extremely demanding conditions would be very expensive.

Therefore, as a first step in the systematization of the motives, the U.S. initiated the development of standards, which were constantly being changed, finalized, and systematized. Radiation from the Sun is taken as the radiation source unit.
Industry of PV system, together with the American Society for Testing and Materials in government research and development laboratories, has defined only two standards for the spectral distribution of terrestrial radiation. These two spectra define a standard range of direct normal and global-standard total (hemispherical radiation, in the spatial corner of 2π srad in comparison to the observed surface) radiation spectrum. Direct radiation is the only component of global radiation. Both of these radiations are in the document of ASTM D-173-03 (http://www.astm.org/) (Figure 1) or in tabular form on the website at http://rredc.nrel.gov/solar/spectra/ am1.5/ASTMG173/ASTMG173.html. ASTM G173-03 includes spectral distribution of the radiated energy from 280 nm to 4000 nm.
Solar cells can be calibrated in calibration laboratories, for example. NREL (www.nrel.gov), and then use them as a standard for calibration of solar simulators, i.e. "referential solar cells. " Most terrestrial solar cells are examined under AM1.5G conditions (including global insolation, the blue graph in Figure 4), and AM1.5D (red graph in Figure 4), which refers to direct insolation. Radiation power, which is understood by a given standard, is 100 mW/m2 or 1000 W/m2. The intensity represents an integral of the spectral distribution of the radiation intensity according to wavelength. For satellite panels, a standard AM 0 (ASTM E490-00A), which includes 135 mW/m2 and responds to extraterrestrial radiation spectrum, is (black graph in Figure 4) [1-7].

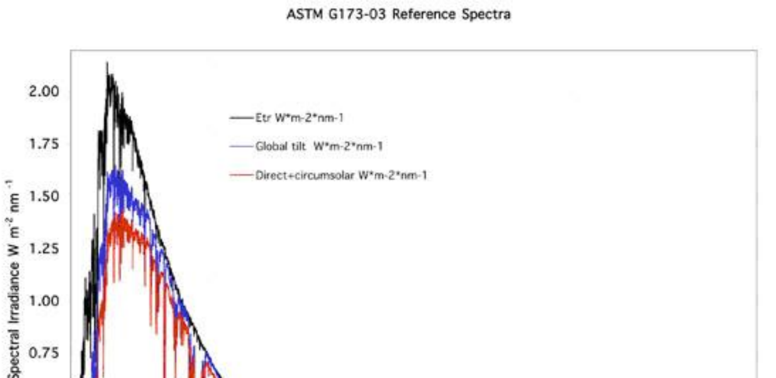

Figure 4. ASTM G173-03 spectrum

Test conditions of solar panels on the surface of the Earth: 1000 W/m2 (1 Sun), spectral distribution of solar radiation AM1.5G ASTM G173-03 and IEC 60904-3 (international standard). ASTM G173-03 represents the spectrum of terrestrial solar radiation on the surface of the specific orientation, of the correct pre-defined atmospheric conditions. This distribution of power (W/m² * nm) in the function of the wavelength allows a unique reference for characterization of spectral selectivity of the PV material, whether they are illuminated by the natural or artificial light sources with different spectral distributions.
Conditions were chosen to represent the average of the 48 states of America, in one year, and pitch angle (angle to the horizontal plane) represents the mean latitude of these states. The surface to which the solar radiation decreases is equal to an angle of 37^{o} with

respect to the equatorial plane-latitude (i.e. normal radiation to the surface plane at the elevation of the Sun above the horizon of 41.81^o) [1-7].
Specifies atmospheric conditions:

- 1976, U.S. Standard atmospheres: temperature, pressure, density of aerosols (natural), air density, density of molecular species classified into 33 layers,
- air mass of 1.5 (corresponding to the corner of the zenith of 48.19^o),
- aerosol optical depth for a wavelength of 500 nm is 0084,
- equivalent thickness of water vapour layer is 1.42 cm,
- equivalent thickness of the layer of ozone is 0:34 cm,
- superficial albedo of earth (ASTER Spectral Reflectance Database).

In order to facilitate prediction of response obtained by solar modules, Smarts software version 2.9.2 can be used. We get the spectrum of electromagnetic radiation at any latitude. Figure 5 shows the simulated standard AM 0 and AM 1.5D [1-7].

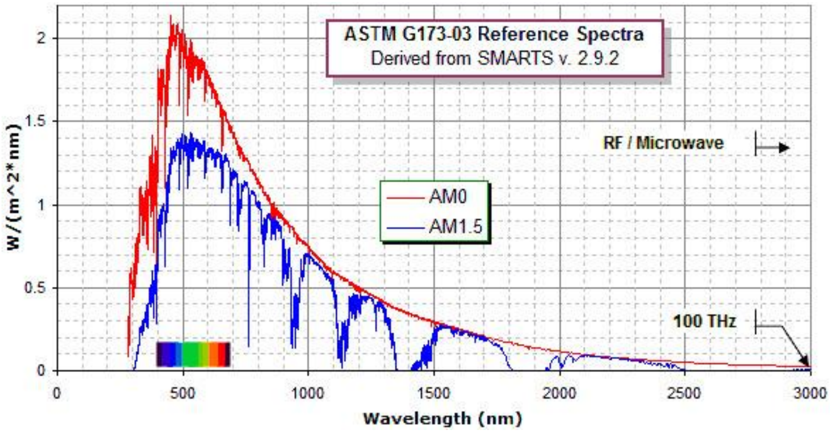

Figure 5. Simulation of AM 0 and AM 1.5D spectrum in SMARTS's programme.

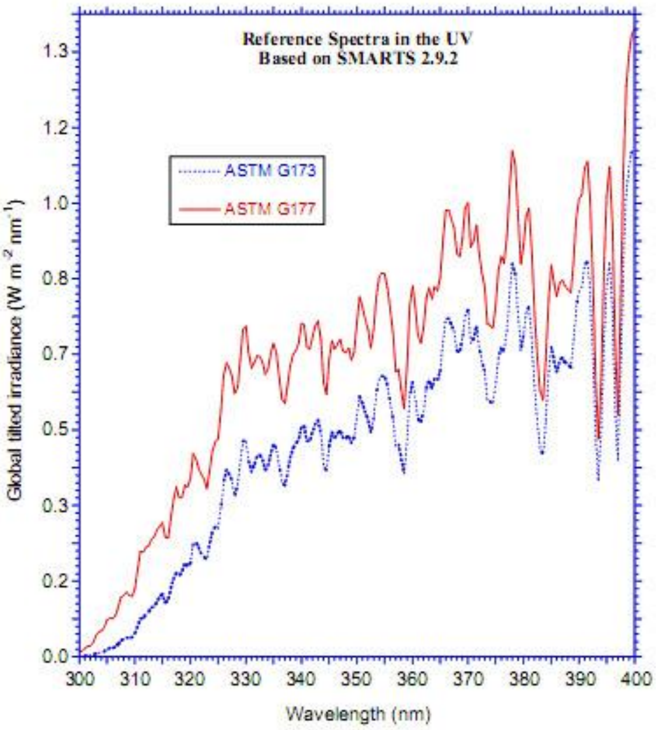

Figure 6. ASTM G177-03 vs. ASTM G173-03

When you need to examine the degradation of solar cells, then other standard of ASTM G177-03 is applied, limited to the UV spectrum of 280 nm-400 nm, which is different from the G173-03 in increased intensity (Figure 6).
Historically observed, spectrum standards were generated separately, as a standard of E-891-82 and E-892-82, for direct, respectively, the global radiation. Then, in 1999 a new standard was adopted that has brought together the two preceding, under the designation of ASTM G159-98, with the corresponding regular international standard of ISO 9845-1 in 1992 (based on ASTM E-891-87 and ASTM E-891-87; among other things, there was a change in spectral range from 2450 μm to 4045 nm). The current standard was adopted in 2003. The Global standard G173 will be defined as a standard of IEC 60904-3 "Principles for measurement of terrestrial photovoltaic (PV) components with a reference spectral of irradiation. All of the required standards can be found at http://www.astm.org and http://www.pvresources.com/en/standards.php.

4. SOLAR ENERGY POTENTIAL OF THE BALKAN REGION

It is widely believed that the future belongs to the so-called non-conventional energy sources. Solar energy cannot completely replace traditional energy sources. No matter, it is considered that the solar energy devices have serious potential.
It is believed that the amount of solar energy that is available on the Earth's surface is 20 thousand times greater than the need for electrical energy. Collecting solar energy can be done in several ways. You can use a solar receiver to collect only electricity, heat, or just use a hybrid panels and collect heat and electricity. It is also possible to use the solar concentrators to increase the effect of multiple collection.
Measuring the effect of solar panels so far has been performed with many different installations. Each installation had its specific characteristics that met the demands of measurements at the time.
Actual duration of sunshine or insolation represents the number of hours when the sun is shining over a point and is determined by instrumental measurements. The largest number of locations in the Balkans has a mean annual sunshine duration of more than 2,000 hours. Maximum solar radiation occurs in July and minimum in December. From the seasons, the most sun-shined is summer and the least is winter, until the spring is more sun-shined than autumn. The difference between the spring and autumn sum of the actual duration of sunshine is greatest in the north, at least in the southeast of Balkans. The Balkans is a place that has very good conditions for the use of solar energy. But, you should pre-establish a general energy policy for the whole of the Balkans, or its countries, and in this way make an approach to the savings of expensive imported energy as soon as possible. However, for state intervention in energy markets (tax policies, subsidies and other measures in favour of solar energy), participation of solar energy would be significant, and in 2015, it could reach significant percentages. In order to achieve these estimates, there is a need for many more additional researches. Solar systems must be economically acceptable and technically developed so that they could produce a lot of energy that is cheaper than other sources.
Evaluation of the potential of solar energy usually requires a ground and satellite measurements: precise measurement results on the ground, interpolated on the basis of satellite data measurements in a wide range, in order to estimate better the solar radiation throughout the whole territory which is under consideration.
At this moment, the reliable data obtained by measurements on the ground are not available, and creating of solar maps is based on satellite data.

Figure 7 presents the Global variations in irradiation in the world [10]. In Montenegro, the number of hours of sunshine (insolation) is over 2,000 hours yearly, for greater part of the territory and more than 2,500 hours per year along the coast. Podgorica has more sunshine hours than Rome and Athens. Vojvodina has over 2059 hours and the town of Prizren 2150 hours during the actual mean annual duration of the actual sunshine.
Mean annual sunshine duration for the Balkan region, is over 2,000 hours.

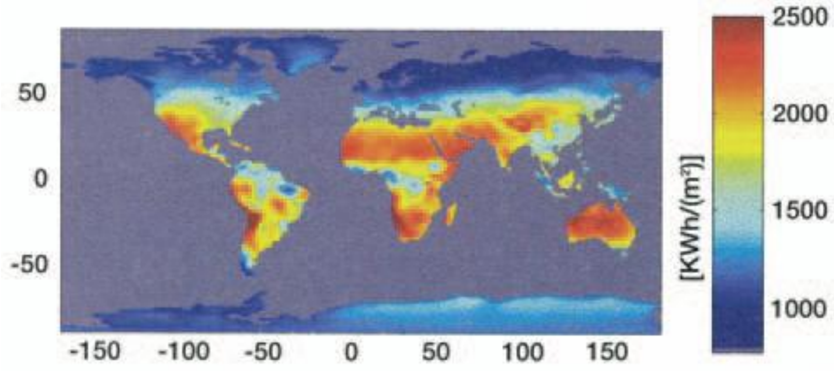

Figure 7. Global variations in irradiation [10]

Spatial distribution of mean annual actual duration of sunshine (h) for the period April - October in Serbia (1961-1995) is shown in Figure 8 [9].

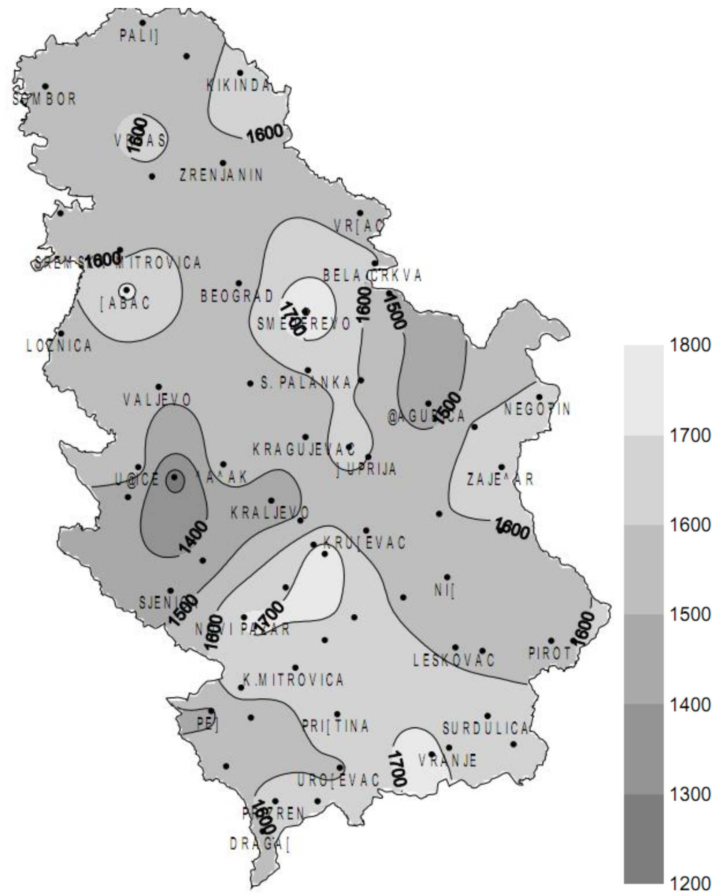

Figure 8. Spatial distribution of mean annual actual duration of sunshine (h) for the period April - October in Serbia (1961-1995) [9]

Table 2. Mean daily sums of global solar radiation energy on horizontal surface in some places for kWh/m^2 2002nd [10]

Mesto City	Mesec Month												Ukupno godišnje Total/yr	Srednje godišnje Aver/yr
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII		
Beograd	1,40	2,20	3,35	4,85	6,00	6,45	6,75	6,00	4,65	3,05	1,60	1,15	1446,80	3,96
Vršac	1,00	2,00	3,35	4,40	6,00	6,40	6,55	6,85	4,60	3,00	1,55	1,00	1424,75	3,90
Palić	1,30	2,10	3,45	5,00	6,15	6,25	6,35	5,85	4,30	2,85	1,40	1,15	1407,40	3,80
Novi Sad	1,45	2,35	3,20	4,65	5,80	6,20	6,35	5,75	4,40	2,90	1,45	1,20	1392,64	3,82
Niš	1,75	2,60	3,45	5,00	6,10	6,35	6,70	6,15	5,35	3,45	1,85	1,50	1531,40	4,20
Kuršumlija	2,15	3,00	3,60	5,05	5,85	6,05	6,55	6,10	5,30	3,50	2,00	1,75	1550,50	4,25
Peć	1,85	2,95	3,70	4,85	5,95	6,15	6,75	6,15	4,90	3,65	2,25	1,60	1546,25	4,24
Priština	1,85	2,90	3,70	5,25	6,30	6,60	6,95	6,30	5,10	3,35	1,90	1,60	1578,25	4,32
Vranje	1,70	2,70	3,65	5,15	6,15	6,40	6,50	6,35	5,25	3,45	1,85	1,50	1543,40	4,23
Loznica	1,50	2,30	3,05	4,35	5,30	5,75	6,15	5,60	4,30	2,80	1,45	1,20	1333,50	3,65
Kragujev.	1,50	2,40	3,35	4,80	5,85	6,10	6,45	5,90	4,85	3,30	1,70	1,30	1447,85	3,97
Negotin	1,35	2,05	3,25	4,85	6,05	6,60	6,95	6,25	4,75	2,90	1,45	1,20	1453,35	3,98
Zlatibor	1,50	2,30	3,10	4,35	5,10	5,65	5,90	5,35	4,30	2,75	1,60	1,30	1316,40	3,61

The duration of sunshine has a different potential depending on the demo-geographic characteristics of places, so that in the mountainous areas it is slightly weaker (Ljubljana 1804, Uzice 1723 hours per year); north-eastern part (Brestovac 1886, Petrovaradin 1991, Vrsac 2222 hours per year), Macedonia is above average 2,000 hours (2387 Stip, Prilep 2531 hour per year) while the coast is with the highest potential (2747 Hvar, Split 2642, M. Losinj 2443, Ulcinj 2530 hours per year) [11] (Table 2).

An increasing number of companies and organizations are actively involved in the promotion, development and manufacture of photovoltaic systems. Companies that manufacture and distribute electrical energy in cooperation with manufacturers of solar equipment, municipalities and funding plan, conduct all major projects, gaining the necessary experience, mobilizing public awareness and lowering the cost of electricity. Market value of photovoltaic, is currently more than U.S. $ 2 billion annually and is expected to rise by more than $ 10 billion annually until 2012. Latest representatives of photovoltaic solar industry are some of the world's leading oil and other hi-tech companies - BP Amoco, Shell, Kyocera, Mitsubishi, Sanyo and Sharp). It is estimated that it has a total installed photovoltaic capacity worldwide that exceeded 3 GW.

Previous experiences in the world show:

- In Israel, all owners of houses and apartments are legally bonded to incorporate a system for water heating. The effects of such a law (with consistent use) actually are sensitive: the annual amount of electricity using solar system is 8% of total energy consumption in Israel.
- In Greece, setting up of solar energy receiver is not a matter of prestige, but the need to save a considerable amount of electricity as well as to preserve the environment, since this technology is best suited for use in tourist regions. The last example best explained by the fact that solar energy is applicable for larger systems. In fact, the Greek government decided to create the world's largest solar power plant. Solar cells on Crete since 2003, providing electricity for a hundred thousand people, and another in March 1999. lighted the first lamp. The total investment for the plant on the southern coast of the island of Crete was $ 120 million.
- The Scandinavian countries have also found interest in using this technology, regardless of geographical location much less favourable than is the case with Israel, Greece, or our country. An example might be cited Sweden, which built the plant and a surface of 4320 m² of solar energy receiver 5. This system delivers hot water for 550 households.

- Italian power companies came to the conclusion that with the help of solar system save electricity, especially in summer, when electricity is cheaper, and water reservoirs are stored for the winter, when electricity is sold at a higher price.
- In Western Europe, the significant funds are being allocated for an experimental plant in combination with heat pumps.
- Thirty years ago in the U.S. were not provided the resources to investigate solar energy, while in 1980, the investment amounted to about $ 500 million. Great importance of using solar energy is reflected in space technology, which the U.S. had developed almost to perfection.
- The Balkan countries have very good conditions for the use of solar energy. But, you should pre-establish a general energy policy for the region or individual country, thus enabling an approach to savings of expensive imported energy. However, for state intervention in energy markets (tax policies, subsidies and other measures in favour of solar energy) participation of solar energy would be, of course, significantly, and by 2015 it could reach significant percentages. In order to achieve these estimates, there is need for many more additional researches. Solar systems must become economically acceptable and technically developed that can produce a lot of energy that is cheaper than other sources.

5. CONCLUSION

The fact that solar energy is mostly clean, reliable, inexhaustible and free, drove the people to continually try to use it as an energy source. That is partially successful, as all fossil fuels on the planet caused the accumulated effect of solar energy, but their capacity is now very limited. Like all new technologies, especially those related to energy production, are very costly, so profitability is in question. If the lifetime of the original solar panels and other necessary equipment for using solar energy was approximately the same to the time of profitability, it is clear why this aspect of energy production was poorly represented.
Cost of introducing solar system has led Germany, one of the most developed countries of the world, which because of their geographical position does not has nearly as favourable conditions for the use of solar energy, in this sector to be number one of energy supply. Five years ago, the source of energy in Germany was used in different by more than 200,000 households. Thanks to strong government initiatives, Germany has become the largest solar energy market. The results of research conducted by "Looks research" say that the United States, where the interest in solar power was weak until recently, should be equalized with Germany until the 2013, while China, in the field of solar energy will stay behind America [8].

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